Ghana Journal of Science, Technology and Development
Volume 1, Issue 1. July 2014
journal homepage: http://gjstd.org/index.php/GJSTD

Distribution and Utilization of Freshwater Oyster, *Etheria* Sp. (Bivalvia, Unioniforme, Etheriidae) in the Major Rivers of Northern Volta Basin of Ghana

Akwasi AMPOFO-YEBOAH

Department of Fisheries & Aquatic Resources Management, University for Development Studies, Tamale, Ghana

Correspondence email: ampoyeb@yahoo.com

Abstract

A survey was conducted to gather information on indigenous knowledge on the freshwater oyster (Etheria sp. Lam.1807), its distribution and utilization along the major rivers (i.e. Oti, the White Volta and Black Volta) forming the northern Volta Basin of Ghana. The occurrence of the oyster in the major rivers entering the Volta Lake indicates a widespread distribution of this mollusc in Ghana. The river Oti in the north-east serving as an international boundary between Ghana and Togo, the Black Volta on the north-west also serving as international boundary between Ghana and La Cotê d'Ivoire, and the White Volta running through the central portion, all harbour populations of the freshwater oyster. Etheria sp. has been a staple food for the inhabitants along the rivers where the oyster occur for many years. The oysters are collected from the riverbed mainly during the dry season, when the water level is low using locally manufactured implements like hoes, chisels and hammer. Biochemical analysis of the smoked meat from Nawuni, on White Volta, showed that it contained 40.7% protein, 27.4% carbohydrate, 8.6% fat, 3659 mg/100 g calcium and 2210 mg/100g phosphorus. Proximate biochemical composition on dry matter of the species compared favourably with other edible bivalves in West Africa. The freshwater oyster shells are currently, not being utilized for any known purpose in Northern Ghana, though marine oysters are utilised in livestock feed production. This paper serves as a baseline study on the freshwater oyster in northern Ghana, which has opened up more areas for further research.

Keywords: Bivalves, Freshwater oyster, Etheriidae,, Etheria spp., Volta Basin, Northern Ghana

INTRODUCTION

Throughout the world bivalves play an important role in the national economy of many countries, be it in the form of a highly developed industry or as source of cheap protein to many who need them. Quayle (1980) indicated that in most tropical and subtropical countries shellfishes especially the bivalves and crustaceans are a major source of much needed protein for many rural communities and they are not considered as luxury food item as in the temperate zones. The exploitation of bivalve resources in developing countries is mostly done on the subsistence level (Vakily, 1994). Bogan (2008) noted that freshwater bivalves whilst providing a filtering service in rivers and lakes, also serves as a supplemental food source. Many species of bivalves are often found in dense aggregations or colonies and filter out large quantities of blue-green algae, diatoms, bacteria, fine-particulate organic matter as well as silt, absorb heavy metals and large organic molecules.

The family Etheriidae is a small family of sessile, cemented oyster-like bivalves with irregular shells. They are obligate freshwater organism and spend their entire life cycle in freshwater. This family has a confused taxonomy. It was earlier thought to comprise of three genera, Pseudomulleria, Anthony, 1907 which occurs in the India peninsular; Mulleria, Férrussac, 1823 in tropical South America and Etheria, Lamarck, 1807 in Africa and Madagascar (Yonge, 1962; Van Damme, 1984; Mandahl-Barth, 1988). According to Bogan and Hoeh (2000), the family Etheriidae has been recognized as a distinct taxon well over time (160 years), with three cemented genera: Acoustae (Columbia, South America), Pseudomulleria (India) and Etheria (Africa and Madagascar). However, from recent advances in the use of deoxyribonucleic acid (DNA) sequence data and anatomical analysis; Acoustae rivolii (Deshayes, 1827) from Rio Magdalena in Columbia and Pseudomulleria dalyi (Smith, 1898) from Southern India were shown to belong to the families Myceptopodidae and Unionaidae respectively. The Etheriidae is now believed to be represented by a single genus and species Etheria elliptica, which was first described by Lamarck in 1807. This family is a cemented freshwater oyster that lives in Africa and extreme northwest Madagascar. Its larval stage or structure is still not known (Mandahl-Bath, 1988; Bogan, 2008; Bogan and Roe, 2008).

