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Full Length Research Paper

Microphyto benthic composition of the fecal matter of a benthic gastropod *Pachymelania aurita* (O.F. Müller, 1774) in an estuarine ecosystem: Microphyto benthos as important food source for benthic invertebrates.

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The microphyto benthic assemblage in the fecal matter of a benthic gastropod *Pachymelania aurita* in a tropical estuarine lagoon was investigated by microscopic examination of the fecal matter. Two hundred and forty specimens comprising 120 juveniles and adults were used for this study. Comparison was made between microphyto benthos consumed by juveniles and adults. And to determine the actual source of the microphyto benthos recorded, comparison was also made between species recorded in the fecal matter of specimens direct from the wild and those exposed to sediment in the laboratory. The microphyto benthic organisms recorded consist of two major groups, blue-green algae (*Anabaena, Aphanocapsa*) and diatoms (*Navicula, Synedra, Cyclotella, Nitzchia)*. *Navicula* and *Cyclotella* were the most important taxa in terms of abundance and frequency. There were no variations in the microphyto benthos consumed by the adults and juveniles. The assemblage observed in the fecal matter of specimens of *P. aurita* exposed to sediment in the laboratory represent a slightly different array of organisms with representation of Cyanobacteria which were absent in the fecal matter of specimens collected directly from the wild. The result of the study further buttresses the claim that benthic microalgae serve as major source of organic matter supporting benthic invertebrates.

Keywords: Microphyto benthos, fecal matter, food, benthic invertebrates.

INTRODUCTION

Microphyto benthos do not only constitute an important carbon source for benthic food webs, but also provide an essential link to organic matter and inorganic compounds which are available to top predators and higher trophic levels (Miller et al., 1996). They are also an important food source because they are available all year round and the periodic re-suspension of large numbers of cells in the water column makes them easily accessible to filter and suspension feeders as well as benthic grazers (Adams and Sterner, 2000). The microphyto benthic community forms a highly active biofilm at the sediment water interface and has a significant impact on the exchange of dissolved and particulate matter between the water column and sediment, therefore influencing processes such as nutrient fluxes (Potter et al., 1975) and the stabilization of the sediment (Yallopet al., 1994).

The diversity and functional role of microphyto benthic communities has become a major topic in benthic research in the last two decades (Blanchard, 1991; Sundbaeck and Joensson, 1988; Montagna et al., 1995; Plante-Cuny and Plante, 1984). Microphyto benthos (MPB) also known as benthic microalgae (BMA) inhabit the surface of sediments, and are usually only visible as a greenish or brownish tint (Round et al., 1990; Miller et al., 1996). Their key function as primary producers in littoral zones has been emphasized in many studies (Daehnick et al.,1992; Pinckney and Zingmark, 1991; Colijn and De Jonge, 1984) and their great importance within the benthic food-web has also been pointed out (Sumner and McIntire, 1982; Plante-Cuny and Plante, 1984; Underwood and Thomas, 1990; Hillebrand et al., 1999; McCormick and Stevenson, 1989; Herman et al., 2000).

Apart from detritus and bacteria, the secondary production in shallow aquatic systems can be supported largely by the primary productivity of benthic microalgae

(Daehnicket al., 1992; Miller et al., 1996). Previous studies on grazer-microalgae interactions have stressed the relative importance of the microflora as food source for benthic consumers (Fenchel, 1968; Fenchel, 1975; Sumner and McIntire, 1982; Plante-Cuny and Plante, 1984; Underwood and Thomas, 1990; Hillebrand et al., 2002; McCormick and Stevenson, 1989). Consequently, there is now a consensus of opinion that the microphyto benthos can be considered as the major food source for herbivore invertebrates. Additional support to these findings has been given by recent stable nitrogen, carbon and sulphur isotope studies which have demonstrated that benthic microalgae are the basis for secondary production at the bottom of shallow freshwater and marine aquatic systems (Hecky and Hesslein, 1995; Herman et al., 2000; James et al., 2000). Due to its high abundance and productivity, the microphyto benthos is considered to be a reliable and highly nutritious food source (Fry and Sherr, 1984; Plante-Cuny and Plante, 1984; Decho and Fleeger, 1988; Jernakoff et al., 1996; James et al., 2000) and there is sufficient evidence that the relative importance of labile fractions derived from the renewable pool of microphyto benthos by far outweigh the significance of refractory detritus material as a food source for benthic organisms.

