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Length-Weight Relationship of the Freshwater Clam, *Galatea paradoxa* (Born 1778) from the Volta Estuary, Ghana

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Abstract: The length-weight relationship of the threatened freshwater clam, *Galatea paradoxa* (Born 1778) from the Volta Estuary, Ghana was studied over a two-year period, from March 2008 to February 2010, to aid in the development of stock assessment models for the sustainable management of the remaining clam stock. Data reported in this study were collected at monthly intervals and covered varying depths of the Estuary ranging from 0.5 to about 10 m. Overall, a total of 5276 clams with shell lengths ranging from 3.40 to 89.24 mm and total weight from 0.10 to 154.00 g were sampled during the study period. The length-weight relationships were highly significant ($p<0.0001$) for all the months and the b-values ranged from 2.023 (January 2010) to 3.874 (June 2009). The calculated b-values indicated that clams exhibited different growth patterns at different periods but overall, the pooled samples of 5276 individuals exhibited an isometric growth pattern ($b = 3.003$). The observed monthly growth patterns exhibited by *G. paradoxa* appeared to be largely influenced by the reproductive cycle of the organism. During the periods leading to spawning, the clams generally exhibited positive allometric growth patterns (weight increasing faster than length) which appeared to be strongly linked to the build-up of proteins and carbohydrates in their tissues. Successive negative allometric growth patterns (length increasing faster relative to weight) were, however, observed from March to June 2008 and from December 2009 to February 2010, which are possibly indicative of the loss in tissue weight that occurs as a direct result of the spawning process. It will thus be suitable to institute a close season to coincide with the spawning period of the clams to avoid the harvesting of clams during the spawning period which will enhance future recruitment of the clam stock.

Key words: Length-weight, *Galatea paradoxa,* spawning, growth patterns, Volta Estuary, Ghana

INTRODUCTION

Length-weight data are very useful tools as far as fish sampling programs are concerned (Morato *et al*., 2001) mainly because size is generally considered more biologically relevant than age in fish, as most ecological and physiological factors depend more on size than on age. As noted by Erzini (1994), changes in size have important implications for different aspects of fisheries science and population dynamics. King (2007) noted that the relationships between the lengths and weights of organisms can be used to assess the well-being of individuals within a population and also to determine potential differences between separate unit stocks of the same species. Wilbur and Owen (1964) observed that bivalves are organisms that exhibit relatively large temporal variations in meat content and body weight in response to physiological conditions such as spawning and variation in environmental parameters. These variations in the equilibrium constant usually provide information on the physiological deviations in the condition of bivalves.

The freshwater clam, *Galatea paradoxa* (Born 1778) is a widely distributed filter-feeding organism in West and Central Africa and usually inhabits the lower reaches of most of the major Rivers extending from the Gulf of Guinea area to the River Congo (Moses, 1990). In Ghana, the main clam bed lies at the portion of the Lower Volta River at Ada Foah, where commercial exploitation takes place mainly for the flesh. The clam fishery of Ghana serves as a viable source of employment and livelihood for the surrounding riparian communities. Studies by

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Amador (1997) and Agbeko (2010) on the socio-economic status of the clam fishery further revealed that it constitutes a very cheap source of animal protein source to the local communities along the Volta Estuary and beyond and represents a viable option for culture-based fishery in future.

Despite its economic and nutritional importance, there is a dearth of biological information on the *G. paradoxa* inhabiting the Volta Estuary of Ghana. It is on this basis that this research was conducted to assess the length-weight relationship of *G. paradoxa* from the Volta Estuary, Ghana. The results of this research will serve as a baseline data for other researchers and aid in the development of stock assessment models for the sustainable management of the threatened clam stock at the Volta Estuary.

MATERIALS AND METHODS

Study area: The study was conducted between Ada and Aveglo, at the Volta Estuary, Ghana, over a 24 month period, from March 2008 to February 2010. Ada (Latitude 05°49' 18.6"N and 000°38.46' 1"E) and Aveglo (05°53 28.2" N and 000°38' 24.7"E) are approximately 15 km apart and represent the the most active clam fishing grounds at the Volta Estuary (Fig. 1).