Observations by the working team of Water Research Institute (WRI) of the Council for Scientific and Industrial Research (CSIR) on the Onchocerciasis Control Programme (OCP, from 1974 to 2002), revealed that, during the dry seasons of each year rural communities along the major rivers in the Volta Basin of Northern Ghana collect the Etheria for food (Dr James Samman, former Deputy Director CSIR-WRI, personal communication, September, 1997). Considering the time and energy expended in collecting, processing, preserving and marketing the oyster, the "Oyster Fishing Industry" appears to be of some socio-economic importance to the rural community. However, information on the distribution and utilization and nutritional value of these species along these rivers appears to be scanty, fragmentary, and incomplete. It is also, not scientifically documented in Ghana.

This paper attempts to report on the various locations where the freshwater oyster has been found by way of locating shells in the community and current populations found in the river or stream bed. It also looks into the indigenous knowledge on the freshwater oyster and its utilisation.

MATERIALS AND METHODS

Study Area

The study was undertaken in Northern Ghana (Northern, Upper-East and Upper-West regions) between January to May 1998; January to May 1999 and January to July 2008. The study area lies between latitudes 8^0 and 11^0N, and longitudes $2^0$45'W and $0^0$30'E. Within this area flow River Daka, River Oti, Black Volta and White Volta, and their numerous tributaries including Rivers Nasia, Kulpawn, Tono and Sisile (Fig 1). The villages of Nawuni on the White Volta, Bamboi on the Black Volta and Sabari on River Oti were chosen for detailed study of the fishery of the species. The choice of these sites was based on ease of accessibility, current availability of the species and the fact that they are among the popular fishing areas of the freshwater oyster. Evidence of a thriving oyster fishing industry, is given by the heaps of shells found in the rivers channel, along the banks and the riverine communities of the Northern Volta basin (Fig 2).

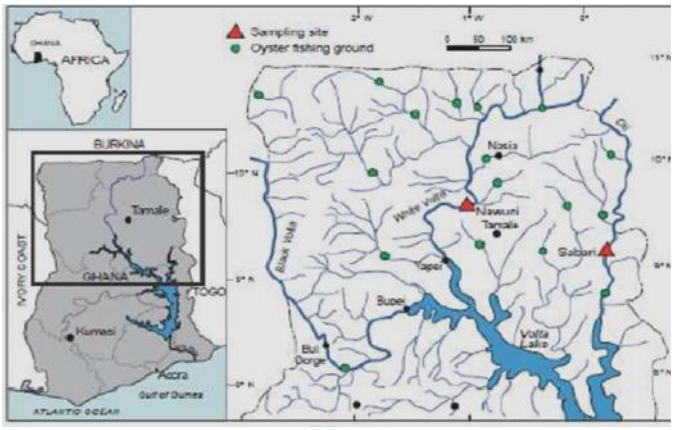

Figure 1. Map of northern part of Ghana, some major fishing grounds (green colours) and the sampling sites (red colour) of the freshwater oyster (Etheria sp.) in northern Volta basin
(adapted from Ampofo-Yeboah *et al*, 2009)

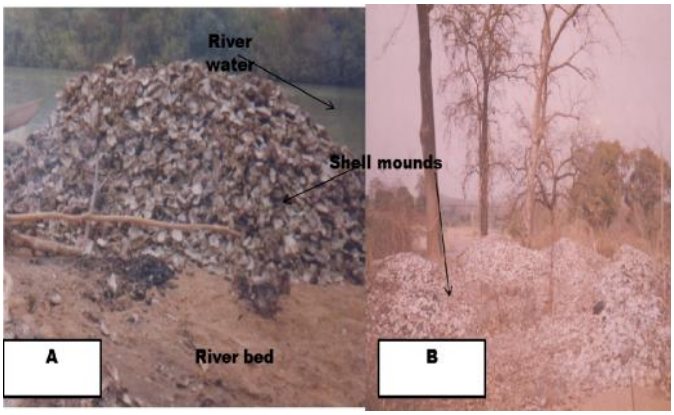

Figure 2. Mounds of freshwater oyster shells **(a)** in the bed of White Volta at Nawuni and
(b) Kpalba village in the River Oti Basin

