Age and growth of the freshwater clam *Galatea Paradoxa* (Born 1778) from Apoi Creek, Niger Delta, Nigeria

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SUMMARY

Age and growth of freshwater clam, *Galatea paradoxa* from Apoi Creek, Niger Delta, Nigeria was studied within three months (June - August 2105). Fifty clams were aged monthly by counting the surface ring curves, while 552 clam samples were collected and measured for shell length, shell height and shell width to determine the growth rate and pattern. The smallest clam (51.01 ± 1.65 mm) collected was 5 years while the largest (82.96 mm) was aged 15 years. The Ford – Walford plot gave a slope of 10.981 and intercept of 0.904, with an asymptotic length ($L\infty$) of 114.39 mm and a growth coefficient of 0.10 year^{-1}. The mean sizes of clam collected from the Apoi Creek were given as shell length (68.24 ± 0.48 mm), shell width (39.61 ± 0.51 mm), shell height (46.97 ± 0.54 mm) and a yield of 28.86 ± 0.85 g. The slope (b) in the shell length – weight (2.43 ± 0.05) and shell length – yield (2.64 ± 0.06) relationship showed that the clam had a negative allometric growth pattern.

Keywords: Apoi Creek, bivalve, clam, Ford – Walford, freshwater, surface rings

INTRODUCTION

Age and growth parameters of mollusks (bivalves) provide indispensable data for understanding the dynamics of mollusk populations and essential indications for fisheries management (Beamish and Macfarlane, 1987). Ability to comprehend the dynamics involved in age determination of bivalves is an essential tool in fishery biology.

In tropical regions, the determination of age and growth pattern often imposes difficulty (Menon, 1953; De Bont, 1967). The hard shell of bivalves may show rings, but these are not necessarily annual, and their frequency per year must be determined in each case before they can be used to

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measure growth rates. These rings may be associated with external or internal factors such as dry season in which case they generally occur (climatic factors), either once or twice a year; or they may reflect fluctuation in food supply (environmental factors) (Kamal, 1969), stock density (habitat type), etc. they also be associated with other factors such as spawning (biological factor) (Hopson, 1965) or loss in condition.

The aim of this study is to adequately establish valid data that will be of vital value for the management of the fishery and plans for the sustenance of the freshwater clam *G. paradoxa* in Apoi Creek by:

1. Determining the age of freshwater clam, *G. paradoxa* in Apoi Creek, and

2. Determining the growth rate and pattern of freshwater clam *G. paradoxa* in Apoi Creek.

MATERIAL AND METHODS

Clam sampling

This study was carried out within the months June - August 2015, where five hundred and twenty two (522) clam samples were collected from fishers in the Apoi Creek (Latitude 4° 34' 56.96" , Longitude 5° 48' 50.94"), Southern Ijaw Local Government Area of Bayelsa State, in the central Niger Delta. Obviously, clam of smaller sizes was not picked by the fishers because, according to them, it is less economically important to them. Clams of different sizes were randomly collected on weekly bases and were analyzed. The samples were sacked in white bag which exposed them to air and was transported from Apoi Creek to the Fisheries Laboratory, Niger Delta University for measurements.

Age and growth measurements

Each clam was numbered with pen marker to differentiate one from another. A pair of digital caliper with accuracy of 0.01 mm was used to measure the shells' length (maximum dimension of the anterior – posterior axis), shell height (maximum distance from the hinge to ventral margin) and width (maximum distance between outer edges of the halves) of each specimen. A sensitive weighing balance (Searchtech Instrument FA2104A) was used to obtain weight of each sample, which had accuracy of about 0.01 g. Each live clam was weighed individually to obtain total weight. Furthermore, stainless steel knife was used to cut open the shells, and the soft tissue was diligently removed with the aid of the knife from each clams' shell.

The soft tissue yield was obtained by subtracting shell weight from total weight. The shells were air-dried in room temperature for a period of two to three weeks to conspicuously project the concentric growth rates and age marks (i.e. the shell surface ring curves) to clearly differentiate properly age and growth marks on the hard shell. Samples that did not project properly the surface ring curves, torch light was pointed inside one of the mirror image of the clams' shell which settled cases of obfuscate in growth marks and surface ring curves. The surface ring curves were counted and matched with the shell's length measured.

