Impact of Biochemical and Calorific Contents on the Reproductive Activity of the Marine Edible Snail *Turbo coronatus* Gmelin 1791

Freije, A. * and Al-Sayed, H.

Department of Biology, College of Science, University of Bahrain,
P. O. Box 32038, Kingdom of Bahrain

afrije@sci.uob.bh*

ABSTRACT

The edible marine snail Turbo coronatus from Shaikh Ebrahim Island spawns mainly in the spring, with a spawning peak in May in which all reserves studied (total proteins, carbohydrates, and total lipids) declined to a seasonal minimum value. A second minor but continuous spawning period was also observed between September and December. Whole, wet and dry tissue weights as well as ash-free dry weight (AFDW) were significantly lower in May and September, whereas water content was maximum in December and minimum in April. Total lipids formed the main reserve, while total proteins and carbohydrates contribution was less. The increased levels of the calorific content per AFDW were due mainly to accumulation of total lipids (42%) and secondly of carbohydrates (37.5%) and total proteins (36%) in the period prior to the major spawning in May, in which gamete maturation usually takes place. The dry weight proportions of the main components were: total proteins 60.97-82.18%; carbohydrates 3.39-9.35%; total lipids 4.00-8.00%; and ash 9.13-18.79%. Calorific content varied between 3.36-4.43 kcal/g dry weight.

Keywords: carbohydrate; lipid; nutrition; protein; snail; spawning; *Turbo coronatus*

INTRODUCTION

Turbo coronatus are intertidal algal browsing animals widely distributed on rocks, (Jones, 1986). Despite their abundance in many areas in Bahrain such as Budaiya, Meridien, Asry, Marina club and Jaww (Green, 1994), relatively little is known about seasonal changes in their biochemical composition, calorific content and reproductive cycle.

The seasonal changes in biochemical composition of marine invertebrates are generally attributed to gametogenesis, reproductive cycle and availability of food supply. In marine organisms, lipid, protein and carbohydrate are extremely important biochemical components, which are involved in many metabolic reactions related to gametogenesis and spawning (Martinez, 1991; Sprung, 1995; Berthelin et al., 2000).

Environmental factors, specifically food availability and temperature have been shown to influence seasonal fluctuations in energy reserve levels (i.e. proteins, carbohydrates and lipids) in marine molluscs (Arakawa, 1990; Robinson, 1992; Ruiz *et al*., 1992; Park *et al*., 1999 a,b; Kang, et al., 2000; Martinez et al., 2000; Hyun *et al*., 2001).

The aim of the present study was to describe the relationship between the reproductive cycle and energy reserves in adult *Turbo coronatus* by measuring seasonal changes in tissue weight and biochemical composition. We also include estimates of calorific values of the

biochemical components of mature animals during the period March 2003-March 2004. This study is the first in the region (Arabian Gulf) that provides information about the chemical composition, spawning, and the nutritional values of the edible snail *Turbo coronatus*.

MATERIALS AND METHODS

Sampling and preparation of materials

Samples of 20 individuals were hand picked from the surface of the intertidal rocks at Shaikh Ebrahim Island every month. Water temperature and salinity were measured on the collection day. Most snails used over the experimental period were within the shell size of 20-22 mm in length, and 15-18 mm in width, measurements were made with vernier calipers (± 0.1 mm). The months of October and February were an exception, since the shell length of most snails was below 20mm in October (16.06 ±0.3mm), and more than 22mm in February (24.47±0.54mm). Snails were transported to the laboratory and kept in sea water for 24 hours in order to allow gut clearance. The soft tissues were removed, weighed and dried in an oven at 60°C to a constant weight. The dried material from approximately 4-5 individuals was mixed together and then ground to a powder using a mortar and pestle. The powdered materials were stored in a desiccator over activated silica gel until analysis.

Biochemical analysis

Total proteins were estimated as total nitrogen, using the procedure of Guebel et al. (1991). Since most proteins contain 16% nitrogen, the total nitrogen values were then multiplied by a protein conversion factor of 6.25. Carbohydrates were determined using the phenol-sulphuric acid method of Martinez (1991). For the lipid assay, aliquots were extracted following the procedure of Folch et al. (1957). Cholesterol determination was carried out following the procedure of Postama and Stroes (1968).