Distribution and Main Areas of Fishery of the Freshwater Oyster

Prospecting for occurrence of Etheria species and a general survey for information on the past and present status of the oyster fishery, utilization and popularity as a source of food based on indigenous knowledge along the major rivers forming the northern Volta Basin of Ghana was conducted between January 1998 and December 1999. A follow up study was also conducted from January to July 2008. This study was made using questionnaire in semi-structured interviews with the oyster collectors, fishermen and other village residents from the communities living within the basins of rivers Oti, Daka, White Volta and Black Volta. Information gathered were based on fishing activity, implements used and the level of exploitation along the river courses. Communities within the basins of these major rivers were also searched for the shells or relics of them. Observations were also made on collection and processing methods employed in the oyster fishery between February and April 1998. The survey for distribution and utilization along the major rivers (i.e. Daka, Oti, White Volta and Black Volta) forming the northern Volta Basin of Ghana was conducted between January 1998 and December 1999, and January to July 2008 to gather information on indigenous knowledge on the freshwater oyster (Etheria sp. Lam.1807). The information gathered is presented in Table 1.

Table 1. **Some local names of Etheria sp**.

Tribe	Local name of Etheria sp.
Dagombas	Zama
Gonjas	Kepkante
Konkombas	Tikroi
Mos	Kpento
Dargartis	Zanzang
Ewe (Battors)*	Adza
Hausas*	Kawa

*Do not use the oyster as food

Biochemical Composition

The biochemical composition of the freshwater oyster was determined for fresh meat (from Nawuni on the White Volta and Sabari on River Oti and smoked meat (i.e. the form being eaten, from Nawuni on the White Volta) at Council for Scientific and Industrial Research (CSIR) – Food Research Institute (FRI). As a measure of the nutritional value of the oyster, the following were considered: moisture, ash, protein, carbohydrate, fat, energy, iron, phosphorus and calcium.

The fresh meat was minced in a Hobart mincer and sub-sampled for the determination of the proximate composition and mineral contents based on methods and procedures outlined by AOAC (1970), 11th Edition and as used by Eyeson and Ankrah (1975), for specimen from Nawuni on the White Volta and Sabari on River Oti . The same was done for smoked specimen from the White Volta at Nawuni in March 1998. About 5 g of the minced samples was oven-dried at 105 $\pm$ 1^0C to a constant weight and the difference between the wet and dry weights gave the moisture content. Protein content was determined by estimating the total nitrogen using the macro Kjeldahl method and multiplying the value by a conversion factor of 6.25 (AOAC, 1970). Fat was extracted by the continuous Soxhlet extraction method while the ash content was determined by igniting 5g of the dry meat to ash in a muffle furnace at 550^0C. Carbohydrate was obtained by subtraction of the protein, fat and ash values from 100. The concentration of iron was determined by reducing a portion of the ash solution with ascobic acid. A solution of dipyridyl was then added and the colour intensity measured with a colorimeter (Coleman Model 8). The iron content was read from a standard curve. Phosphorus was determined by adding molybdate sulphuric acid to the ash. The molybdo-phosphate was reduced with ascorbic acid. The optical density was measured colorimetrically and the phosphorus content calculated by reference to a standard curve. Calcium was precipitated as oxalate by dissolving a portion of ash in hydrochloric acid (HCl). The oxalate was then dissolved in sulphuric acid (H_2SO_4). The liberated oxalic acid was titrated against potassium permanganate ($KMnO_4$) solution to give the calcium content.

RESULTS

Distribution

The freshwater oyster, Etheria sp. was found to occur throughout the northern Volta River systems which feed the Volta Lake (Fig. 1). The oyster colonies were usually found close to the banks and shallow parts of the river with rocky or stony beds (Fig 3). At Bamboi, on the Black Volta and Nawuni on the White Volta, the oysters usually possessed long hollow tube-like projections on the upper valve, and they also tended to be more gregarious (Fig 4a). Oysters from Sabari on the Oti River had smooth shell without projections, attached usually singly on stone slabs and were less gregarious (Fig 4b).