Fifty freshwater clams *G. paradoxa* of different sizes were aged monthly within the experimental period. Generated data on age – length within the experimental period was pooled in the computation of the age – length range, mean length – at – age and standard deviations. Air drying of the shells after sampling before aging; and the use of torch light pointed at one mirror image of the shell aided in elimination of obfuscation in surface rings' count which corresponded to size – classes of clams with the shell lengths.

The length – at – age data generated from surface rings was re – arranged to form $L_{t+1} = a + bL_{t.}$; where L_{t+1} and L_t pertain to length separated by a constant time interval (1 year), and intercept (a) and slope (b) are constants of the Ford - Walford plot.

From the Ford – Walford equation, the intercept and slope were used to determine the asymptotic length (L_∞) as provided by King (1995):

$L_\infty = [a / (1 - b)]$

And the growth coefficient (k) = $-\log_e b$.

The relationship between shell length to total weight and yield were independently evaluated using log – transformation of the equation:

$Y = aX^b$

Where 'y' is either total weight or yield
'X' is total length
'a' is the intercept
'b' is the slope.

Routine regression analysis was completed using Statistical Package for the Social Sciences (SPSS) version 16, (Heck *et al.*, 2012). The co – efficient of determination (r^2) was used as an indicator of the quality of the regression of the linear regression.

Student's t- test was applied to ascertain whether the slope (b) was significantly different from 3.0, indicating the pattern of growth: isometric (b = 3), positive allometric (b > 3.0) or negative allometric (b < 3.0) (Spiegel, 1991). Five percent significance level was adopted in all cases.

RESULTS

The length – at – age and respective standard error (mm) along with maximum and minimum length of *G. paradoxa* obtained from shell surface rings are shown in Table 1. Since the very small sizes of clams were not collected during sampling, the first sizes (43.19 – 57.27 mm) of clams aged were 5 years. Ages of clams collected in this study ranged between 5 and 15 years. The mean length – at – age 5 years is 51.01 ± 1.65 mm while age 15 years is 82.96 mm.

Table 1. Mean length-at-age and the respective standard errors (mm) along with maximum and minimum length of *G. paradoxa* obtained from shell surface rings

Age (years)	N	Mean length ± S.E (mm)	Minimum	Maximum
5	8	51.01 ± 1.65	43.19	57.27
6	28	54.42 ± 0.70	47.7	64.06
7	22	60.78 ± 1.08	53.27	69.07
8	26	66.30 ± 0.96	54.58	79.49
9	22	67.89 ± 1.49	53.79	80.5
10	16	73.09 ± 1.40	63.49	83.79
11	13	78.26 ± 2.66	62.1	95.19
12	5	78.34 ± 2.45	70	83.52
13	5	86.35 ± 3.81	74.47	94.98
14	4	82.40 ± 4.54		
15	1	82.96		

N = sample size

Clams of age fifth (5th) and twelfth (12th) to fifteenth (15th) were not properly aged due to their low numbers in the population as well as the difficulty in discriminating between the rings at their margins. Consequently, the Ford – Walford plot was based on the age - length data of six to eleven (6 – 11) years.

