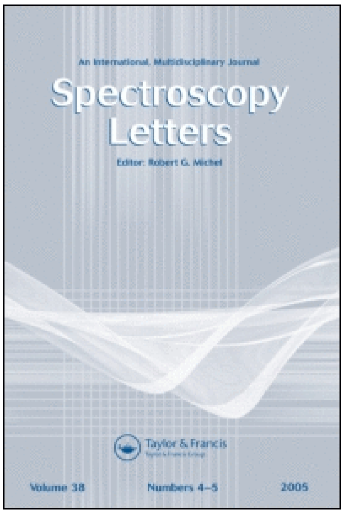

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Changes in the Condition Index and Chemical Contents of Venerupis (*decussata decussate L.*) from the Egyptian Coastal Waters.

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Changes in the Condition Index and Chemical Contents of Venerupis (*decussata decussata L.*) from the Egyptian Coastal Waters.

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Abstract

Changes in the condition index and chemical contents of adult and young aged exotic Manila *Venerupis* (*decussata decussata L.*) have been studied. Animals were collected monthly from El-Mex Bay during the period from April 1993 to April 1994. Monthly variations in total lipid, phospholipid , triglyceride , free fatty acids (FFA), phosphorus, potassium and magnesium were determined in animals of different sizes. Their average values being; 20.93%, 10.54%, 1.04%, 1.26%, 4.23 mg/g, 3.26 mg/g and 1.71 mg/g dry weight for the corresponding parameters respectively. Mostly,there was a fall in the condition index associated with considerable rise in total lipid and their constituents (Phospholipid, FFA and triglycerides). Venerupis tissues are of extremly high lipid and relatively high phospholipids, it constitutes about 49% of the roe lipid comparing to about 6% FFA and 5% triglycerides and consequently low cholestrol content. It has very low Iodine value, mostly within the average of 27.8 to 31.85, and is characterized by low density and low unsaturated lipids.

Fluctuations in the lipid content of the animals followed the relative change in food intake throughout the year and the state of maturation. A marked reduction in lipid and some of its constituents was associated with lowering temperature in winter, as the result of the reduction in feeding activity. The major period of spawning occurred from June through September, and is accompanied by lipid metabolism.

P and K were found to promote the growth rate and increased with increasing the condition index and showed high bioaccumulation rate, in contrast to Mg.

Introduction

Venerupis decussata decussata L. are restricted in its distribution and abundance. It occurs along the USA pacific coast, strait of Georgia, British Columbia, Queen Charlotte Islands (Walne, 1972; Nosha and Kenneth, 1973; Johannessen, 1973 a&b), and some areas along the Egyptian coastal waters (Hassan, 1974; El-Nady 1977).

The biochemical composition of bivalves has long excited interest, it shows some seasonal variations associated with their reproductive cycles. In bivalve molluses, two types of reproductive cycles are found. In the first group, prolifiration of gonads begins in spring, in the second, gonad development begins before the winter (Chipperfield, 1953). In spite of the differences in the reproductive cycles, the seasonal variations in biochemical composition in most species had showen many similarities (Walne, 1972).

Lipid, the main storage reserve, tend to be high in the spring, and this is almost certainly associated with the ensuring reproductive activities. During reproduction a decrease in lipid was recorded, which may be associated with the utilization of lipid as an energy reserve during adverse winter conditions (Walne 1972).

Among the striking feature of the biology of most Lamellibranchs is its ability to store large quantities of fat during the feeding season, to be used as a source of energy when food production in the sea is at minimum. As a result, wide variations in fat content being recorded during a single year of life or a short - term period.

This study contribute extensively to our knowledge occurrence of shallow - water exotic Manila, and pointed out that no commercial quantities of this clam have occured in the Egyptian waters. Its importance lies mainly in the serve as a model of the life history of the other species.

The prime importance of fat in determining the dietetic value of the organisms and its importance as a physiological characteristic, has resulted in the studying of the lipid in the commercial importance species of bivalves such as clams (*Venerupis decussata decussata L.*).

In this work we have studied the changes in the condition index, total lipid and lipid constituents; phospholipids, free fatty acids (FFA) and triglycerides in addition to the lipid saturation (iodine value, IV) in both mature and immature stages of venerupis. The bioaccumulation of the non-critical elements; P, K and Mg were also determined in view of time and age variations.

Material and Methods

Sampling was carried out over one year, from April 1993 to April 1994. They were collected alive monthly from the local fishermen of El-Mex Zone, which is subjected to higly industrial waste water discharge, and brackish water from Umum Drain, rendering the area more polluted. Details of length, weight (rate of growth) and state of maturation are available for nearly all of the organisms analysed. Analysis were made as soon as possible after collection, usually within 2 days. Length-weight relationship was studied on about 100 organism of different sizes of the combined sex during August.