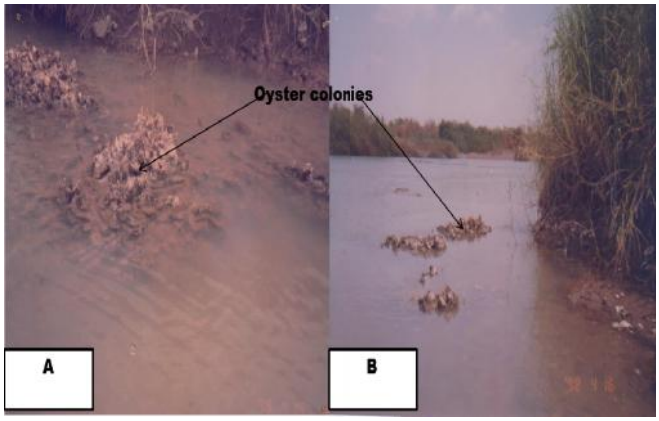

Figure 3. Freshwater oyster colonies in the bed of the White Volta at Nawuni **(a)** shallow part near the bank and **(b)** in the middle of the river (note the island formed from previously harvested oyster shell mound on the right).

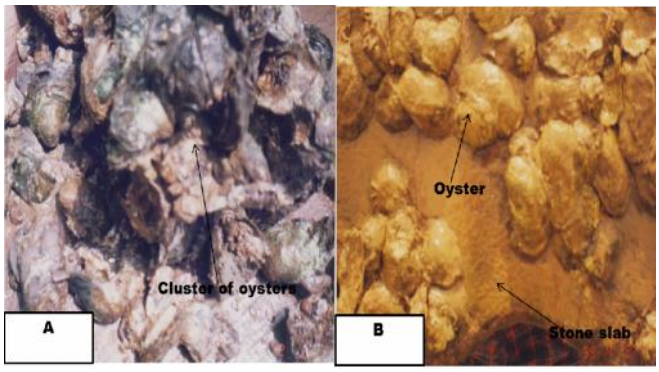

Figure 4. **(a)** Cluster of oyster attached to rock surface removed from the White Volta at Nawuni **(b)** Oysters attached singly to stone slab removed from the Oti River at Sabari.

The oyster occurred along the stretch of River Oti that serves as international boundary between Ghana and Togo The river runs from Saboba in the northeastern part of Ghana through Sabari to Damanko at the edge of the Volta Lake (Fig 1).

Live specimens were collected from River Oti and its tributaries such as Manyeri stream (Fig 5a) near Kpalba, between Saboba and Damanko. Oyster beds were located in the Daka River and its tributaries at Benchineyili, near Yendi. Along the course of White Volta, the oyster was found at Duu on the confluence of White Volta and Red Volta in the Upper East Region through Nawuni (where live specimen were collected) and Daboya to Yapei where the river enters the Volta Lake. Major tributaries of the White Volta such as the Red Volta, Rivers Nasia, Kulpawn, Tono and Sisile all harboured colonies of the freshwater oyster. The oyster colonies were also found in the main canals of the Tono Irrigation Dam (Fig 5b), near Navrongo in the Upper East Region. In the Black Volta, the oyster beds stretch from Lawra, upstream in the Upper West Region through Bamboi to Bupei where the river joins the Volta Lake. Oyster beds have also been located in some of the major tributaries such as Kombe, near Lawra joining the Black Volta.

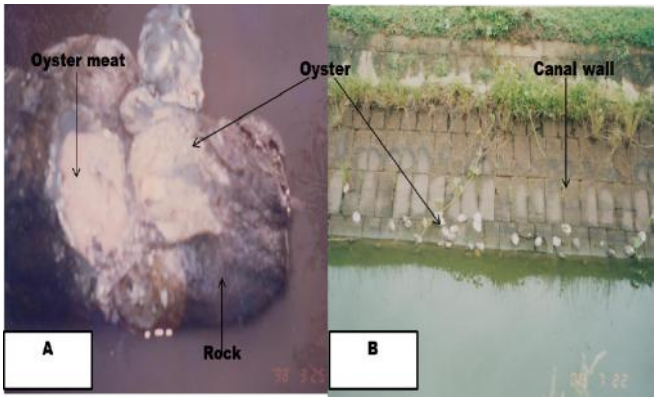

Figure 5. Freshwater oyster attached to **(a)** rock surface in Manyeri stream, a tributary of the Oti River,
(b) main canal wall of the Tono Irrigation Dam, near Navrongo Upper East Region