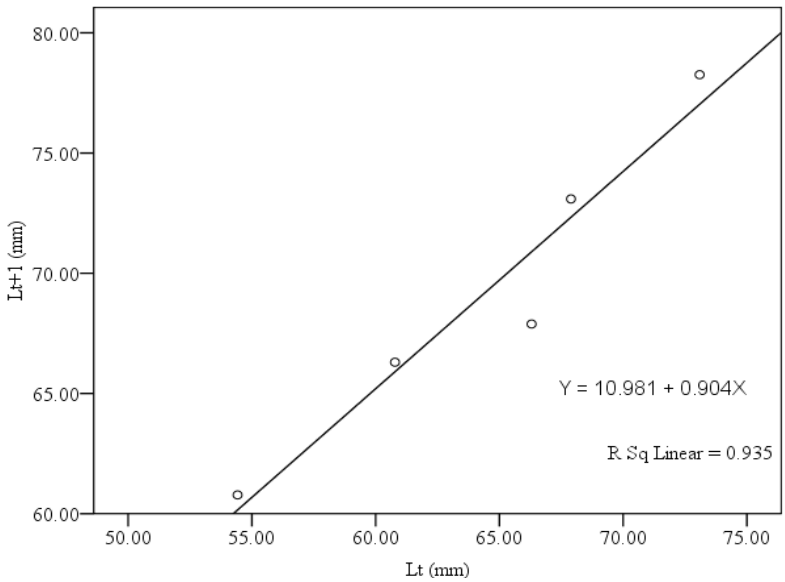

Fig. 1: Ford-Walford plot, using the mean lengths of *Galatea paradoxa* individuals (Lt+1) against Lt

The Ford – Walford gave a slope of 0.904 and intercept of 10.981 (Figure 1). A value of 114.39 mm was obtained as the asymptotic length of the clams analyzed from Apoi Creek, with growth coefficient (k) of 0.10 year^{-1}.

A plot (Figure 2) of shell length against the age of individual clams determined from the counting surface rings shows that the regression equation is y = 32.01 + 4.032 x. This indicates that the length of 5 – year old clam from surface rings could be found in the range between 10.98 mm (Figure 1) and 32.01 mm (Figure 2).

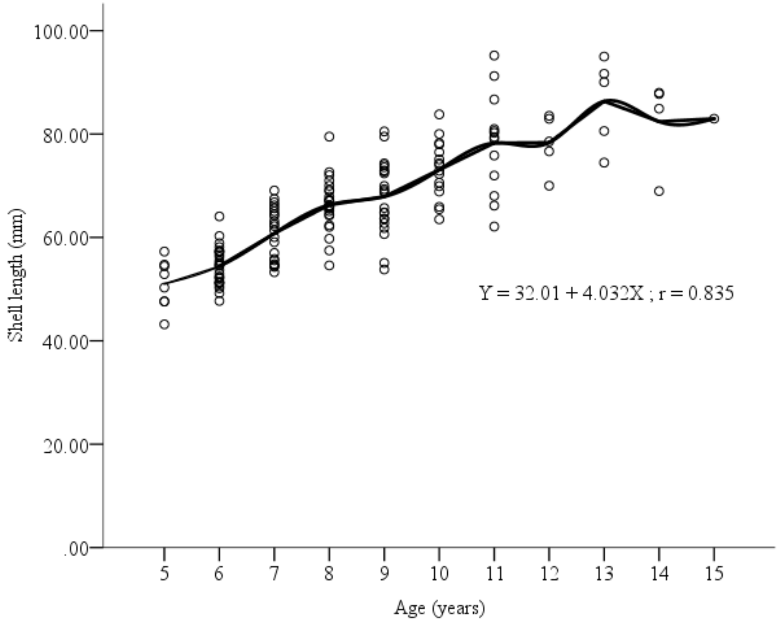

Figure 2. Plot of shell length against age of individual clams determined from the counting of shell surface rings

Table 2: Size ranges of *G. paradoxa* in Apoi Creek

Shell dimensions	June	July	August	Whole study period
Total length (mm)	(45.09 – 97.43) 69.43 ± 0.74	(47.61 – 95.21) 69.30 ± 0.66	(43.19 – 73.99) 58.30 ± 1.02	(43.19 – 97.43) 68.24 ± 0.48
Width (mm)	(23.02 – 47.10) 32.35 ± 0.29	(24.38 – 73.37) 44.77 ± 0.85	(34.19 – 56.86) 46.94 ± 0.79	(23.02 – 73.37) 39.61 ± 0.51
Height (mm)	(32.70 – 75.78) 54.49 ± 0.54	(18.96 – 72.62) 43.65 ± 0.74	(24.36 – 39.69) 30.18 ± 0.45	(18.96 – 75.78) 46.97 ± 0.54
Total weight (g)	(30.00 – 228.00) 88.58 ± 2.64	(15.71 – 217.01) 87.85 ± 2.32	(26.65 – 101.58) 58.14 ± 2.60	(15.71 - 228.00) 85.15 ± 1.64
Shell weight (g)	(18.00 – 158.00) 58.38 ± 1.75	(11.17 – 160.43) 59.22 ± 1.54	(18.02 – 69.89) 39.82 ± 1.79	(11.17 – 160.43) 56.89 ± 1.09
Soft tissue yield (g)	(10.10 – 344.83) 31.56±1.69	(4.54 – 77.91) 28.64±0.85	(8.63 – 34.38) 18.32±0.87	(4.54 – 344.83) 28.86±0.85