Data collection: Data reported in this study were collected at monthly intervals for the two-year period and covered the area between Ada and Aveglo at varying depths ranging from 0.5 m to about 10 m. At the shallow portions, samples were collected by wading through the water and hand-picking the clams. At the deeper portions however, samples were obtained from fishermen who employed the Hookah technique in harvesting clams. All size classes harvested from the fishery were included in the sample collection. Samples were transported submerged in river water in insulated chests to the laboratory and processed within 12 h. In the laboratory, individuals were cleansed to remove mud and dried with blotting paper before length and weight measurements were taken. Shell lengths (maximum antero-posterior distance) and total weight (shell weight+flesh weight) were taken using a Powerfix digital caliper (±0.01 mm) and a Sartorious BP 6100 electronic balance (± 0.01 g), respectively. The clams were blotted dry in absorbent paper prior to weighing. The length and weight data collected over the sampling period were used to evaluate the length-weight relationship of *G. paradoxa* using the non-linear regression equation expressed below by Ricker (1973):

$$W = aL^b$$

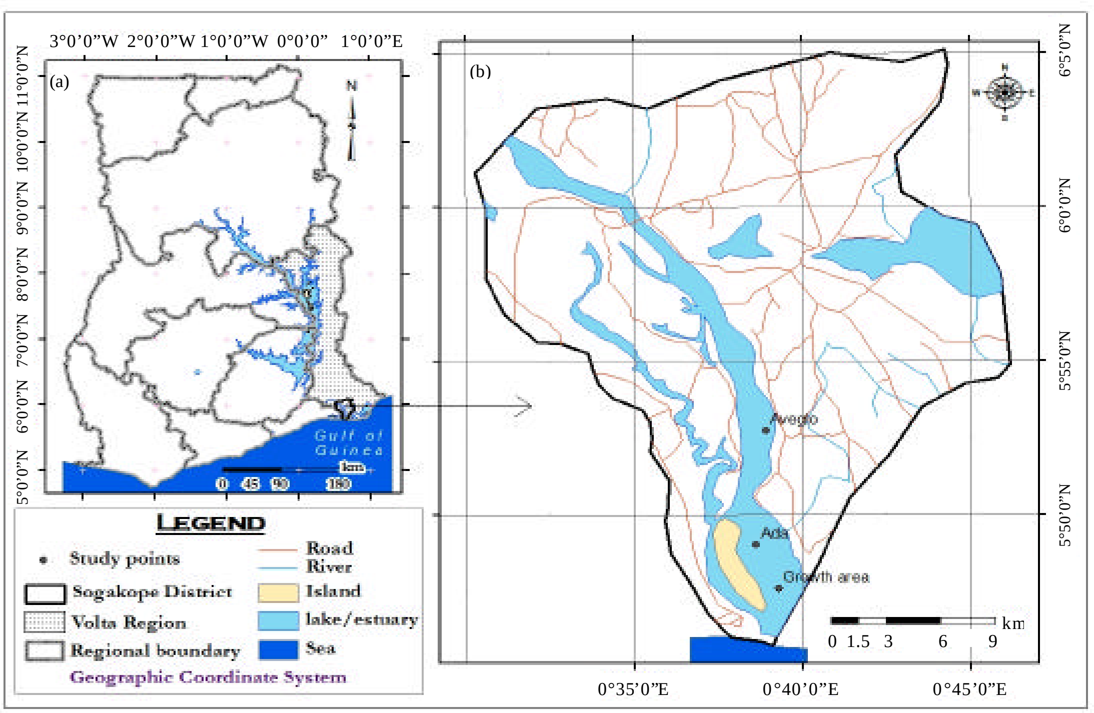

Fig. 1: Map showing the clam sampling location between Ada and Aveglo in the Volta Estuary in Ghana

where, W is the total weight, L is the total length, a is the regression constant (intercept) and b is the regression constant (slope).

Statistical analysis: Student's t-test was applied to verify whether the constant b) was significantly different from 3.0, indicating the type of growth: isometric (b = 3.0), positive allometric (b>3.0) or negative allometric (b<3.0) (Spiegel, 1991). In all cases a significance level of 5% was adopted.