Condition index (the ratio of the dry flesh weight to the total dry weight, flesh + shell x 10^3 was determined according to Gabbott and Walker, 1971. Condition factor was calculated using Fulton's condition factor (K = 100 x weight/length^3) (El-Nady & Abdel - Aziz, 1994).

Total lipid was determined by refluxing portions of the dried sample in a soxhlet apparatus with a 2:1 mixture of chloroform - methanol, according to the procedure of Bligh and Dyer, 1959. Water content was determined by difference between the wet and dry weight of the flesh, after drying at 70°C to constant weight. Iodine value (IV) of the roe lipid was determined using Hannus method (El-Samra, 1972).

The lipid fractions of principale interest; the phospholipids, free fatty acids triglycerides were isolated from the samples by saponification and extraction (Ackman et al. 1969).

Phosphorus content was determined according to the method of Aspila et al. 1976. Potassium and Magnesium were estimated, after acid digestion of the soft parts (Tariq et al. 1991). They were measured using flam photometer and atomic absorption spectrophotometer respectively.

Statistical analysis: One way ANOVA, linear correlation, regression analysis were used. Student's t-test was used to compare means at P = 0.05 and 0.01 levels of significance.

Results and Discussions

1- Seasonal variation in length, weight and condition index of exotic Manila (*Venerupis decussata*).

Morphometric data for the bivalve venerupis was obtained. Inclusion of age as a variable considerably an important factor that would be encountered. As the size is a good estimation of age, it was throughly estimated. The mean length varied between a minimum of 2.06 cm in September and a maximum of 5.67 cm in June, i.e seasonal variations in the growth rate (length and weight) of the species seemed to be more significant. The species commenced in spring (April) reaching its maximum during summer when the gonads were ribe, the average weight ranged from 0.27 - 1.27 gm and 1.03 - 16.59 gm/body tissue in immature and mature species respectively. The growth rates of length, hight and breadth were found to change with increasing length, causing a change in the form of the shell. Until the length reaches 13 mm the shell's growth tends towards an oblong form. Between 13 and 43 mm the trend is towards a spherical form. Above 43 mm a spherical flattened form and increased thickness is achieved. Similar observations were recorded by Johannessen (1973 a & b) with some deformations of the inner shell surface of the same species as a result of infection by trematoda metacercaria, the older species showed severe deformation. According to Nosho and Kenneth, (1973) the mean length of venerupis at annual age increments was, 24 mm after 1 year, 30 mm after 2 years, 40 mm after 3 years and 44 mm after 4 years.

Association between the total length and wet weight of the body (shell + tissue) without gender was significant ($r = 0.92$, $p < 0.01$). Seasonal variations in the growth rate of venerupis are mostly controlled by its feeding activity (LeGoff & Daguzan, 1991 and Zwarts, 1991). In winter, the relative reduction in the standing crop of plankton (Dowidar and El-Nady 1982 and Akamine et al. 1991) and the low water temperature seemed to suppress the feeding activity of the, animals, in addition to the fall in the filtration rate, lead to decrease in the condition index. While, increasing in the feeding activity during spring blooming of plankton resulted in rising the weight of the species during summer, and increased in both condition factor and condition index ($P < 0.05$), in which increased temperature may resulted in higher metabolic rate and this increased energy demand that can be met either from food or reserves. During gonad maturation (in September), pronounced fall in the previous factors was recorded. In general, the condition index increased in immature than the mature animals, ranging from 77 (in December) and 156 (in April). i.e. the young animals grow faster than the old ones, as recorded by Johannessen, 1973a.

Lipid - Iodine value relationship

The lipid content of venerupis displayed seasonal variations, being 20.93 ± 8.22 and 17.97 ± 6.21% for mature and immature animals respectively. In mature organisms, gonads start to develop in early summer, and remarkable decrease in lipid was observed (Fig. 1), due to its consumption as a source of energy during gonad formation, and lipid metabolism might occurred, as reported for some molluses e.g sepia officinalis (Bouchaud, 1991). According to Nosho and Kenneth, 1973 the major period of spawning for *V. japonica* occurred from May through September. Spatfall was heaviest from June through October. So, sexual maturation would alter the lipid distribution. It is also consumed as a source of energy during cold months, where it showed pronounced fall in both young and old animals. The lipid content in venerupis is characterised by the major peaks in June, October and January in mature animals, and a minor peak occurred in April. On the other hand, the great reduction in filtration rate at low temperature that reach to zero (Walne, 1972) induced that, feeding activity would be reduced for long periods during the winter months, compared to the high filtration rate in summer, and consequently increased feeding activity, growth rate and lipid content. A pronounced reduction in lipid in young animals from September through March was recorded, when water was relatively clear and of low particulate materials.