The sizes of *Galatea paradoxa* in Apoi in Creek are shown in Table 2. The shell total length ranged from 43.19 to 97.43 mm with a mean ± standard error of 68.24 mm ± 11.17. The soft tissue yield had a mean weight of 28.86 g ± 0.85, accounting for about 34% of the live weight. The soft tissue yield decreased from June to August 2015.

The regression coefficient values obtained from the slope and the intercept ('a' and 'b') and correlation coefficient (r) are shown in Table 3. Logweight/loglength generated from June to August with inclusion of combined, gave negative allometric growth pattern. In logyield/ loglength, clams also had negative allometric growth, except only in July did they have Isometric growth pattern.

Table 3: Growth pattern of G. *paradoxa* from Apoi Creek

Relationships	n	a	b ± S.E	r	r^2	Growth pattern
Logweight/loglength						
June	226	0.003	2.39 ± 0.07	0.909	0.83	Negative allometric
July	243	0.002	2.52 ± 0.08	0.906	0.82	Negative allometric
August	53	0.003	2.41 ± 0.10	0.96	0.83	Negative allometric
Combined	522	0.003	2.43 ± 0.05	0.917	0.84	Negative allometric
Logyield/loglength						
June	226	0.001	2.49 ± 0.10	0.851	0.72	Negative allometric
July	243	0.0002	2.85 ± 0.10	0.885	0.78	Isometric
August	53	0.0005	2.56 ± 0.11	0.953	0.9	Negative allometric
Combined	522	0.0004	2.64 ± 0.06	0.879	0.77	Negative allometric

DISCUSSION

The mean lengths – at – age determined in this study are closed to the ones reported by Adjei – Boateng and Wilson (2013) for the same species from the Volta River Estuary, Ghana. For example, while they reported 49.5 mm for 5 – year old clam, 51.01 ± 1.65 mm was recorded in this study. King (2000) could have mistakenly reported 53 mm clam as age one instead of age five, since he did not sample for smaller sizes of clam (Adjei – Boateng and Wilson, 2013).

The Asymptotic length ($L\infty$) for *Galatea paradoxa* from Apoi Creek (114.39 mm) even though higher, is close to the 111.0 mm obtained by King (2000) in Cross River, but, much higher than the 102 mm reported by King (2000) in Nun River, 107.4 mm observed by Vakily (1992) and 105.7 mm recorded by Adjei – Boateng and Wilson (2013) in Volta Estuary, Ghana. It is, however, lower than the 145.1 mm obtained by Vakily (1992) from the re-analyzed data collected by Kwei (1965) at an upstream station (Akosombo) on the Volta River

The low growth rate (0.10 $year^{-1}$) observed in this study is lower than 0.14 – 0.18 recorded in Volta Estuary (Adjei – Boateng and Wilson, 2013).

This poor growth could be attributed to many factors such as environmental conditions (Weatherley and Gill, 1987).

The mean length (68.24 mm) of clams landed (age nine) in Apoi Creek are lower than 7.41 cm ± 0.34 reported in Ikebiri Creek in the same Niger Delta (Kingdom et al., 2012), but are still within the size range (60 mm shell length and above) recommend to be harvested by Moses (1990) in the Cross River, Nigeria. The soft tissue yield (34%) was however higher than the 24% reported by Kingdom et al., (2012) in Ikebiri Creek in Niger Delta. The difference in the period of study and physiological state of clams in the two locations could be responsible for the difference in the soft tissue yields.