RESULTS AND DISCUSSION

A total of 5276 clams with shell lengths ranging from 3.40 to 89.24 mm and total weight from 0.10 to 154.00 g were measured over the sampling period. Mean length and weight values, length and weight ranges (minimum and maximum) of the clams, the parameters of length-weight relationships (a and b), the Standard Error (SE) of b and the coefficient of determination (r^2) for each month are given in Table 1. Length-weight relationships for the separate sexes of *G. paradoxa* could not be determined because of difficulty in determining sex from any external physical characteristics or colour of the gonads. Length weight relationships were highly significant ($p<0.0001$) for all the months and the b-values ranged between 2.423 (January 2010) to 3.874 (June 2009). The clams exhibited different growth patterns at different periods of the study. The findings of this study corroborated that of Wilbur

Table 1: W-L relationship parameters of *G. paradoxa* from the Volta Estuary, Ghana

Period	n	a of b r^2 (Mean±SD)	b of b r^2 (Mean±SD)	Length range (mm)	Weight range (g)	Type
Mar. 08	108	0.0504±2.906	0.1904± 0.95	5.81-64.18 (39.47±11.40)	0.10-66.00 (24.48±13.83)	Isometric
Apr. 08	104	0.0510±2.895	0.2195±0.93	5.88-64.64 (39.66±11.12)	0.10-65.30 (24.99±14.72)	Allometric (-)
May. 08	444	0.0586±2.069	0.0727±0.89	21.40-59.07 (33.49±6.49)	4.40-65.40 (15.85±8.02)	Allometric (-)
Jun. 08	357	0.0526±2.593	0.0957±0.88	23.72-61.30 (34.97±6.45)	5.90-64.20 (17.35±8.32)	Allometric (-)
Jul. 08	223	0.0412±3.547	0.3174±0.80	26.33-66.01 (45.90±7.32)	5.30-66.10 (31.45±11.23)	Allometric (+)
Aug. 08	218	0.0418±3.547	0.2406±0.93	22.39-82.23 (46.46±14.22)	4.70-138.00 (37.78±28.99)	Allometric (+)
Sep. 08	179	0.0502±3.011	0.2051±0.85	22.75-64.05 (39.25±7.254)	7.30-63.90 (23.02±11.10)	Isometric
Oct. 08	382	0.0466±3.495	0.1134±0.92	20.02-79.76 (39.07±10.11)	4.3-153.2 (24.22±17.57)	Allometric (+)
Nov. 08	277	0.0502±3.047	0.1321±0.88	23.63-64.38 (36.94±7.36)	5.90-75.20 (20.91±10.49)	Isometric
Dec. 08	279	0.0480±3.600	0.1290±0.93	6.84-72.04 (36.99±10.52)	0.13-106.90 (23.97±15.13)	Allometric (+)
Jan. 09	75	0.0494±2.934	0.2151±0.95	29.43-72.32 (42.63±10.27)	7.30-88.50 (27.63±19.56)	Isometric
Feb. 09	169	0.0429±3.286	0.3033±0.93	6.840-77.45 (46.05±15.71)	0.13-116.20 (41.32±26.69)	Allometric (+)
Mar. 09	225	0.0414±3.044	0.1813±0.94	28.44-81.97 (47.15±9.80)	10.00-142.10 (38.71±21.10)	Isometric
Apr. 09	236	0.0462±3.209	0.1811±0.91	26.16-63.75 (41.55±7.90)	8.10-82.70 (30.76±13.77)	Allometric (+)
May. 09	164	0.0441±3.457	0.2820±0.89	25.04-70.24 (44.57±9.14)	8.40-87.10 (34.29±16.20)	Allometric (+)
Jun. 09	191	0.0449±3.874	0.2743±0.88	23.33-73.30 (44.64±10.30)	5.80-81.90 (31.47±17.43)	Allometric (+)
Jul. 09	224	0.0483±3.344	0.1523±0.93	20.21-67.29 (40.75±10.33)	4.20-84.30 (26.86±15.07)	Allometric (+)
Aug. 09	160	0.0417±3.446	0.2978±0.93	10.57-89.24 (33.62±16.02)	3.30-154.60 (23.12±31.57)	Allometric (+)
Sep. 09	184	0.0553±2.525	0.1672±0.91	19.42-59.25 (38.34±9.035)	4.60-63.10 (23.51±12.25)	Allometric (-)
Oct. 09	158	0.0414±3.104	0.1823±0.83	26.38-74.92 (46.53±10.16)	8.80-102.40 (38.00±20.58)	Allometric (+)
Nov. 09	211	0.0480±3.225	0.1789±0.89	24.03-69.64 (40.44±9.23)	6.40-76.30 (24.66±13.84)	Allometric (+)
Dec. 09	236	0.0528±2.491	0.1154±0.87	22.70-63.42 (34.55±6.60)	4.00-61.20 (16.36±8.36)	Allometric (-)
Jan. 10	231	0.0564±2.423	0.0965±0.91	19.71-60.08 (33.99±7.56)	3.30-47.60 (14.99±8.22)	Allometric (-)
Feb. 10	143	0.0523±2.429	0.1501±0.88	21.00-63.78 (36.23±7.29)	6.10-70.40 (17.43±9.69)	Allometric (-)

n: Sample size, SD: Standard deviation, SE: Standard error, a: Regression constant (intercept), b: Regression constant (slope), r^2: Coefficient of determination and Owen (1964), who stated that, the values of equilibrium constant b lie between 2.4 and 4.5 in most of the bivalves.