Ash

Five samples of the dried material were placed in a muffle furnace at 500-600°C for 12 hours to ensure complete incineration of all organic matter. Ash-free dry weight (AFDW), water content and water percentage were calculated.

Determination of the calorific content

The calorific content for each biochemical composition (kcal/AFDW) was calculated. The energy conversion factors of 4.1 kcal.g^{-1}, (17.2 kJ.g^{-1}), 4.3 kcal.g^{-1} (17.9 kJ.g^{-1}), and 8.42 kcal.g^{-1} (34.69 kJ.g^{-1}) for carbohydrate, protein, and lipid were respectively adopted in the present study (Craige et al., 1978; Beukema and De Bruin; 1979). The calorific content of the soft tissues of *Turbo coronatus* (kcal/g dry weight) and the calorific content of a standard animal, considered as an individual of 4.58 g total weight, and 22.02 mm length, was then calculated from the biochemical components.

Reproductive activity

In the present study, the reproductive activity of the snail *Turbo coronatus* was determined by the use of the seasonal variations of the standard animal AFDW, which normally indicate the onset of organic matter accumulation for reproduction (Beninger and Lucas, 1984).

STATISTICAL ANALYSIS

Monthly data of total biochemical composition, tissue wet weight; tissue dry weight and water percentage were analyzed using ONE WAY ANOVA to test for seasonal variations. The monthly mean values of each measured parameter were also statistically compared using

Duncan's Multiple Range Test. All statistical analysis was performed using STATGRAPHIC software version 5.

RESULTS

Temperature and salinity

Significant fluctuations in water temperature and salinity were recorded throughout the study (Table 1), with a maximum water temperature of 36.90±0.00°C reached in August, and a minimal value of 19.76±0.03% in December. The salinity showed a significant fluctuation, ranging between 40 and 45‰.

Table 1. Monthly variations in environmental parameters of the seawater, Ash (g), AFDW (g), and tissue water percentage of *Turbo coronatus* (mean ± SE). Figures in the same column having same superscript are not significantly different at P≤0.05.

Month/Year	Temperature ˚C	Salinity ‰	Ash	AFDW	Water % (n=20)
March 03	23.80±0.10^{c}	42.00±0.00^{b}	0.04±0.001	0.35	67.22±2.72^{b,c}
April 03	29.70±0.85^{e}	40.00±0.00^{a}	0.04±0.001	0.36	50.02±2.52^{a}
May 03	27.83±0.38^{d}	42.66±0.00^{b,c}	0.03±0.001	0.17	67.60±1.01^{b,c}
June 03	31.20±0.00^{f}	43.00±0.00^{b,c}	0.02±0.001	0.10	66.42±1.91^{b,c}
July 03	34.50±0.00^{g}	43.00±0.57^{b,c}	0.04±0.002	0.32	66.71±1.13^{b,c}
August 03	36.90±0.00^{h}	40.38±0.00^{a}	0.04±0.003	0.26	65.92±1.58^{b}
September 03	31.90±0.00^{f}	40.38±0.00^{a}	0.03±0.003	0.18	68.18±0.81^{b,c}
October 03	30.26±0.21^{e}	45.00±0.00^{e}	0.01±0.007	0.15	66.77±2.07^{b,c}
November 03	23.36±0.03^{c}	43.33±0.33^{c,d}	0.02±0.002	0.12	69.41±1.16^{b,c}
December 03	19.76±0.03^{a}	45.00±0.00^{e}	0.02±0.003	0.29	71.42±0.73^{c}
January 04	20.00±0.10^{a}	44.66±0.33^{e}	0.02±0.001	0.25	70.77±0.34^{b,c}
February 04	20.36±0.20^{a,b}	43.33±0.88^{c,d}	0.05±0.008	0.22	69.40±0.52^{b,c}
March 04	21.10±0.11^{b}	44.33±0.33^{d,e}	0.02±0.001	0.22	66.36±0.54^{b,c}

* Statistically significant at P≤0.05.