Fishery and Utilization

Uses as Food

Results of the interviews indicated that the oyster has been a staple food for some tribes in northern Ghana for many centuries. The tribes, which exploit Etheria as food, are shown in Table 1. The Etheria fishing industry involves collection, preservation and marketing.

The meat is eaten either fresh or dried. Fresh meat is eaten boiled and used to prepare palm oil or vegetable stew. Dried ones are pounded into powder and mixed with soup. The results on nutritional values of fresh meat samples obtained from the White Volta at Nawuni and River Oti at Sabari, and the smoked meat sample obtained from the White Volta at Nawuni are shown in Tables 2 and 3.

Uses of the Shell

Information gathered indicate that the shell was used for preparing local paint, and as a component in the poultry industry. To be used as a paint the shell is burnt, crashed or pounded into a powder. It is then mixed with water and used as white wash, to paint walls and floors of homes, particularly, in the eastern part of Northern Region along the Oti River. To use the shell as 'shell grate', it is washed in antiseptic, such as dettol or azar and dried. The dried shell is half-burnt (i.e. not to ash), ground and sieved to get the fine powder. The fine powder is mixed with other poultry feed ingredients such as maize and wheat bran in various proportions and given to the birds (Mr Akorli, Retired Educationist & Poultry Farmer, Sakasaka Low Cost, Tamale, personal communication).

In most parts of Northern Ghana, particularly the eastern section, no information was obtained on the use of the shells. The riverine communities in this area did not have any use for the shells, which have accumulated over the years. Mounds of shells were found in villages such as Gnani and

Kpalba about two kilometres from the banks of River Oti. In the White Volta basin, however, some poultry farmers mostly from Tamale (about 11.3 kilometres from the river), use the shells as a mineral source in poultry feed. However, this usage has declined over the years, because it is claimed that the procedure for converting the shells into a more useful form tends to be cumbersome. Mounds of shells were found in the riverbed and along the banks of the White Volta downstream to the lake portion at Yapei.

Collection

The Etheria fishing industry is based on their collection from the wild on subsistence level. Simple farm tools are used in the collection; these include small hoes, chisel-like metals and hammer. As the oysters are attached to rock surfaces, hard substrates or other shell on the riverbed (Figs 3 - 5), the collectors use these instruments to pry them loose.

The oysters are collected mainly during the dry season (January to April) when the water level drops. The harvesters usually use their feet to locate the oysters on the riverbed, except in the shallow parts of the river where the water is so clear that they can be seen attached to the substrata. The Etheria fishing is traditionally a woman's occupation, by both young and old (Fig 6a), assisted by young men who are not engaged in intensive finfish fishing especially when the water is a little deep and diving becomes necessary for collection of specimens.. The other types of fishing are considered a male's job. The collectors usually fish from early morning to dusk. Whatever is collected is sent to the banks or islands/sand bars, where the meat is removed and processed. Although, on a small scale, the fishery is an important local industry, which provides source of food and income for the rural communities.

Processing

The meat can only be removed when the shell opens up. The oysters are boiled in a metal pot (Fig 6a) for about 15 minutes or more till the shells open up. The meat is then removed with the fingers or any object, which can easily scoop it out (Fig 6b). The meat obtained for the day is washed and sent home for further processing. In the house, the meat is smoked over an earthen-oven (Fig 7) after which it is sun dried to a hard brown flake colour. Information gathered indicates that if the meat is well smoked and sun dried, the meat can be stored up to one year in tact or in powdered form.

Figure 6. **(a)** Cluster of oyster being boiled in metal pot **(b)** collector removing boiled oyster from the shell at Nawuni on the White Volta at Nawuni.