The regression coefficient of slope in this study fell between 2.4 and 4.5 as reported for bivalves by Wilbur and Owen (1964) in Obirikorang et al. (2013). The negative allometric growth exhibited by clam in this study is similar to the growth pattern also recorded in Ikebiri Creek, (Kingdom et al., 2012). However, this observation contradicts the report of Obirikorang et al. (2013), who observed that during June to November, freshwater clam growth patterns were generally isometric and positive allometric. The implication in this study is that length increases faster relative to weight and indicates loss in tissue weight that occurs as a result of the spawning process (Galstoff, 1964; Etim et al., 1991; Obirikorang et al., 2013). However, as it has been advised elsewhere (Kato and Hammai, 1975; Gaspar et al., 2001), weight – length relationships should be limited to the sizes of clams used for the parameter estimation, and should not be extended or extrapolated to juvenile stages.

CONCLUSIONS

The mean size (68.24 mm) of clams landed are age 9 years. Negative allometric growth pattern was observed in loglength/logweight throughout the study period, while in logyield/ logweight provided Isometric growth pattern only in the month of July (b = 3). Negative allometric growth pattern observed could be as a result of the spawning process during the study period.

REFERENCES

Adjei – Boateng D, and Wilson, G.J. (2013). Age Determination and Growth Rate of the freshwater Clam *Galatea paradoxa* (Born 1778) from the Volta River Estuary, Ghana. *Journal of Aquatic Science* 1(2):31 – 38.

Arawomo, G.A.O. (1980). The growth of *Saratherodon* (Tilapia) *niloticus* in Opa Reservoir, University of Ife Ile-Ife, Nigeria *proceedings* of FISON 2nd *Annual Conference*. pp 221- 22.

Bauer, G. (1992). Variation in the life span and size of the freshwater pearl mussel. *Journal of Animal Ecology* 61: 425-436.
Bayne, B. L. (1976). Aspects of reproduction in bivalve mollusks. In: Wiley M (ed.) Estuarine processes, Vol 1. Use, stresses and adaptation to the estuary. *Academic Press* New York, 432-448.
Beamish, R.J. and Macfarlane, G.A. (1987). Current trends in Age Determination Methodology. In: Hall G.E. (Eds) Age and Growth of Fish, summerfelt, (Eds). Iowa State University Press Ames, I.A.; U.S.A. pp: 15-42.
Bentley R. (1983). Anatomy, Ecology and Affinities of the Australia early Cambrain Bivalves. *Journal of Paleontology (Paleontology society) 57* (1): 73-92 http://istor.org/stable/1304610.
Berry, P. F. (1978). Reproduction, growth and production in the mussel, *Perna perna* (Linnaeus), on the east coast of South Africa. *Invest Rep Oceanography Research Institute Durban* 48: 1-28.
De Bont, R.J. (1967). Some aspects of age and growth of in temperate and tropical waters. The Biological Basis of Freshwater Fish Production p.67 Shelby, D. Gerking (ed). Backwell Oxford.
Deveries, D. R. and Frie, R. (1996). Determination of age and growth. In: Fisheries techniques, Murphy, B.R. and Willis D.W>Wills (Eds), *America Fisheries Society,* Maryland, Bethesade, pp: 483-512.
Eves, R. J. and Moyer, S. N. (1988). Evaluation of techniques for age determination of freshwater mussels (Unionidae). *American Malacological Bulletin* 6: 179-
Fiori, S. M. and Morsan, E. M. 2004. Age and individual growth of *Mesodesmaard cl mactroides* (Bivalvia) in the southernmost range of its distribution. *Journal of Marine Science* 61: 1253-1259. 188.
Ford, S.E. (2001): Pests, parasites, Diseases and Defense mechanism of the hard clam, *Mercenaria*, In: Biology of the Hard Clam, J.N. Kraufer and M. Castagna Elsvier. Davel, *Agriculture Fish. Sci.* 31: 592 – 628
Gaspar, M.B., Santos, M.N. and Vasconcelos, P. (2001). Weight – length relationships of 25 bivalve species (Mollusca: Bivalvia) from the Algarve coast (southern Portugal). *J. Mar. Biol. Ass. U.K.* 81: 805 – 807.
Gaspar, M. B., Pereira, A. M., Vasconecelos, P. and Monteiro, C. C. (2004). Age and growth of *Chamelea gallina* from the Algarve coast (Southern Portugal): influence of seawater temperature and gametogenic cycle on growth rate. *Journal of Molluscan Studies* 70: 371-377.
Giribet, G. and Ward Wheeler (2002). "On bivalve phylogeny: a high – level analysis of the bivalvia (Mollusca) based on combined morphology and DNA sequence data" Invertebrate Biology 121 (4): 211- 324.
Gupta, S.K. (2006). General and applied Ichthyology (Fish and fisheries) for B.Sc/B.F.Sc. / M.F.Sc. and other courses in fisheries science S. Chand and Company Ltd. First edition. pp 824-832.

