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Original Article

A Comparative Study of the Anatomy of Two West African Edible Bivalves, *Aspatharia Sinuata* (Mutellidae: Unionacea) and *Egeria Radiata* (Donacidae: Tellinacea)

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ABSTRACT

The need for a better understanding of the biology of *Egaria radiata* and to shed light on the sequence of events in the adaptation of this important West African fishery clam, which enabled it to first invade and gradually adapt itself to the freshwater environment, a pre-requisite to developing techniques for the expansion of sustainable production of the species, through fisheries and aquaculture, informed this study. This paper, therefore, reports on a comparative study of the anatomy of *E. radiata* (a hemi-freshwater clam) collected immediately above the region of salt water penetration of the Cross River area, Nigeria, and *Aspatharia sinuata* (an established holo-freshwater bivalve) obtained from inland waters. The results indicated that though the two species have certain anatomical features, common, indicating strong evolutionary relationships and adaptation to freshwater environment, the species nevertheless differed considerably in certain features that get modified in the course of Bivalvia transition from salt to freshwater environments; suggesting different levels of adaptation to freshwater environment, probably, occasioned by variation in the period of arrival at such habitats by the two species. For example, the two species differed in structure and complexity of the stomach, presence/absence of caecum, association of the style sac with the midgut, length and coiling of the intestine and distribution of the gonads in the visceral mass. These variations probably indicate differences in feeding and breeding habits, related to differences in distribution and behaviour of the two species. The findings of this study revealed that *E. radiata* is on a definite transition from marine to freshwater habitat and it should be possible to hasten this migration by culturing the species entirely in freshwater captivity or, at least, transplanting the young clams from their present region of distribution at the lower reaches of inland waters, to new beds upstream to give them time to attain maturity before harvesting, in order to prevent extinction of the species, going by the reported limited area of its distribution and low production-to-mean-biomass (P/B ratio), resulting from over exploitation.

Key words: Freshwater, Habit, Habitat Characteristics, Molluscs, Salt water.

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INTRODUCTION

Though, aquatic molluscs constitute an important component of the diet of native tribes in the Coastal areas of West Africa, the biology of members of the Phylum is poorly understood (Furnish *et al.*, 1997; Adebayo-Tayo and Ogunjobi, 2008) thus, hampering increased production through aquaculture even in the face of increasing demands. According to Schneider (1979) and Yoloye (1984), more than 10 species of aquatic molluscs are collected in large numbers for food in West Africa. Evidence, mostly from comparative anatomy, suggests that the Phylum probably evolved from soft-bodied unsegmented ancestors, linking it to the evolution of Platyhelminthes and Nemertine worms (Salvini-Plawen, 1980). Definite efforts at understanding the biology of edible bivalves of West Africa were limited to shell characteristics, classification, feeding habits, geographical distribution, spawning and growth (Purchon, 1963; Kwei, 1965; Afinowi, 1975; Yoloye, 1975; Blay, 1986; Blay and Yoloye, 1987; Odiete, 1987). However, except for a few studies including, Etim *et al*. (1991); Etim (1996); Etim and Taege (2008), very little is known about the biology of a particularly important species of bivalve, i.e., *Egaria radiata*, despite its popularity as a cheap source of animal protein in West Africa.

The need for a better understanding of the biology of *E. radiata* is of particular interest in view of its unique position among the bivalves. According to Purchon (1962), at least four major lineages and a number of minor lineages of bivalves have invaded the fresh water ecosystems. The most ancient of these are cosmopolitan in distribution; their origin as fresh water forms and dispersal through the fresh water systems of the whole world having preceded the subdivision of the land mass into separate continents. Thus, *Pisidium* and *Sphaerium* in the family Sphaeridae are found in fresh waters in all continents (De Kock and Wolmarans, 2008). Great antiquity is also revealed by the development of special adaptations, for example, in the family Mutellidae, whose larva is an ectoparasite of fish (Fryer, 1964). However, Purchon revealed that *E. radiata* (Family Donacidae), is a comparatively recent addition to the fresh water fauna. The species is confined to relatively short lengths of certain West African waters, immediately above the main region of salt water penetration and may possibly be dependent on increased salinity for breeding purposes (Purchon, 1963; Baxter, 1977).