The average lipid content in *V. decussata* lies within the order of magnitude that of some fish species such as Hake (El-Nady and Abdel-Aziz, 1994), and higher than that of fresh water crayfish (15%, Wolfe, 1964), crustacean, blue crab (0.52%) and parapenaeus spp. (0.91%) as recorded by Dabrouski et al. 1969.

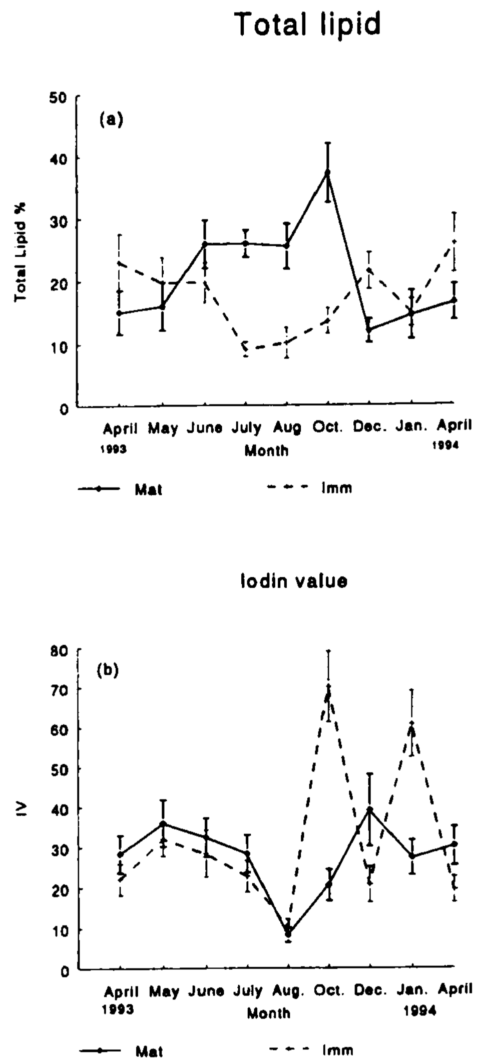

Fig. 1. Monthly average values of total lipid % and Iodine value in mature and immature *V. decussata*.

Iodine value (IV) being one of the characteristics used to define oils by species of origin and purity. IV are considered to be extremely low at about 100 (Ackman & Eaton, 1967), accordingly, roe lipid of venerupis are of low IV, being 15.13 - 104.47 and 8.26-44.87 in immature and mature organisms respectively. It displayed seasonal variations, that differ with size. Unlike that in some fish (Ackman et al. 1969), size does not appear to have an important influence on fat content or IV. In the young aged animals, IV increased in October and January which are mostly in line with the generalization that low temperature induces a higher IV in venerupis fat (Hilditch and Williams, 1964; Malins and Wekell, 1969). In mature animals, it increased in May, June and December (Fig. 1). The general behaviour in fat IV seemed to be of significant inverse correlation with the total lipid ($p < 0.05$). The total fat IV fell by about 18 unit from June through August, at a time when total fat decreased approximately from 26 to 18% (during gonad maturation). The animals are not believed to feed extensively during this period.

The tentatively suggested rise in venerupis oil IV immediately after spawning probably represents fat deposition from feeding on organisms contain high IV fatty acids (Ackman and Hooper 1970). This could be laid down as low-density fat of low IV as slowly as possible to permit elimination of surplus water after spawning. Generally, the lipid of venerupis is of low density in comparison with fish oil of high IV fatty acids (104-135, Ackman and Eaton, 1970), Shrimp (165-176), Euphausid (138) as recorded by Ackman and Eaton, 1967 and zooplanktonic crustacea (200, Yamada, 1964).

Phospholipid, Free fatty acids and Triglycerides

Comparisons of fatty acid composition are essentially on a "type of lipid" basis. Seasonal variations in phospholipid (PL), free fatty acids (FFA) and triglycerides displayed similar trends in their distribution among the young and old animals and are in great correspondence with the lipid distribution ($p < 0.01$). The maximum peak of lipid being recorded in October was mostly associated with that of triglycerides, FFA and phospholipids. However, they are inversely correlated with the saturation value (IV) where $p < 0.01$. The reduction in IV of depot fat should provide a compensating decrease in density of the remaining fat, as fatty acids of low IV have lower densities.

Venerupis roe lipid contain about 49% phospholipid, 6% FFA and 5% triglycerides. Phospholipids are extremely increased because they are probably intimately involved in cell membranes and function, and therefore represent residual "essential" lipid remaining when all depot lipid reserves such as triglycerides have been exhausted. It is then increased when total lipid has accumulated (Fig. 3). Similar observations were found for rock lobster (50% phospholipid, De Koning and Mc Mullan, 1966) and zooplankton (54% phospholipid and 8% triglycerides, Brockerhoff et al. 1964). As cholestrol is one of the essential constituents of triglycerides, venerupis oil and consequently its soft parts are of low cholestrol content.