Hence, microalgae are utilized in aquaculture as live feeds for all growth stages of bivalve molluscs (e.g. oysters, scallops, clams and mussels), for the larval/early juvenile stages of abalone, crustaceans and some fish species, and for zooplankton used in aquaculture food chains. Over the last four decades, several hundred microalgae species have been tested as food, examples of microalgal species that have been tested include *Chaetoceros calcitrans, C. muelleri, C. gracilis, Thalassiosirap seudonana, Skeletonema* spp., *Tetraselmis suecica, Rhodomonas* spp., *Pyramimonas* spp., *Navicula* spp., *Nitzschia* spp., *Cocconeis* spp. *Amphora* spp. (Brown, 2002).

The benthic gastropod filter feeder *Pachymelania aurita* is a common species in Nigerian Coastal waters and occurs along the West African coast from Senegal to Angola, and constitute an important source of protein for inhabitants of villages along the coastline, notably in the Nigeria Niger Delta. The species is gathered and consumed and also sold in markets. The juveniles of *P. aurita* are important component of the staple of snail-eating fish. *Pachymelania aurita* lives in sandy-mud sediment in the open lagoons and avoids areas with a strong current. It lives at water depths of down to 5 m. It is a euryhaline species inhabiting areas of salinity variation between 0 and 27‰ and prefers the upper region of the infra-litoral. The weak teeth and the fringed mantle border further attest to the fact that it is a filter feeder, which means that a larger percentage of their food come from microalgae especially microphyto benthos.

The volume of literature in the various aspects of the biology and ecology of this species attest to the popularity and economic importance of the species. Its substrate preference (Ajao and Fagade, 1991; Uwadiae et al., 2009), reproductive behavior and life cycle (Egonmwan, 2007) have been reported. The ecology of the genus in relation to changes in temperature, salinity and survival out of water under experimental conditions has been documented (Oyenekan, 1975). The production and population dynamics of *P. aurita* in the brackish water Lagos lagoon have also been studied by Ajao and Fagade (1990). A major deficiency in the research attention given to the species and the information available on the culture potentials of *P. aurita* is on its food. In this study, the fecal matter of *P. aurita* was microscopically examined to identify benthic microalgal species which may constitute important food items for the species.

MATERIALS AND METHODS

Collection of specimens

Specimens of *P. aurita* used for this investigation were collected using a van Veen grab from the Lagos lagoon, south-west Nigeria. Several hauls were emptied into a wide open plastic bowl after retrieval from the water and specimens of *P. aurita* stored in plastic containers with water from the habitat and taken to the laboratory.

Laboratory study

In the laboratory, 240 specimens comprising 120 adults and juveniles respectively were selected on the basis of good health. Out of these selected specimens 120 made up of 60 adults and juveniles respectively, were placed in separate Petri dishes containing water from the habitat. The remaining 120 specimens made up of 60 specimens of adult and juveniles respectively were placed in a holding tank (no sediment) with water from the habitat for 72 hours. This was to enable the specimens discharge all faeces produced prior to the experiment. These specimens were transferred to another holding tank (with sediment from the habitat) for 72 hours to enable them feed, after which they were then placed in separate Petri dishes containing water from the habitat for 72 hours.

The faeces released into the Petri dishes by the individual specimen were collected into different plastic bottles and fixed with 10% formalin solution. Microscopic examination of the fecal matter of the individual specimens was carried out and the microphyto benthic organisms identified to the lowest possible taxonomic level using suitable identification guides such as John *et al*. (2002) and Prescott (1964). The microphyto benthic composition of the fecal matter of *P. aurita* was analyzed using the frequency of occurrence and numerical