If *Egaria* is a comparatively recent addition to fresh water fauna, it is to be expected that it will not be so highly adapted to its new environment as are the most ancient fresh water bivalve groups. This may, perhaps, explain the inability of the species to survive in a fresh water aquarium system whereas, a population of *Aspatharia brompti* which belong to the more ancient Mutellidae ancestry was unaffected (Purchon, 1963). Thus, comparative studies on the physiology of *Egaria* and *Aspatharia* would doubtless be very rewarding, as this will shed light on the sequence of events in the adaptation of the various lineages of bivalve which enabled them to first invade fresh waters and gradually adapt themselves to the new environment. The current comparative study of the anatomy of *E. radiata* and *A. sinuata* was, therefore, undertaken as a preliminary to further physiological studies aimed at elucidating the migration of bivalves from the sea to fresh water.

MATERIALS AND METHODS

Specimen Collection, Identification and Preservation

The specimens of *A. sinuata*, studied in this work were collected from Oyun River at Offa in Kwara state, Nigeria, while those of *E. radiata* were obtained collected from the Cross River at Itu, Nigeria. The identities of the bivalve species were authenticated at the Department of Zoology, University of Ilorin, Nigeria. The specimens were preserved in F.A.A. (Formaldehyde, Alcohol, Acetic acid), of composition 50ml of 95% ethyl alcohol, 2 ml glacial acetic acid, 10ml of 40% formalin and 40ml distilled water.

Dissection and Anatomical Investigations

For each bivalve species, representative samples were selected and dissected following the techniques of Blay, (1986). Briefly, the right shell valve of a specimen was carefully removed with the aid of a wedge and a sharp scalpel. Then, a vertical cut was made in the mid-ventral border of the right mantle lobe. The flaps were raised and pinned to the wax on the floor of the dissecting dish, above the dorsal margin of the shell.

To study the internal structures, a longitudinal cut was made through the body along the mid dorsal line, below which the digestive system was revealed in the visceral mass. For the pericardium, an incision was made in the pericardial wall, after the removal of the right mantle lobe. Then, the side of the pericardium was removed, exposing the heart. The nervous system was examined by scraping the mantle tissues away gently at the surface of the visceral mass just behind the anterior end of the labial palps. The ganglion lied just below the epithelium and was rendered conspicuous by its orange colour. The visceral ganglion was located by separating the epithelium of the under-side of the posterior adductor muscle. For the fused pedal ganglia, a median longitudinal incision was made in the foot and this was continued upwards until the substance of the digestive gland was reached. The glands were teased with a needle and washed repeatedly with pipette to remove fragments, until the ganglia were found, which were rendered conspicuous by their orange colour.

RESULTS

Figure 1 and 2 showed details of the internal structures of *A. sinuata* and *E. radiata*, respectively, after dissection. In both species, a slit-like mouth lies just below the anterior adductor muscle, opening into a short, straight and flattened tube, i.e., the oesophagus. The oesophagus passed backwards and upwards to enter the stomach, a globular organ, covered by a mass of pale-green digestive glands. From the posterior end of the stomach, arises the intestine which enters the mass of the foot where the pericardial cavity starts. From here it turns to the posterior side and passes in to the rectum before finally opening to the exterior at the anus.

A number of differences were noted in the gut of the two species, however. In *A. sinuata*, the style sac was combined with the midgut, and the stomach lacks a caecum. Also, the coilings of the intestine are fewer hence, making the length of the intestine shorter (Fig. 1). On the other hand, the stomach in *E. radiata* has a large postero-dorsal bifid caecum, with a style sac completely separated from the midgut (Fig. 2). The style sac is long and straight, passing downwards and backwards in to the posterior part of the foot. Again, unlike *A. sinuata*, the midgut in *E. radiata* arises from the ventral wall of the stomach, in front of the orifice of the style sac, running backwards parallel with the style sac and then ascends from the region of the keel of the foot towards the pericardium. The intestine makes a number of closely packed coils before entering the pericardium on its anterior wall.

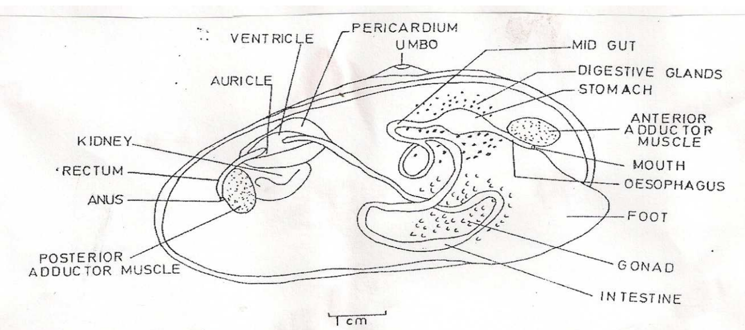

Figure 1: Dissection to show the internal structures of *Aspatharia sinuata*.