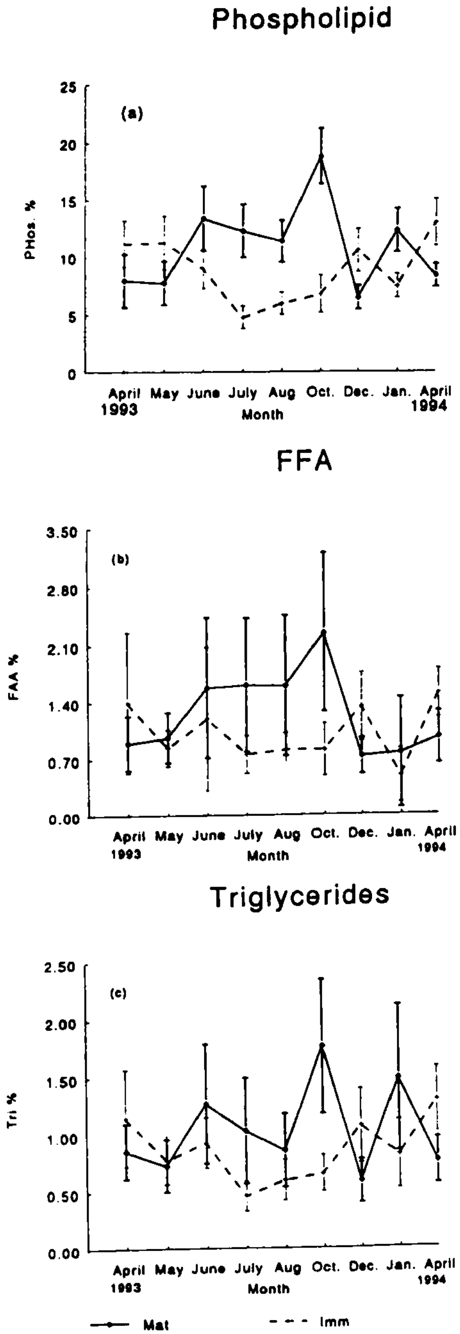

Fig. 2. Monthly average values of Phospholipid (a), FFA (b) and Triglycerides (c) in mature and immature *V. decussata*.

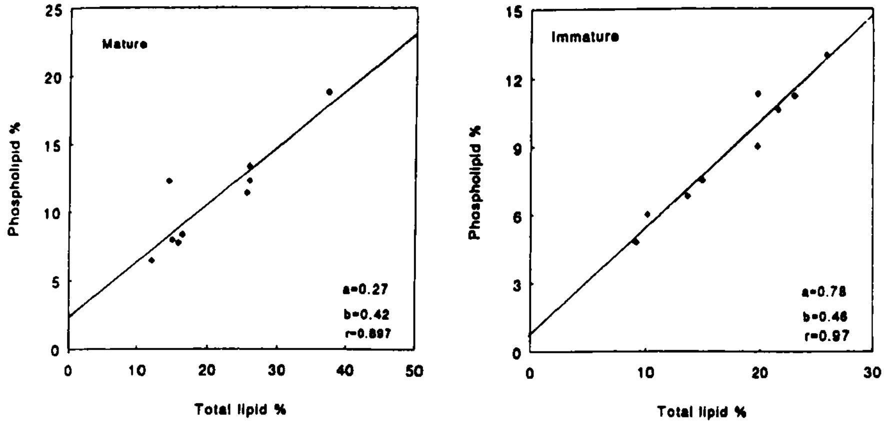

Fig. 3. Relation between total lipid % and phospholipid in *V. decussata*.

The average values of triglycerides ranged from 0.59 - 1.76% (mean 1.04%) and 0.46 - 1.29% (mean 0.86%) dry body weight in mature and immature animals respectively, and it is directly correlated with total lipid (Fig. 5). It is therefore possible to view typical high fat with typical high FFA formation (Fig. 4), as two aspects of one development: the catastrophic mobilization of depot fat as a source of energy in the later stages of sexual maturation and during spawning. Nevertheless, the soft parts of venerupis showed apparently intact phospholipids in mature animals (10.54%) slightly higher than that of immatures (8.91%). FFA has probably occurred similarly to the body lipid hydrolysis in both mature and immature stages (Fig. 2). In matures, the total lipid and their constituents have shown distinct pattern in their distribution, they increased markedly during summer due to high feeding activity (prespawning), decreased to minimum levels in September (spawning period), where sever hydrolysis of phospholipids has occurred and exhausted. Then increased in October due to intenssive feeding after spawning. In immatures, they only increased in spring as a result of food availbility. However, Association in phospholipids between mature and immature animals is more pronounced ($p < 0.05$) while it was displayed in case of FFA and triglycerides (Fig. 2). Moreover, the amount of PL was appreciably higher, indicating that less hydrolysis had taken place in these less active organisms, comparing to fish of low PL and severe hydrolysis (Ackment et al. 1969). The fatty acid compositions of phospholipids and triglycerides are dissimilar in most marine organisms (Addison et al. 1968). Mac Callum *et al.* 1969, believed that, the type of phospholipid initially present, are essentially similar in composition in most marine animals, with phosphatidyl choline predominating (~ 60%),