Bivalve shell growth and shape are known to be influenced by biotic (endogenous/physiological) and abiotic (exogenous/environmental) factors. A variety of environmental factors are known to influence shell morphology and the relative proportions of many bivalve species (Gaspar *et al*., 2002). For examples, the type and quality of phytoplankton as a food source of the bivalve, (Alunno-Bruscia *et al*., 2001; Kovitvadhi *et al*., 2006), water quality (Buddensiek, 1995; Lajtner *et al*., 2004), water depth (Claxton *et al*., 1998; Karayucel and Karayucel, 2000; Lajtner *et al*., 2004), currents (Blay, 1989; Fuiman *et al*., 1999), water turbulence (Hinch and Bailey, 1988), type of sediment (Newell and Hidu, 1982; Lajtner *et al*., 2004), type of bottom (Claxton *et al*., 1998) and wave exposure (Akester and Martel, 2000).

The monthly growth patterns exhibited by *G. paradoxa* appeared to be largely influenced reproductive cycle of the organism. Studies by Etim *et al*. (1991) and Adjei-Boateng *et al*. (2011) revealed that spawning in *G. paradoxa* starts in June each year and is completed between October and November. This study observed that during these periods the clam growth patterns were generally isometric (growth with unchanged body proportions and specific gravity) and positive allometric (weight increasing faster than length). The allometric growth trends observed during the spawning period appear to be strongly linked to the build-up of proteins and carbohydrates in the tissues of the clams. Prior to and during the spawning months, proteins and carbohydrates are accumulated in the clam tissues for gonad tissue production, energetic storage and consumption (LaTouche and Mix, 1982; Paez-Osuna *et al*., 1995) leading to an increase in the tissue weight of the clam and consequently an increase in total weight relative to shell length. The successive negative allometric growth patterns (length increasing faster relative to weight) observed from March to June 2008 and from December 2009 to February 2010 are possibly indicative of the loss in tissue weight that occurs as a direct result of the spawning process. Galstoff (1964) and Etim *et al*. (1991) observed that the ripe clam gonad may comprise 31 to 41% of the total body weight and thus, when shed during spawning period accounts for an appreciable weight loss.

Despite the different growth patterns exhibited by the clams during different stages of the study, the overall combined samples (5276 individuals) exhibited an isometric growth pattern (b = 3.003) over the two-year period (Fig. 2). This result confirms the findings of a study by Ofori-Danson and Amoah (2007) on the length weight relationship of *Galatea paradoxa* at the same location, which revealed that the bivalve in its natural habitat exhibits an isometric growth pattern (b = 2.9129).

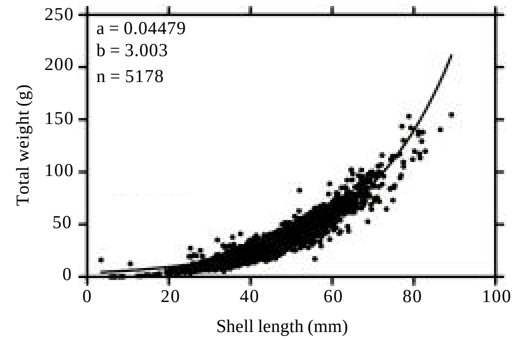

Fig. 2: Length-weight relationship of *G. paradoxa* from the volta estuary, Ghana over a two-year period (March, 2008-February, 2010)

CONCLUSION

The study revealed that the freshwater clams *Galatea paradoxa* exhibited different growth patterns at different periods of the study, which appeared to be largely influenced by their reproductive cycle. Overall, however, the pooled samples over the 24 month period exhibited an isometric growth pattern. The results of this study appeared to support earlier findings that spawning in *G. paradoxa* starts in June each year and is completed between October and November each year, thus making it imperative to institute a close season that coincides with this period to enhance stock recruitment in future.

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