Shell size and tissue weight

The seasonal changes in shell size, whole weight and tissue weight are summarized in Figs. 1-2 and Table 2. A minimal drop in the whole weight was registered in September (3.42±0.12g), whereas whole weight increased to reach a maximum value in February (5.58±0.12g). A sharp decrease in shell length (16.06±0.30) was registered in October, and in shell width (15.40±0.28-16.77±0.29) from September-November. The wet and dry tissue weight decreased, to reach a minimum value in June.

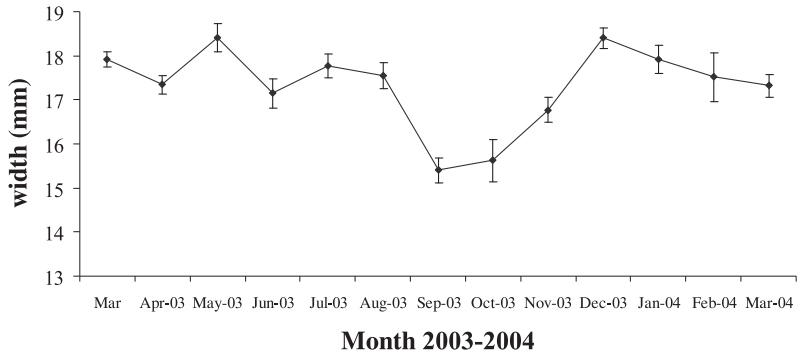

Fig. 1: Monthly variations in average shell width (mm) of *Turbo coronatus* (mean ± SE).

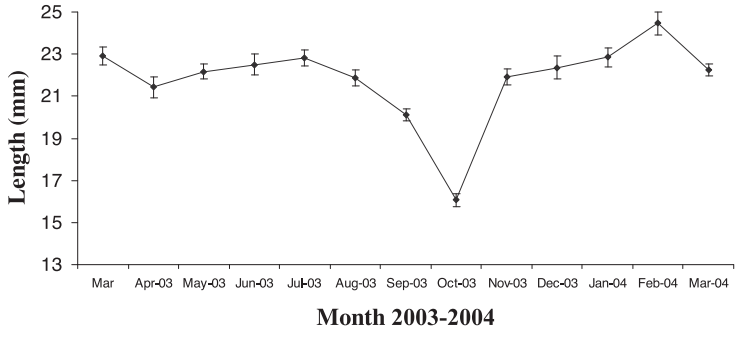

Fig. 2. Monthly variations in average shell length (mm) of *Turbo coronatus* (mean ± SE).

Table 2. Monthly variations in whole weight (g), tissue wet weight (g), and tissue dry weight (g) of *Turbo coronatus* (mean ± SE). Figures in the same column having same superscript are not different at P≤0.05.

Month / Year	Whole weight (n=20)	Wet weight (n=20)	Dry weight (n=20)
March 03	$4.71\pm0.16^{d,e}$	1.14 ± 0.10^{g}	$0.33\pm0.01^{c,d,e}$
April 03	$4.77\pm0.15^{d,e}$	$0.83\pm0.04^{c,d}$	0.40 ± 0.01^{f}
May 03	4.85 ± 0.21^{e}	0.64 ± 0.03^{b}	0.20 ± 0.00^{b}
June 03	$3.89\pm0.15^{a,b}$	0.38 ± 0.02^{a}	0.12 ± 0.00^{a}
July 03	$5.00\pm0.22^{e,f}$	$1.07\pm0.03^{f,g}$	$0.35\pm0.01^{d,e}$
August 03	$4.05\pm0.14^{a,b,c}$	$0.90\pm0.04^{d,e}$	0.30 ± 0.01^{c}
September 03	3.42 ± 0.12^{a}	0.65 ± 0.02^{b}	0.21 ± 0.01^{b}
October 03	$3.68\pm0.14^{a,b}$	$0.71\pm0.03^{b,c}$	0.23 ± 0.01^{b}
November 03	$4.15\pm0.19^{b,c,d}$	$0.69\pm0.03^{b,c}$	0.21 ± 0.01^{b}
December 03	5.74 ± 0.19^{g}	1.18 ± 0.03^{g}	$0.33\pm0.01^{c,d,e}$
January 04	$5.09\pm0.19^{e,f}$	$1.03\pm0.03^{e,f,g}$	0.30 ± 0.01^{c}
February 04	$5.58\pm0.37^{f,g}$	1.18 ± 0.06^{g}	0.36 ± 0.01^{e}
March 04	$4.59\pm0.17^{c,d,e}$	$0.94\pm0.03^{d,e,f}$	$0.31\pm0.01^{c,d}$

* Statistically significant at P≤0.05.