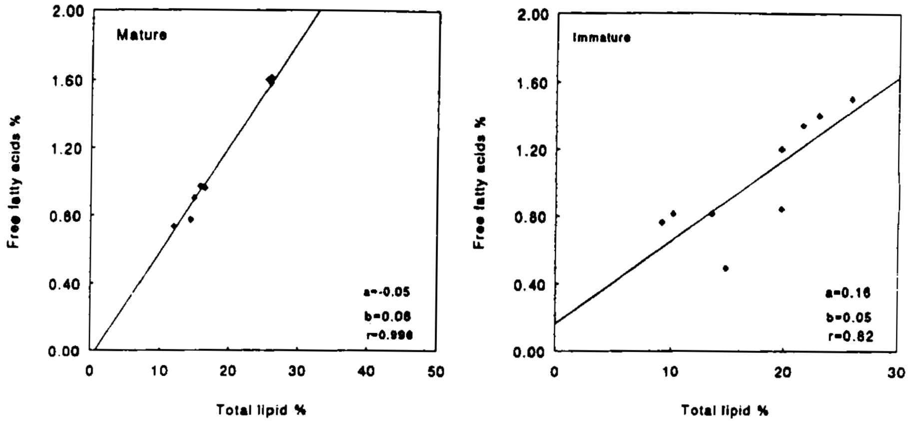

Fig. 4. Relation between total lipid % and free fatty acids in *V.*

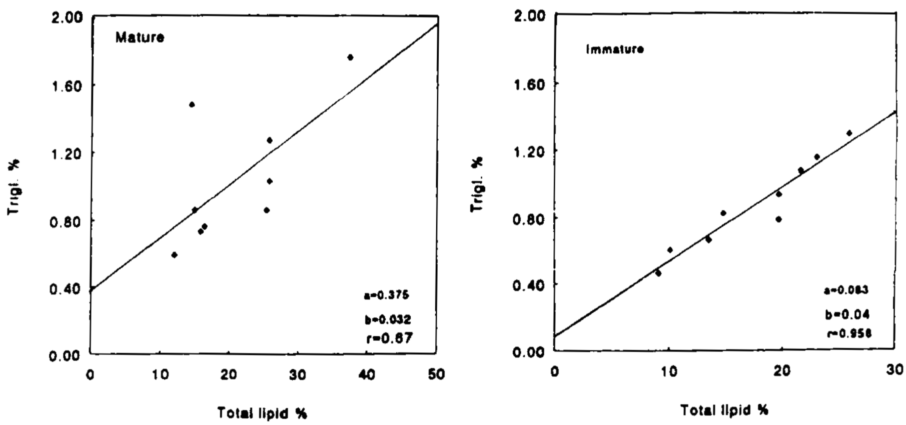

Fig. 5. Relation between total lipid % and triglyceride in *V. decussata.*

phosphatidyl ethanolamine and serine present in lesser amounts. However not all organisms are subject to similar seasonal fluctuations in lipid and its composition. In some species lipid reserves are obviously catabolized during periods when food is scarce, in others the metabolism becomes sluggish to tide the animals over this period, so fat is probably still the most important energy source under the later conditions.

Unfortunatly, most bivalves have only a limited capability of metabolizing some organic pollutants such as petroleum hydrocarbon compounds, due to lack the hepatic microsomal enzyme, hence, they can accumulate large quantities of these contaminants

Table 1. The average values of P, K and Mg in *V. decussate*, water and sediments and their bioaccumulation factor.

element	Conc. in *V. decussata* (1)	Conc. in water gm/l (2)	Conc. in sediment mg/g (3)	accumulation factor
P	4.09	1.4×10^{-5}	0.70	2.90×10^{5}
K	3.33	0.40	10.10	8.90
Mg	1.90	1.30	18.7	1.46

1- Present work
2- El-Nady, unpublished data
3- Mahmoud et al. 1992

(Berthou et al. 1987). Moreover, the increased concentration of some heavy metals in the ambient water in El-Mex Bay and consequently in venerupis (El-Nady in press) seemed to give rise to pronounced reduction in the lipid content and growth rate ($p < 0.05$) according to the following order: Zn > Fe > Pb > Ni > Cd.

Accordingly, the toxic metals (Zn, Pb) might inhibit the growth of venerupis and reduce its nutritive value.