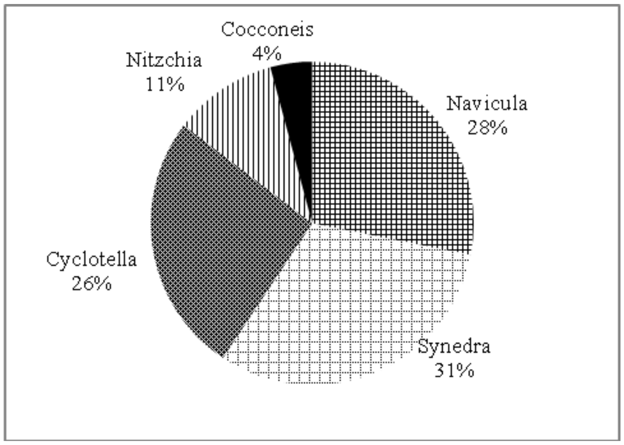

Figure 1. Overall percentage composition of microphyto benthic taxa in specimens of *P. aurita* direct from the wild.

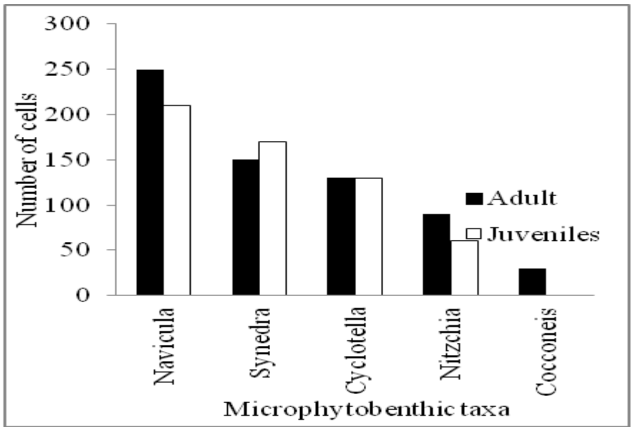

Figure 2. Overall percentage composition of microphyto benthic taxa in specimens of *P. aurita* exposed to sediment in the laboratory

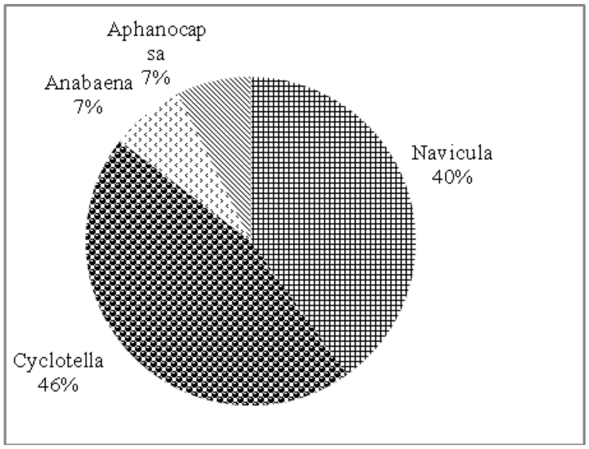

Figure 3. Abundance of microphyto benthos in the fecal matter of specimens of *P. aurita* direct from the wild.

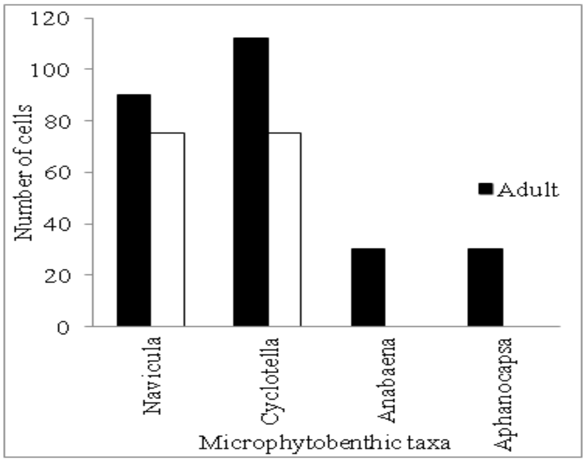

Figure 4. Abundance of microphyto benthos in the fecal matter of specimens of P. aurita expose to sediment in the laboratory.

abundance methods (Thomas et al., 1985; Ugwumba, 1990; Ugwumba and Adebisi, 1992).