Ash and water percentages

The water percentage of the soft tissues and the ash percentage are summarized in Table 1. The results showed a significant decrease in water percentage in April only (50.02±2.52%). Ash percentage reached a minimal level in December (9.13%), whereas the maximum level was registered in February (18.79%).

Biochemical composition

Seasonal changes in the biochemical composition of the soft tissues are summarized in Table 3. Total protein reached a maximum value in April (82.18±1.2%) and a minimal value in August (60.97±6.8%).

Table 3. Monthly variations in Total Protein concentration (%), Carbohydrate concentration (%), Total lipids concentration (%), Ash (%), Cholesterol concentration (%), and Cholesterol percentage of total lipids of *Turbo coronatus* (means ± SE). Figures in the same column having same superscript are not significantly different at P≤0.05.

Month/ Year	Total Protein conc. (%)	Carbohydrate conc. (%)	Total lipids conc. (%)	Ash (%)	Total (%)	Cholesterol conc. (%)	Cholesterol % of total lipids
March 03	74.60±6.4^{a,b}	5.73±0.16^{b,c}	6.72±0.63^{c}	10.26	97.32	0.57±0.00^{g}	08.47
April 03	82.18±1.2^{a}	5.59±0.23^{b}	8.00±0.67^{d}	10.00	105.77	0.56±0.00^{g}	07.00
May 03	62.70±1.9^{a}	3.93±0.15^{a}	6.88±0.23^{c}	15.00	88.53	0.53±0.02^{f}	07.70
June 03	62.84±0.5^{a,b}	6.33±0.27^{b,c,d,e}	4.82±0.35^{a,b}	16.67	90.66	0.26±0.01^{b}	05.38
July 03	70.88±1.3^{a,b}	8.59±0.56^{f}	4.42±0.42^{a,b}	11.11	95.00	0.48±0.00^{e}	10.83
August 03	60.97±6.8^{a}	9.35±0.39^{g}	5.50±0.46^{b}	13.33	89.14	0.38±0.01^{d}	06.90
September 03	67.08±1.5^{a,b}	5.52±0.21^{b}	5.25±0.31^{a,b}	17.33	95.18	0.39±0.01^{d}	07.42
October 03	75.89±1.8^{a,b}	6.55±0.08^{c,d,e}	4.50±0.18^{a,b}	11.01	97.95	0.26±0.00^{b}	05.77
November 03	69.84±8.8^{a,b}	6.41±0.33^{c,d,e}	4.13±0.35^{a}	16.85	96.60	0.23±0.00^{b}	05.57
December 03	69.39±2.1^{a,b}	5.80±0.05^{b,c,d}	4.13±0.22^{a}	09.13	88.45	0.32±0.00^{c}	07.75
January 04	75.96±3.6^{a,b}	6.72±0.12^{e}	4.50±0.18^{a,b}	10.41	97.59	0.20±0.00^{a}	04.40
February 04	69.39±7.9^{a,b}	6.61±0.16^{d,e}	4.00±0.37^{a}	18.79	98.79	0.31±0.00^{c}	07.75
March 04	62.84±1.1^{a}	6.97±0.29^{e}	5.44±0.17^{b}	11.25	86.50	0.31±0.00^{c}	05.70

* Statistically significant at P≤0.05.

The carbohydrate content dropped gradually, to reach a minimum value of 3.93±0.15% in May. A second drop in carbohydrate content was registered in September (5.52±0.21%). There was a distinct seasonal cycle of changes in lipid content. Total lipid content reached the maximum level in April (8.00 ± 0.67%), whereas the greatest decrease in total lipid content was recorded during the months of October and February, with a minimal value of 4.0 ± 0.37% recorded in February. Cholesterol content varied between 4.4-10.83% of the total lipids, as shown in Table 3. The lowest values were registered in January (4.4% of the total lipids) and the highest in July (10.83% of the total lipids). No relationship existed between total lipids and cholesterol when expressed as percentage of total lipids. However, a positive correlation was observed when the data were expressed as a percentage of dry weight ($r = 0.79$, $p \leq 0.005$).