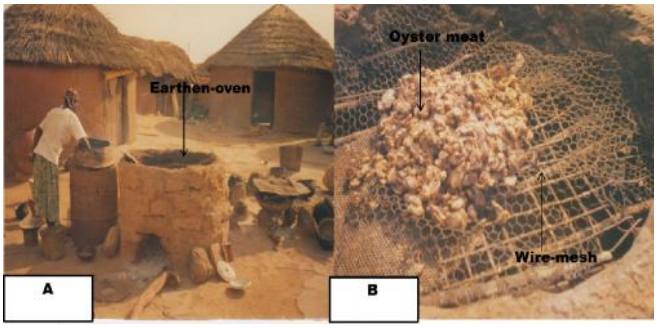

Figure 7. Freshwater ouster meat being smoked **(a)** on earthen-oven **(b)** on wire-mesh at Nawuni on the White Volta.

Economic Importance

Revenue from the sale of oysters is the main source of income for many women in the area of study. There are seasonal and spatial differences

in prices of the smoked oyster meat. For instance, in March 1998 the price of a bowl full of smoked oyster meat (about 0.30 kg) cost ¢2,500.00 (GH¢0.25) at Gnani, and ¢4,000.00 (GH¢0.40) at Kpalba which is about 1.5 km away. At Sabari, the price per bowl of smoked oyster meat was ¢2,500.00 (GH¢0.25) in March 1998 but in April it sold for ¢3,500.00 (GH¢0.35). At Nawumi the price was between ¢2,000.00 (GH¢0.20) and ¢3,000.00 (GH¢0.30) throughout the collecting season (i.e. March - April) in 1998.

Biochemical Composition

Table 2 shows the results of the analysis of the nutritional value of smoked oyster meat, the form in which the locals normally eat the meat.

Table 2. **The nutritional value and mineral content of smoked Etheria meat from Nawuni (White Volta)**

Parameter	Nutritional value
Moisture	9.1 %
Ash	14.2 %
Fat	8.6 %
Protein	40.7 %
Carbohydrate	27.4 %
Energy	350.0 (kcal/100g)
Iron	19.3 (mg/100g)
Calcium	3659.0 (mg/100g)
Phosphorus	2210.0 (mg/100g)

Table 3 shows the values obtained from analyses conducted on the fresh meat of oysters from the two sampling sites. The values obtained are similar suggesting that the meat of the oyster from both rivers have similar nutritional value. Table 4 shows a comparison of biochemical composition of Etheria sp. and some other bivalves (i.e. both marine and freshwater forms) found in West African waters. The protein, carbohydrate, lipids and ash contents of Etheria sp. fall within the range determined for the other bivalves

The food value of Etheria sp. is therefore, fairly comparable with that of well-known commercial bivalves.

Table 3: **Biochemical composition of the fresh meat of Etheria sp. from Nawuni (White Volta) and Sabari (River Oti)**

Parameter	Nawuni (White Volta)	Sabari (River Oti)
Moisture	78.1 %	76.3%
Ash	3.8 %	3.8 %
Fat	1.6 %	1.9 %
Protein	12.4 %	12.6 %
Carbohydrate	4.1 %	5.4 %
Energy	70.4 (kcal/100g)	79.1 (kcal/100g)
Iron	57.6 (mg/100g)	58.3 (mg/100g)
Calcium	1144.4 (mg/100g)	919.2 (mg/100g)

Table 4: **Biochemical composition of Etheria sp. compared with other Bivalves in West Africa**

Species	Protein	Carbohydrates	Fats	Ash	Source
Etheria sp.* (White Volta, Ghana)	56.6	18.7	7.3	17.4	This study
Etheria sp.* (River Oti, Ghana)	53.2	22.8	8.0	16.0	This Study
Aspatharia sinuate (River Oyun, Nigeria)	31.4	31.7	5.2	25.2	Blay (1986)
Egeria radiata (Lower Volta, Ghana)	54.3	30.4	7.5	7.9	Kwei (1965)
Crassostrea tulipa (Benya Lagoon, Ghana)	59.3	20.0	8.0	12.7	Yankson et al (1997)
Crassostrea tulipa (Pra Estuary, Ghana)	67.7	10.7	7.9	17.4	Yankson et al (1997)
Crassostrea gasar (Lagos Lagoon, Nigeria)	40.1	21.3	9.7	-	Ajana (1980)

(Dry weight basis, percentages) *Values converted from fresh weight basis in Table 3

DISCUSSION

The freshwater bivalves fauna of Africa and South America are poorly known and there is still much confusion, around the number of species recognized. Freshwater bivalves are represented by 19 families, categorized into 5 separate orders and grouped into 3 different subclasses of the Class Bivalvia. Most families are represented by only a single or few species (Bogan, 2008).