Heck, R.H., Tabata, L.N. and Thomas, S.L. (2012). *Multilevel modeling of categorical outcomes using IBM SPSS.* New York, NY: Routledge Academic.

Hibbert, C.J. (1977). Growth and survivorship in a tidal – flat population of bivalve, *Mercenaria mercenaria* from Southampton water. *Mar. Boil*. 44: 71 – 76.

Holopainen, I. J. and Hanski, I. (1986). Life history variation in Pisidium (Bivalvia: Pi-sidiidae). *Holarctic Ecology* 9: 85-98.

Hopson, A.J. (1965). Winter scale rings in *Lates niloticus (*Pisces: Centropomidae*)* from Lake Chad. *Nature Land*. 208, 1013-1014.

Jones, W. E. and Demetropoulos, A. (1968). Exposure to wave action: measurements of an important ecological parameter on rocky shores on Anglesey. *Journal of Experimental Marine Biology and Ecology* 2: 46-63.

Jørgensen, C. B. (1976). Growth efficiencies and factors controlling size in some mytilid bivalves, especially *Mytilus edulis* L.: review and interpretation. *Ophelia* 15: 175-192.

Jørgensen, C.B. (1990): Bivalve filter feeding: Hydrodynamics of bioenergetics, physiology and Ecology. Olsen and Olsen, Treed ensborg, Denmark: 140pp.

Kamal, Y. (1969). Studies of age growth of *Cirrhina mgrigala* (Hamilton) from the River Yamma at Alla habad. *Proc. Natn Inst-Sci. India,* 13, 35, 72-92.

Kato, Y. and Hamai, I,(1975). Growth and shell formation of the surf clam, *Spisula sachalinensis* (Schrenck). Bulletin of the Faculty of Fisheries, Hokkaido University, 25: 291 – 303.

King, M. (1995). Length – weight relationships of Nigeria freshwater fishes. Naga. The ICLARM Quaterly 19: 49 - 52

King, R.P. (2000): Population structure, growth performance and mortality rates of the freshwater clam *Galatea paradoxa* (Born, 1778) in Nun River, Nigeria. *Archive of Fishery and Marine Research* 48: 21 – 30

King, R.P; Moses, S.B. and Brey, T. (2012). Morphometric length-weight relationships and length distributions of five populations of the freshwater bivalve *Aspatharia sinuate* (Donacidea) in Nigeria. *Malacologia,* 30: 365-372.

Kingdom, T., Allison M. E. and Gbenefadei, P. (2012): Shell Growth of`Fresh water clam (*Galatea paradoxa*) in Ikebiri Creek, Bayelsa State, Nigeria. *International Journal of Applied Research and Technology* 1 (6): 215 – 219.

Kraeuter, J.N. and Castagna, (2001). Biology of hard clam, Elsvier. Devel. *Aquaculture Fish Sci.* 3: 238pp.

McQuaid, C. D. and Lindsay, T. L. 2000. Effect of wave exposure on growth and mortality rates of the mussel *Perna perna*: bottom-up regulation of intertidal populations. *Marine Ecology progress Series* 206: 147-154.

Menon, M.D. (1953). The determination of age and growth of Fishes of Tropical and Subtropical water. *Journal Bombary Nat. Hist.* Sci. 51,3.

Moore, R.C. (1968). Determination of age and growth. In: Fisheries techniques, Murphy, B.R. and Willis D.W>Wills (Eds), *America Fisheries Society*, Maryland, Bethesade, pp: 483-512.