RESULTS

Taxa composition and Abundance

The microphyto benthic composition of the fecal matter of *P. aurita* comprised two major groups; Cyanobacteria and Diatoms. The composition of microphyto benthic taxa in specimens of *P. aurita* direct from the wild and those exposed to sediment in the laboratory are depicted in Figures 1 and 2 respectively.

In the fecal matter of *P. aurita* specimens collected directly from the wild only Diatoms (*Navicula*, *Synedra, Cyclotella, Cocconeis, Niztchia*) were represented. A total of 1220 cells were observed, with *Navicula* contributing the highest number (460) of cells, while *Synedra* which contributed 320 cells ranked second in the number of cells recorded. *Cyclotella* was another important contributor (260 cells) to the microphyto benthic algae in the fecal matter of *P. aurita*. *Nitzchia* and *Cocconeis* were represented with 150 and 30 cells respectively. Analysis of the composition of faeces in adults and juveniles revealed that 650 cells were recorded in the adults while 570 cells occurred in the juveniles. Numbers of cells recorded by microphyto benthic taxa in adult fecal matter were *Navicula* 250, *Synedra* 150, *Cyclotella* 130, *Niztchia* 90 and *Cocconeis* 30. In the juveniles, the number of cells observed for the different taxa were *Navicula* 210, *Synedra* 170, *Cyclotella* 130 and *Nitchia*60. *Cocconeis* was not represented in the juveniles (Figure 3).

The microphyto benthic composition observed in the faeces of specimens of *P. aurita* exposed to sediment in the laboratory were slightly different from those recorded in the faeces of specimens direct from the field. Two major microphyto benthic groups (Diatom and Cyanobacteria) comprising four taxa (*Navicula, Cyclotella,*

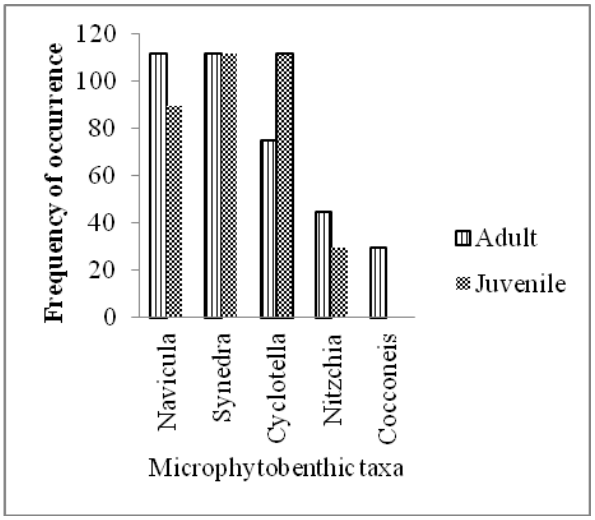

Figure 5. Frequency of occurrence of microphytobentos in the fecal matter of specimens of *P.aurita* direct from the wild.

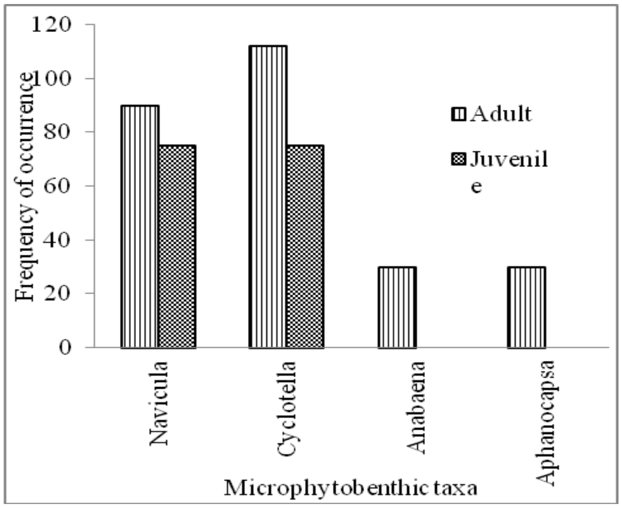

Figure 6. Frequency of occurrence of microphytobentos in the fecal matter of specimens of P.aurita exposed to sediment in the laboratory.