Information on the biology and ecology of the freshwater oyster is scanty and appears fragmentary. Recent advances in the use of deoxyribonucleic acid (DNA) sequence data and anatomical analysis has shown that the family Etheriidae, which is one of the 6 families of the order Unioniforme is represented by a single genus and species the Etheria elliptica (Lamarck, 1807), that lives in Africa and extreme northwest Madagascar (Bogan, 2008). The freshwater oyster (Etheria sp) is now known to have afro-tropic distribution (Bogan, 2008; Bogan and Roeh, 2008). It is widespread in Africa: in the basins of the Nile, Lake Tanganyika and Lake Victoria; the basins of Chad, Zaire, Niger and Senegal; part of the rivers in Angola and north Madagascar (Pilsbry and Bequaert, 1927; Van Damme, 1984; Mandahl-Barth, 1988). Based on the outcome of the semi-structured interview conducted in this study as well as personal observations, and collection it appears that generally, the freshwater oyster occurs in all the major rivers and their tributaries that enter the Volta Lake. The species also occurs in many streams in the Volta basin. It has been found in the rivers of Oti, Daka and the Black and White Volta, and all their tributaries, all of which are major tributaries of the Volta Lake in Ghana. One fascinating occurrence is the existence of the oyster in the main canals (Fig 5b) of the Tono Reservoirs. The River Oti on the north-eastern side of the country serving as an international boundary between Ghana and Togo, the Black Volta on the north-western serving as international boundary between Ghana and Côte d'Ivoire and the White Volta running through the central portion of northern Ghana, all harbour populations of the oyster. It is therefore, evident that the freshwater oyster Etheria elliptica (Lamarck, 1807) is widely distributed in the three northern regions of Ghana.

Although Etheria elliptica (Lamarck, 1807) occurs throughout the entire Northern Volta system, they were only found on rocky/stony sections of the rivers where the stones and rocks provide surfaces for attachment. Etheria elliptica (Lamarck, 1807) like the Volta clam, Galatea paradoxa (Born, 1778), (formerly Egeria radiata, Donacidae, Lam), is among the bivalve species, which are exclusively freshwater (Purchon, 1977; Bogan, 2008). It differs from all other freshwater bivalves by possessing an irregular, unequivalve shell. It is oyster-like with one valve, the left , cemented to a hard surface such as rock, a shell of its kind, a stone slab (Fig 4a) or other firm substratum from which it takes its shape (Pilsbry and Bequaert, 1927; Yonge, 1962; Bogan and Hoeh, 2000). The river oyster was found cemented to rock or stone slabs or substratum (Figs 3-5) in all the rivers and streams visited. In places, such as Nawuni on the White Volta (Fig 3) and Bamboi on the Black Volta, the colonies are of such a great size that, they impede navigation when the water level is low. Oysters found in River Oti at Sabari appear to attach separately on stone slabs (Fig 4). The freshwater oyster, Etheria sp. first described by Lamarck in 1807 has long been exploited for food by the riverine communities. Pilsbry and Bequaert (1927) indicated that, the river oyster lived attached to rocks in deep and rapidly moving water or found in the rapids throughout the River Congo Basin. It was widely used by native peoples for food, and as source of lime by early Belgian settlers. According to Van Damme (1984) mounds of oyster shells have been found in the lower Nile basin, suggesting extensive exploitation of the animal. In this study, it was also established that, inhabitants in Northern Ghana have used the freshwater oyster as food for centuries.

While they were little known in the urban centres, these oysters were consumed on a larger scale in the rural areas, particularly, among riverine communities, where the meat is eaten fresh, smoked or dried.