Phosphorus, Potassium and Magnesium

The average values of the non-critical elements in soft parts of venerupis being 4.09, 3.33 and 1.9 mg/g dry weight for P, K and Mg respectively (Table 1). Only P content being increased with increasing total lipid and its constituents ($p < 0.01$) where as an inverse one ($p < 0.01$) with the saturation value (IV) was recorded.

The rate of accumulation of P, K & Mg in the soft tissues increased markedly in the organisms with an inverse order with their concentration in the surrounding medium (water and sediments, Table 1). Particularly for P, where its bioaccumulation factor reach several thousands (2.9×10^5). The animals obtain most of their body P via filtration through different accumulating mechanisms rather than from water or sediments. De Jorge et al. 1966, found its concentration being 1.38 mg/g fresh weight in *M. xerecus*, however practically, no phosphorus may found in sea water.

Mg concentration in venerupis increased during the period of sexual maturation and high filtration rate in spring and summer, as it is one of the biochemically function elements for all living organisms and can accumulate it through different food chain. Stapleton, 1968 found that Mg concentration in the squid has been reported to increase during sexual maturity.

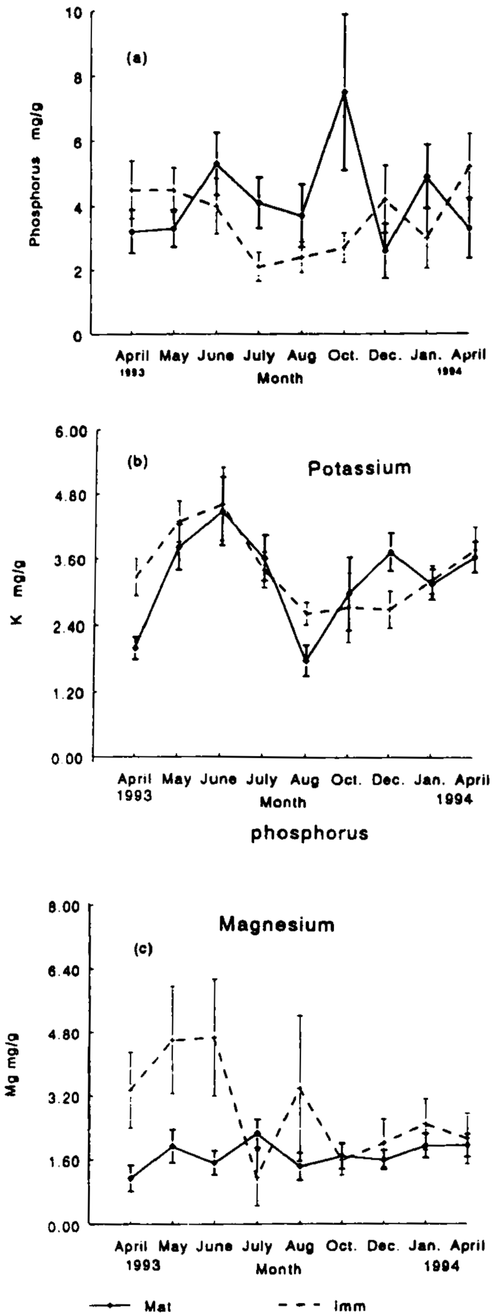

Fig. 6. Monthly average values of phosphorus (a), potassium (b) and magnesium (c) in *V. decussata*.

The concentration of K, Mg and P in venerupis were high when compared with those of other animals (tubes of Telepsavus, Zola, 1967). The obtained results certainly indicate active incorporation of these elements in the animals. Similar accumulation of P and Mg have been reported for the tubes of polychaetes (Pautard and Zola, 1968).

Biomineralization in molluscs statocysts is unusual, in which these ions are secreted into a comparatively large volume of fluid deposition, rather than being secreted by a membrane applied to the mineralized structure (Morris, 1991). Also the ionic composition of the statocyst fluid, suggests possible mechanisms by which "diurnal" growth increments are formed in molluscs. This was demonstrated from the increasing concentration of K and P (with exception of Mg) with the growth rate (length and weight) of venerupis and increasing the condition index ($p < 0.05$), in contrast to what happened with heavy metals (Hiss and Robert, 1987). The low concentration of Mg within the body tissue may indicate an active transport mechanism, probably in the form of a Na/Mg or K/Mg Pump (Morris, 1991), as the concentration of Mg is in the order of that found in sea water. The rate of bioaccumulation of K seemed to behave similarly in both mature and immature animals ($p < 0.05$). Unlike that of Mg where the bioaccumulation increased in an inverse order with age during different times (Fig 6 a-c), as the young animals grow faster than the old ones (Johannessen, 1973a).