The heart in the both bivalve species are very identical, each situated above the dorsal border of the ctenidia, posterior to the stomach but anterior to the posterior adductor muscle (Figs 1 & 2). The heart consists of a median muscular chamber, the ventricle, wrapped around the rectum and two (right and left) thin-walled lateral auricles. The apices of the auricles are attached to the ventricle and their bases extend along the axis of the ctenidia. The excretory organs, in both species, are two kidneys, lying beneath the pericardium, one on each side of the body. Each kidney is more or less U-shaped, with a spongy glandular lower arm opening in to the pericardium. The upper arm forms the urinary bladder, the two bladders communicating with each other by an oral aperture. Each bladder, again, communicates with the exterior by a minute aperture which is situated between the inner lamella of the gill and the visceral mass. The wall of the bladder is ciliated. In *A. sinuata*, the gonads occupy the spaces between the coils of the midgut and hindgut, behind the mass of the digestive glands (Fig. 1). In this species, the gonads extend in to the foot. Although, the gonads also surround the coils of the intestine in E. radiata, they did not extend deep in to the foot musculature (Fig. 2). In both species, the genital ducts empty in to the dorsal gill chamber.

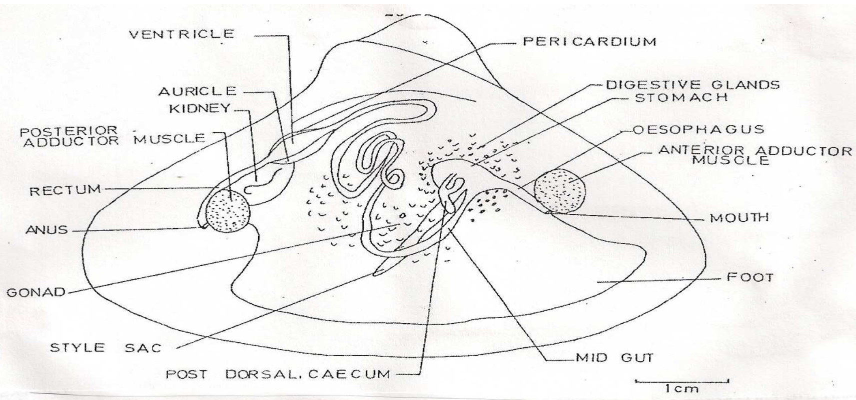

Figure 2: Dissection to show the internal structures of *Egaria radiate.*

DISCUSSION

The results of this study showed close similarities in the anatomy of *A. sinuata* and *E. radiata*, probably, confirming close ancestral relationships between Mutellidae and Donacidae bivalves, as earlier suggested (Purchon, 1963; Kondo and Sano, 2009). However, the differences noted between the species, especially, those related to the digestive system, suggest differential adaptations to specific environments. The differences noted in the complexity of the stomach and length of the intestine may be due to the nature of food and mode of feeding of the two species. In *E. radiata*, there is a well developed postero-dorsal caecum which opens in to the stomach on the right side above the opening of the style sac. In this species, the postero-dorsal caecum was bifid and the stomach has a large dorsal hood. The significance of these two structures is not clear since, according to Purchon, 1963), *Egeria* is a suspension feeder with the siphons taking in suspended particles. In typical bottom feeding Tellinacea, such as *Tellina*, Yonge (1949) reported that the large particles are temporarily stored in the large postero-dorsal caecum of the stomach, before trituration between the style sac and gastric shield.

E. radiata had a much longer and coiled intestine than *A. sinuata*. This finding may be due to differences in the kinds of materials actually utilized as food by the two species; usually, animals that feed more on plant materials tend to have longer intestine than their animal-feeding counterparts, as a result of the extra surface are and time needed for the digestion of cellulose (Mills, 2009). Thus, an investigation of the gut contents of the two species may throw more light on this postulation. This is crucial in the event of any aquaculture program aimed at mass-production of these edible bivalves, as productivity will be greatly enhanced when each species is fed its preferred diet.

CONCLUSION

This study revealed a strong evolutionary relationship between *A. sinuata* and *E. radiate,* in view of the similarities observed in the two species. However, differences were observed in the digestive and reproductive systems of the two species, probably, indicating variations in feeding and breeding habits, a knowledge that will be very useful in any aquaculture program aimed at expanded sustainable production of the species. The findings of this study revealed that *E. radiata* is on a definite transition from marine to freshwater habitat and it should be possible to hasten this migration by culturing the species entirely in freshwater captivity or, at least, transplanting the young clams from their present region of distribution at the lower reaches of inland waters, to new beds upstream to give them time to attain maturity before harvesting, in order to prevent extinction of the species, going by the reported limited area of its distribution and low production-to-mean-biomass (P/B ratio), resulting from over exploitation.

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