In most part of Northern Ghana visited, the riverine communities did not have any use for the shells, which have accumulated over years. Mounds of shells were found in village such as Gnani, and Kpaliba, each of which is about 2 km from the banks of River Oti and bamboo on the banks of Black Volta. In the White Volta basin, however, some poultry farmers mostly from Tamale (about 11.3 km from the river), use the shell as a mineral source in poultry feed. However, the usage has declined over the years because it is claimed that the procedure for converting the shells into a more useful form tends to be cumbersome. Elderly respondents (over 60 years old) intimated that the shells were used as local paints. This assertion confirms Pilsbry and Bequaert (1927) account of the use of the shell in Democratic Republic of Congo, by the early Belgian settlers on the account of the relative scarcity of limestones. All the communities visited in the basins of River Oti, Daka, White Volta and Black Volta, showed massive heaps of oyster shells in the villages along the banks, and the river beds (Fig 2). Visits to the upper portions of the Volta Lake at Yapei and Bupei areas showed, mounds of shells in the villages on the banks of the lake. Generally, it may be concluded that the people in Northern Ghana do not have any use for the freshwater oyster shells, which have accumulated on the river beds, banks, and in the villages over the years.

Biochemical composition of some bivalve molluscs have been investigated in Ghana, for instance, Kwei (1965), on Galatea paradoxa, Obodai (1990) and Yankson *et al*., (1994) on Crassostrea tulipa. In the present study, it was discovered that the most widely eaten form of the oyster was the smoked meat, which was therefore subjected to biochemical analysis to determine the extent of nutritional value. The result from the analysis such as protein, carbohydrates, lipids, and ash contents of Etheria elliptica (Lamarck, 1807) fall within the range determined for other bivalves. The food value of freshwater oyster is fairly comparable with that of well-known commercial bivalves, both local and others from elsewhere (Tables 3 & 4). Kintin and Cesarani (1996), have described shellfish, particularly, the oysters as a good body - building food containing a lot of protein, vitamins and minerals. Calcium, iron and phosphorus are among the major mineral elements, which contribute to the proper functioning of the human body and are accordingly, considered as important dietary elements (Pyke, 1989). Analysis obtained from Etheria elliptica (Lamarck, 1807) in this study indicates that, the concentration of the minerals compared favourably with some of the well-known commercial bivalves and foods deemed to be good food sources in these minerals. From the comparisons made, it is evident that Etheria elliptica (Lamarck, 1807), has high protein content and other nutritional elements compared to other bivalves (Kwei,1965; Blay, 1986; Obodai,1990; Yankson *et al*., 1994). It could also be regarded as a good source of essential minerals especially calcium and phosphorus.

CONCLUSION AND RECOMMENDATION

In the light of the results and discussions above, it could be concluded that the freshwater oyster, Etheria elliptica (Lamarck, 1807) occurs literally in all the rivers making up the Volta system in northern Ghana. It has been a source of animal protein supplement for household subsistence needs for centuries, for some people in northern Ghana. The Etheria elliptica (Lamarck, 1807) fishing industry though, based on their collection from the wild and operating on the quiet, constitutes an important basis of a local industry. It may be of great antiquity but certainly provides an important source of food in a protein-deficient area of the country.

The freshwater oyster, Etheria elliptica (Lamarck, 1807) in the two rivers sampled has a very high nutritional value compared to other bivalves; hence their use as food supplement should be encouraged.

This study, although a preliminary one has highlighted the existence in Ghana of a potentially renewable natural resource that is able to produce protein and provide needed artisanal occupation in poor rural communities. It has also opened up more areas for further research.

The freshwater oyster could be recommended for usage as supplementary or additional fish food source in a protein deficient country like Ghana. It would be instructive for future investigations to be conducted on the seasonal variations in the nutritive value of the oyster, so as to determine the time of the year during which the species could be most beneficially exploited.

ACKNOWLEDGEMENT

The author is grateful to National Agricultural Research Project (NARP) and Water Research Institute (WRI) both of the Council for Scientific and Industrial Research (CSIR) and University of Cape Coast, Ghana, for supporting this research.

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