Active uptake of most elements particularly phosphorus can be significant, especially during blooms, when it has been utilized by phytoplankton (Kinnish, 1992), zooplankton facilitate the removal of such elements by consolidating them in fecal material which sinks to the seafloor and concentrate in the bottom organisms. Accordingly, these organisms are considered to be an essential factors in the absorption and redistribution of most elements. On the other hand, adsorption of most metals on to the particulate matter owes to the concomitant rise in the concentration of some major cations in the filter feeding animals, particularly bivalves where they have considerable tissue contact for the uptake of dissolved elements and cannot regulate the concentration of the observed elements as well as other organisms. (e.g. fish).

Refrerences

Ackman, R.G. and C.A. Eaton. Fatty acid composition of the Decapod Shrimp, Pandalus borealis, in relation to that of the Euphausid, Meganyctiphanes norvegica. J. Fish. Res. Bd. Canada, 1967, 24(2): 467-471.

Ackman, R.G. and C.A. Eaton. Biochemical implications of seasonal trends in the Iodine Values and Free Fatty Acid levels of commercially produced Atlantic Coast Herring oils. J. Fish. Res. Bd. Canada, 1970, 27: 1669 - 1683.

Ackman, R.G. and S.N. Hooper. Analysis of fatty acids from Newfoundland copepods and sea water with remarks on the occurrence of arachidic acid. Lipid, 1970, 5: 417-421.

Ackman, R.G.; J. Ke; W.A. MacCallum and D.R. Adams. Newfounland Capeline Lipids: Fatty acid composition and alterations during Frozen storage. J. Fish. Res. Bd. canada, 1969, 26: 2037 - 2060.

Akamine, T.; T. Nakanishi; S. Umezawa and H. Kuribara. Growth of a Sandy Beach Clam, Gomphina melanaegis in Igarashi, Niigata. 1991, Bull. of the Hapan sea National Fisheries Research Institute.

Allen, J.A., "Preliminary experiments on the feeding and excretion of bivalves using *phaeodactylum* labelled with ^{32}P". 1962, J. mar. Biol. Ass. U.K., 42: 42: 609-23.

Aspila, K.I.; Agemian and A.S.Y. Chau. A semiautomated method for the determination of nitrogen, organic and total phosphorus in sediments.1976, Analyst. Vol. 101-187-197.

Berthou, F.; G. Balouët; G. Bodennec and M. Marchang. The occurrence of hydrocarbons and histopathological abnormalities in oysters for seven years following the wreck of the Amoco Cadizin Brillancy (France), 1987, Mar. Environ. Res., 23: 103.

Bligh, E.G. and W.J. Dyer. A rapid method of total lipid extraction and purification. 1959, Canadian J. Biochem. Physiol. 37: 911-917.

Bouchaud, O. Energy consmption of the cattle fish Sepia officinalis L. (Mollusca: Cephalopoda) during embryonic development, preliminary results. Bulletin of Marine science. 1991, Vol. 49, No. (1/2): 333 - 340.

Brockerhoff, H.; M. Yurkowski; R.J. Hoyle, and R.G. Ackman. Fatty acid distribution in lipids of marine plankton. J. Fish. Res. Bd. Canada, 1964 b, 21(6): 1379-1384.

Chipperfield, P.N.J. Observations on the breeding and settlement of Mytilus edulis (L.) in British waters". J. mar. Biol. Ass. U.K., 1953, 32: 449-76.

Dabrowski, T.E.; Kolakowski and Barbara Karnika. Chemical composition of shrimp flesh (Parapenaeus sp.) and its nutritive value. J. Fish. Res. Bd. Canada, 1969, 26(11): 2969- 2974.

De - Jorge, F.B.; J.A. Petersen; A.S.F. Ditadi, and P. Sawaya. Biochemical studies in a eunicid (Polychaeta) of the littoral of Sao Paulo, Brazil. Comp. Biochem. Physiol. 1966, 17, 535-551.

De Koning, A. J., and K.B. Mc Mullan. Phospholipids of marine origin. II. The rock Lobster *(Jasus Lalandii)* J. Sci. Food Agr., 1966, 17: 117-120.

Dowidar N.M. and F.E. EL-Nady. Chemical composition of invertebrate animals from Lake Qarun (Upper Egypt). 1. Acartia Latisetosa (Kriczaguin) (Copepoda, Crustacea). Bull. Inst. Oceanoger. & Fish., ARE, 1982, 8 (2): 239-256.

El-Nady F.E. Studies on the biochemical composition of some Marine invertebrates. M.Sc. Thesis Alexandria University, 1977, 212 pp.

El-Nady, F.E. and S.H. Abdel-Aziz. Cyclical changes in lipid and protein contents of the Hake (Merluccius merluccius L.) from Egyptian Mediterranean waters. Egypt. J. Ger. Soc. Zool. Vol. 1994, 13(A). 141-162.

El-Samra, T.A. Studies on the fat content of Clarias Lazera C. & V. M.Sc. Thesis. Faculty pf Science, Alexandria Univ. 1972, 117. p.