Calorific content

The seasonal changes in calorific value of total proteins, carbohydrates, and total lipids kcal/g of dried weight, kcal/AFDW, and Kcal/standard animal are shown in Table 4. The total calorific values of a standard animal ranged between 0.33 and 1.59 kcal/standard animal, with a maximum calorific value in April. Total calorific values per gram dry weight varied between 3.36 and 4.43 kcal/g dry weight, with a maximum value recorded in April.

Table 4. Monthly variations in Total protein, Carbohydrate, and Total lipid calorific content (Kcal/g dry weight); Calorific content of Total Protein, Carbohydrate, and Total lipid (Kcal/ AFDW); and Total Kcal/standard animal (Kcal/ AFDW) of *Turbo coronatus*.

Month/Year	Total Protein Kcal/g	Total Protein Kcal/AFDW	Carbohydrate Kcal/g	Carbohydrate Kcal/AFDW	Total lipid Kcal/g	Total lipid Kcal/AFDW	Total Kcal/g dry weight	Total Kcal/g wet weight	Total Kcal/ standard animal (Kcal/AFDW)
March 03	3.21	1.12	0.24	0.08	0.56	0.20	4.01	1.32	1.40
April 03	3.53	1.27	0.23	0.08	0.67	0.24	4.43	2.21	1.52
May 03	2.70	0.46	0.16	0.03	0.58	0.10	3.44	1.10	0.59
June 03	2.70	0.27	0.26	0.03	0.40	0.04	3.36	1.14	0.34
July 03	3.05	0.10	0.35	0.11	0.37	0.12	3.77	1.24	0.33
August 03	2.62	0.68	0.38	0.10	0.46	0.12	3.46	1.18	0.90
September 03	2.88	0.52	0.23	0.04	0.44	0.08	3.55	1.14	0.64
October 03	3.26	0.49	0.27	0.04	0.38	0.06	3.91	1.29	0.59
November 03	3.00	0.36	0.26	0.03	0.35	0.04	3.61	1.08	0.43
December 03	2.98	0.86	0.24	0.07	0.35	0.10	3.57	1.00	1.03
January 04	3.27	0.82	0.28	0.07	0.38	0.10	3.93	1.14	0.99
February 04	2.98	0.66	0.27	0.06	0.34	0.07	3.59	1.11	0.79
March 04	2.70	0.59	0.28	0.06	0.46	0.10	3.44	1.17	0.75

DISCUSSION

Reproductive cycle

The reproductive cycle of marine organisms is known to be highly variable with Australian mollusc species *Turbo torquatus* found to undergo two spawning per year (Ward and Davis, 2002), whereas most studies on turbinids elsewhere in the world concluded that they undergo an annual spawning cycle (Toshiaki, 1993; Hideki *et al*., 1995; Foster *et al*., 1999).

Little is known about the biology of the genus *Turbo* in the Arabian Gulf. Growth, reproduction, respiration, feeding, energy flow, and seasonal variations in energy and biochemical composition of *Turbo sarmaticus* in the Eastern Cape have been studied (Lombard, 1977; McLachlan and Lombard, 1980). They have found that *Turbo sarmaticus* spawns during the summer-autumn (December-April). Lasiak (1986) studied the reproductive cycle of *Turbo coronatus* present on the Transkei coast in southern Africa, and suggested that *Turbo coronatus* may be a partial spawner, with a distinct peak in spawning activity between December and February. Lasiak (Lasial, 1986) has also suggested that this species may have multiple spawning events, with the peak in spawning activity occurring during the period of maximum sea temperature.

The present investigations have revealed that *Turbo coronatus* are capable of spawning twice a year, namely in spring and summer, with the main spawning event occurring in the spring. *Turbo coronatus* had one peak spawning in May, and a minor continuous spawning period between September and December when water temperature ranged between 19.76±0.03°C and 31.9±0.00°C. Therefore, major spawning occurred outside the warmer months of July and August, when the water temperature can range between 34.5±0.00°C and 36.9±0.00°C. However, no correlation was found between spawning and temperature during the study period, except a negative correlation with whole weight ($r = -0.60$, $p \leq 0.05$). Although a negative correlation was found between total lipids and cholesterol and salinity ($r = -0.63$ and $r = -0.62$ respectively, $p \leq 0.05$) during the study period, salinity had no significant effect on spawning.