Moore, R.C. (1969): Treaties on Invertebrate Paleontology Port N. *http://en.wikipedia.org/wike/*Bivalvia

Moses, SB. (1990): Growth, biomass, mortality, production and potential yield of the West Africa clam, *Egeria radiate* (Lamark) (Lamellbranchia, Donacidae) in the Cross River System, Nigeria. *Hydrobiology* 196: 1 – 15

Moura, P., Gaspar, M. B. and Monteiro, C. C. (2009). Age determination and growth rate of a *Callista chione* population from the southwestern coast of Portugal. *Aquatic Biology* 5: 97-106.

Naspar, D. E. (2004). Determination of age and growth. In: Fisheries techniques, Murphy, B.R. and Willis D.W>Wills (Eds), America Fisheries Society, Maryland, Bethesade, pp: 483-512.

Obirikorang, K.A., Adjei-Boateng, D., Madkour, H.A., Amisah, S. and Otchere, F.A. (2013): Length-weight Relationship of Freshwater Clam, *Galatea paradoxa* (Born 1778) from the Volta Estuary, Ghana. *Pakistan Journal of Biological Sciences* 16 (4): 185 – 189.

Palmer, A. R. (1990). Effect of crab effluent and scent of damaged conspecifics on feeding. Growth and shell morphology of the Atlantic dogwhelk, Nucella lapillus (L.) *Hydrobiol.*193: 155 – 182.

Park, K.T. and Oh, C.W. (2012). Length weight relationship of Bivalve from coastal waters of Korea. *Naga ICLARM Q.* 25 (1): 21 – 22.

Pauly, D. (1983). Some simple methods for the assessment of tropical Fish stock. *FAO Fish Tech. pap.,* No. 234, 52p. Rome

Pauly, D. (1993). Editorial fish byte section *Naga ICLARM Q*. 15 (2 - 3): 26.

Purchon, R.D. (1963). A note on the biology of *E. radiata* Lam (Bivalvia, Donacidae). *Proceedings of the Malacological Society of London* 35: 251-271.

Raubenheimer, D. and Cook, P. (1990). Effects of exposure to wave action on allocation of resources to shell and meat growth by the subtidal mussel, *Mytilu galloprovincialis. Journal of Shellfish Research* 9: 87-93.

Ross, T.K. and G.M. Lima (1994). Measures of allometric growth: the relationships of shell length shell height and volume to ash – free dry weight in the Zebra mussel, *Dreissena polymorpha*. Pallas and the quagga mussel, *Dreissena bugenis* Andiusov. Proc. *The fourth interzebra mussel conf. MadisonWisconsin.*

Schneider, J.A. (2001): Bivalve Systematics during the 20 century'. *Journal of Paleontology* 75 (6): 1119 – 1127.

Seed, R. (1968). Factors influencing shell shape in the mussel *Mytilus edulis*. *Journal of Marine Biology Association U.K* 48: 561-584.

Seed, R. (1986). The ecology of *Mytilus edulis* L. (Lamellibranchiata) on exposed rocky shores. *Oecologia* 3: 277-316.

Spiegel, T.E. (1991). On bivalve phylogeny: a high – level analysis of the bivalvia (Mollusca) based on combined morphology and DNA sequence data. *Invertebrate Biology* 121 (4): 211- 324.

Tayor, J. and Suzanne W. (2007). A molecular phylogeny of heterodont bivalves (Mollusca: Bivalvia: Heterodonta): New analysis of 185 and 285 RNA gene". *Zoological Scripta* 36(6): 587 – 606.

Thomas, P.C. Suresh, C.H.R. and K.D. Mohapatra (2003). Breeding and Seed production of Fin Fish and shell fish. Daya publishing house, Delhi – 110035. pp. 268 – 270.

Vakily, J.M. (1992): Determination and Comparison of growth in bivalves, with emphasis on the tropics and Thailand. *ICLARM Technical Report 36:*125pp

Van Erkom S. C. and Griffiths, C. L. (1993). Factors affecting relative rates of growth in four South African mussel species. *Aquaculture* 109: 257-273.

Walford, L. A. 1946. A new graphic method of describing the growth of animals. *Biological Bulletin* 90, 141-147.

Weatherley, A.H. and Gill, H.S. (1987). The Biology of Fish Growth. Academic Press London, UK, 443 p.