Fisher, L.R.; S.K. Kon, and S.Y. Thompson. Vitamin A and carotenoids in certain invertebrates. II. Seasonal studies in some marine crustacea. J. Marine Biol. Assoc. U.K., 1954, 33: 589-612.

Gabbott, P.A. and A.J.M. Walker. Changes in the condition index and biochemical contents of adult Oysters (Ostrea edulis L.) Maintained under hatchery conditions. J. Cons. Int. Explor. Mer, 1971, 34, 1: 98-106.

Hassan, A.K. Studies on bottom Mollusca in Abu-Kir Bay. M.Sc. Thesis, Alexandria University, 1974, 319 pp.

Hilditch, T.P., and P.N. Williams. The chemical constitution of natural fats, 4th ed. Chapman and Hall, London. 1964, 664. p.

Hiss, E. and R. Robert. Comparative effects of two antifouling paints on the Oyster *Grassostrea gigas*, Mar. Biol., 1987, 95: 83.

Johannessen, ODD, H. Population structure and individual growth of *Venerupis pullastra* (Montagu) (Lamellibranchia). SARSIA 1973a, 52: 97-116.

Johannessen, ODD, H. Deformation of the inner shell surface of *Venerupis pullastra* (Montagu) (Lamellibranchia) as a result of infection by a Trematoda metacercaria: with a note of parasitism leading to parasitic castration. SARSIA 1973 b, 52: 117-122.

Kennish, M.J. Ecology of Estuaries: Anthropogenic effects, Handbook, Marine Science Series. CRC press. 1992, p. 269.

Konosu, S.; S.Katori; T. Akiyam and Tmori. Amino acid composition of crustacean muscle protein. Bull. Japan Soc. Sci.Fish., 1958, 24: 300-304.

Le Goff, R. and J. Daguzan. Growth and life cycles of the cuttlefish Sepia officinalis L. (Mollusca: Cephalopoda) in South Britany (France). Bulletin of Marine Science. Vol. 1991, 49, No (1/2): 341-348.

Mac Callum, W.A.; D.R. Adams; R.G. Ackman; P.J. Ke, W.J. Dyer; D.I. Fraser and S. Punjamapirom. New foundland capelin: proximate composition. J. Fish. Res. Bd. Canada 1969, 26: 2027-2035.

Mahmoud, B.; M. Kh. El-Sayed, M.A.El-Sabrouti and N.M. Dowidar. Factors controlling the chemical composition of the Egyptian continental shelf sediments. Rapp. Comm. Int. Mer. Médit., 1992, 33.

Malins, D.C. and J.C. Wekell. The lipid biochemistry of marine organisms, p. 339-363. In R.T. Holman [ed.] progress in the chemistry of fats and other lipids. 1969, Vol. X, Part 4. Pergamon Press, Oxford.

Morris, C.C. Statocyst fluid composition and its effects on calcium carbonate precipitation in the squid *Alloteuthis subulata* (Lamarck, 1798): Towards a model for biomineralization. Bull. of Mar. Sci, 1991, 49 (1-2): 379-388.

Nosho, Terry Y. and K. Kenneth. The setting and growth of the Manila clam, *Venerupis Japonica* (Deshayes) in Hood Canal, Washington. PROC. NATL SHELLFISH ASSOC. 1973, 62: 50-58.

Poutard F.G.E. and H. Zola. The location of onuphic acid in Hyalinoccia tubicola.J. Histochem. Cytochem. 1968, 15: 737-744.

Stapletan, R.P. Trace elements in tissues of the *calico bass, paralabax clathratus* (Girard). Bull. Sth. Calif. Acad. Sci. 1968, 67: 49-58.

Tariqu, J.; M. Jaffar and M. Moazzam. Concentration correlations between major cations and heavy metals in Fish from the Arabian sea. J. Mar. Poll. Bull. vol. 22, No. 1991, 11: 562-566.

Walne, P.R. The influence of current speed, body size and water temperature on the filtration rate of five species of bivalves. J. Mar. Biol. Ass. U.K. 1972, 52, 345-374.

Wolfer, D.A. The composition of crayfish carotenoids and the fatty acid composition of crayfish lipids including carotenoids esters. Ph. D. Thesis. Ohio State University, Columbus, Ohio. 1964, 120 p.

Yamada, M. The lipids of plankton. 1964, Bull. Japan. Soc. Sci. Fish., 30: 673-681.

Zola, H. Sugar phosphate polymers in polychaeta tubes and in mineralized animal tissues. Comp. Biochem. Physiol. 1967, 21, 179-183.

Zwarts, L. Seasonal variations in body weight of the bivalves *Macoma balthica, Scrobicularia plana Mya arenaria* and *Cerastoderma edule* in the Dutch Wadden Sea. Netherlands J. of Sea Research. Vol. 1991, 28(3): 231-245.

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