Gross biochemical study

A seasonal increase was observed in the total lipid content in April (8.55 ±0.61%), that could mainly be attributed to the period of increased energetic demand in the gonads due to gamete development. These results are consistent with other studies on molluscs which have shown that as oogenesis proceeded, total lipids become the most important of gonadic materials (Sarkis, 1993). The total lipid content of *Turbo coronatus* ranged from 4.0 ± 0.00 to 8.55 ± 0.61% of dry tissue weight. The results showed a clear period of energy storage (March-April) and another period of energy utilization (May-July). The cessation of reproductive activity was followed by a fluctuation in the lipid content throughout the remainder of the study. The cholesterol content ranged between 4.4 and 10.83% of total lipids and showed significant variation throughout the period of study (0.20 ±0.00–0.57±0.00% of dry weight). A positive correlation between cholesterol and total lipid was recorded ($r = 0.79$, $P < 0.05$), suggesting a primarily structural role.

The present study showed a significant fluctuation in carbohydrate concentration, reaching minimum levels in May (3.93±0.15%), September (5.52±0.21), and December (5.8±0.05). These findings are consistent with other studies on bivalves, which attribute the high levels of carbohydrate and glycogen to full gonadal maturation, whereas the lower levels of carbohydrate and glycogen could thus be the indication of spawning (Berthelin et al., 2000).

The total protein content of *Turbo coronatus* decreased to reach a value of 62.70±1.9% in May, which was accompanied by a significant decrease in percentage of carbohydrate, and total lipids, probably due to spawning. The results of this study are in agreement with other studies on bivalves, which have shown that protein levels increase before spawning, and decrease immediately after spawning (Labarta et al., 1999; Berthelin et al., 2000; Gagne *et al*., 2002). The low concentration of total proteins in August and September coincided with a low total lipid concentration from October till February, suggesting one more distinct phase of continuous spawning between September and December.

Biochemical composition of *Turbo coronatus* (Table 3) showed that total protein makes up 82% of the dry weight. The result of the present study is consistent with several studies on marine organisms which have shown that protein content accounts for 50-85% of the dry weight (Beukem and De Bruin 1979; Shafee, 1981; Beninger and Lucas, 1984). The total protein (62.7-82.18%) content was found to be the major component throughout the study period of the dry weight, whereas carbohydrate and total lipids always remained at a lower level (3.93-9.35%) and (4.00-8.00%) respectively. The summation of the three main components, total proteins, carbohydrates and total lipids, as well as ash yielded totals varying from 88.45-105.77% (mean 94.5% of the ash dry weight), with a mean deficit of 5.5% (Table 3). The lack of summation to 100% is commonly observed in studies of biochemical compositions (92.5%) (Ansell, 1972); and (94%) (Beukema and De Bruin, 1979). The reasons for the lack of summation to 100% are complex. However, others (Beukema and De Bruin ,1979) have suggested that the deficit could mainly be due to free carbohydrates and tightly bound water, since material dried at only 60°C would usually contain 2 to 3% of water.

Peak spawning (May) in *Turbo coronatus*, is associated with a total loss of energy of 22.26%, to which each component contributes in the following proportions: total proteins 19.48%, total lipids 1.12%, and carbohydrates 1.66%. The contribution of each component to the total energy expenditure is 36% for total proteins (from 1.27-0.46 Kcal/AFDW), 37.5% for carbohydrates (from 0.08-0.03 Kcal/AFDW) and 42% for total lipids (from 0.42-0.1

Kcal/AFDW). Therefore, lipids may serve as the main energy reserve, particularly during the non-spawning period, whereas proteins and carbohydrates serve only in a limited capacity as an energy reserve during this period.

Estimation of the calorific content

The calorific content of the snail *Turbo coronatus* fluctuated throughout the study period, most probably due to gametogenesis and spawning. The calorific values ranged from 3.36-4.43 kcal/g dry weight (1.14-2.21 kcal/g wet weight; 0.33-1.59 kcal/standard animal), with a maximum value of 4.43 kcal/g recorded in April, which coincided with the increased values of all biochemical components (total proteins, total lipids, and carbohydrates) prior to the major spawning peak in May. In comparison with other marine organisms studied (Ansell, 1974; Ansell and Bodoy, 1979; Tierney et al., 2002), the calorific content of the snail *Turbo coronatus* estimated in the present work, indicate that this marine organism is rich in protein and poor in carbohydrate and lipid, which makes it a suitable nutritional choice for health- and weight-conscious individuals.

CONCLUSION

The present study suggested that the biochemical composition of the snail *Turbo coronatus* followed a seasonal cycle related to reproductive activity. A significant decrease of biochemical contents was observed in May, resulting in a fall in tissue weight. These changes closely paralleled changes in whole, wet and dry tissue weight. Major peak spawning was initiated in May, while a second minor but continuous spawning was recorded between September and December and was associated with decreased dry weight levels.

Calorific content varied between 3.36-4.43 kcal/g dry weight. The contributions of energy for major spawning event in May were: total proteins 36%, carbohydrates 37.5%, and total lipids 42% of energy during major spawning period. Therefore, the results of this study suggest that energy for reproduction is primarily derived from lipids.

ACKNOWLEDGMENTS

The authors are grateful to Dr. Redha Shams, Director of the National Mariculture Center (NaMaC), Kingdom of Bahrain for providing the facilities used during the collection of samples from Shaikh Ebrahim Island. Thanks are also due to senior Biology students at the University of Bahrain who participated in this project and to Prof. Salim Akhtar, Chemistry Department, University of Bahrain for proof- reading the manuscript.

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تأثير المحتوى الكيميائي والسعرات الحرارية على تكاثر الحلزون البحري *Turbo coronatus* Gmelin 1791

فريجة، أفنان * و السيد، هاشم
قسم علوم الحياة، كلية العلوم، جامعة البحرين، ص. ب. 32038 ، البحرين

الملخص
أستهدف هذا البحث دراسة التكاثر في الحلزون البحري *Turbo coronatus* المتواجد بكثرة في جزيرة الشيخ إبراهيم على الساحل الشرقي من البحرين وذلك خلال الفترة من مارس 2003 إلى مارس 2004. و توصلت الدراسة إلى أن تكاثر الحلزون يبدأ في فصل الربيع ويصل إلى ذروته في شهر مايو وذلك بناءً على تناقص تركيز المواد البروتينية والكربوهيدراتية والدهون إلى أقصى حداً لها. كما وقد لوحظ أن الحيوان يتكاثر لمرة ثانية، ولكن بشكل ثانوي وبصورة مستمرة ، بين شهري سبتمبر وديسمبر. ودلت الدراسة على حدوث انخفاض حاد في الوزن الكلي، والوزن الرطب ، والوزن الجاف، والوزن الجاف الخالي من الرماد خلال شهري مايو وسبتمبر، بينما وجدت أعلى نسبة في المحتوى المائي للأنسجة خلال شهر ديسمبر وأقل نسبة للمحتوى المائي في شهر إبريل. كما توصل البحث إلى أن الدهون الكلية تشكل المخزون الأساسي للحلزون بينما أتت البروتينات الكلية والكربوهيدرات في مرتبة أقل.

وتوصلت الدراسة إلى أن السبب الرئيسي لزيادة مستوي السعرات الحرارية للوزن الجاف الخالي من الرماد يرجع أولاً إلى مخزون الدهون الكلية (42%) وثانياً إلى الكربوهيدرات (37.5%) ومن ثم إلى البروتينات الكلية (36%) وذلك قبل بداية موسم التكاثر في شهر مايو والذي يتم خلاله نضوج الأمشاج. كما وجد البحث أن نسب المواد الرئيسية من الوزن الجاف هي 60.97-82.18% بروتينات كلية؛ 3.39-9.35% كربوهيدرات؛ 4-8% دهون كلية؛ 9.13-18.79% رماد، كما تراوحت نسب المحتوى الحراري بين 3.36-4.43 كيلو كالوري للجرام من الوزن الجاف.