Anabaena and *Aphanocapsa*) were represented. A total 412 cells were recorded with the diatoms contributing higher number of cells. *Cyclotella* contributed 187 cells (112 cells in adult specimens, 75 cells in juveniles) while *Navicula* recorded 165 cells (90 cells in adult specimens, 75 cells in juveniles) as totals for both adult and juveniles. Cyanobacteria (*Anabaena* and *Aphanocapsa*) contributed relatively lower number of cells; each recorded 30 cells in the adult with no representation in the fecal matter of the juveniles (Figure 4).

Occurrence of microphyto benthos

Figures 5 and 6 show the occurrence of microphyto benthos in fecal matter of specimens of *P. aurita* collected from the wild and those exposed to sediment in the laboratory respectively. Four taxa (*Navicula*, *Synedra, Cyclotella, Cocconeis, Niztchia*) belonging to one microphyto benthic group were recorded in the fecal matter of specimens direct from the wild. *Cocconeis* occurred in the fecal matter of adults only. *Navicula* and *Synedra* occurred in 56 (93.3%) specimens of adults, while *Cyclotella*, *Niztchia* and *Cocconeis* were recorded in 34 (56.7% of adults), 23 (38.3% of adults) and 15 (25% of adults) specimens respectively. *Synedra* and *Cyclotella* recorded the highest frequency in the juveniles, both occurring in 56 (93.3% of juveniles) specimens, while *Navicula* and *Niztchia* occurred in 45 (75%) and 15 (25%) specimens of juveniles respectively.

Examining the fecal matter of specimens of *P. aurita* exposed to sediment in the laboratory, two major microphyto benthic groups (Diatoms and Cyanobacteria) were observed. The diatoms *Navicula* and *Cyclotella* occurred in both adults and juveniles, while the Cyanobacteria *Anabaena* and *Aphanocapsa* were only recorded in the adults. *Cyclotella* occurred in 56 (93.3%) adult specimens while *Navicula* was represented in 45 (75%) specimens. The two Cyanobacteria occurred in 15 (25%) specimens. In the juveniles, the two diatoms occurred in 38 (63.3%) specimens.

DISCUSSION

Generally, information on the microphyto benthic community of Nigerian aquatic systems and most likely ingestible microalgal species by zoo benthos are limited. This work therefore is among the first major report on the microphyto benthic community of aquatic systems in Nigeria. The present study provides supporting evidence that microalgae constitute important food resource for benthic fauna. Deposit feeders utilize food sources derived exclusively from benthic microalgae, whereas suspension feeders use a mixture of benthic microalgae and phytoplankton.

Analysis of the fecal content of *P. aurita* shows that the animal consumes miroalgae. The array of species observed is similar to those recorded as stomach contents of some aquatic gastropods (Cummins and Klug, 1979; Thomas et al., 1985; Akintunde, 1988; Ugwumba, 1990; Egonmwan, 1991). The result of this study also corroborates the report of Nwankwo and Akinsoji (1989), which demonstrated the dominance and widespread distribution of diatoms notably *Navicula* and *Nitzichia* in their study area (which is in close proximity to the site where specimens of *P. aurita* used for this study were collected). Benthic microalgae are embedded in a complex sediment structure, so grazers move through the interstitial system or upon the surface and capture mobile flagellates and diatoms, or browse the epigrowth on sand grains (Dillon, 2000; Mitbavkar and Anil, 2002).

The occurrence of diatoms and cyanobacteria as the only microalgae encountered in this study may be linked to their preponderance in aquatic sediment (Nwankwo and Akinsoji, 1989). Several studies (Colijn and Dijkema, 1981; Colijn and De Jonge, 1984) have shown that on sandy and muddy substrate, edaphic microalgae living on a variety of benthic surfaces are often dominated by diatoms whereas coccal and filamentous green algae and Cyanobacteria are usually known to occur at some seasonal stages (Hillebrand et al., 1999).

The overwhelming preponderance of diatoms in the fecal matter of *P. aurita* may be connected to the nutritive value of diatom species. According to Tamtin et al., (2004) and Pratoomyot et al., (2005), although, most microalgal species are similar in nutrient composition, they differ in amount of fatty acids level. The fatty acids content of microalgae differed according to taxonomic group and the growth conditions (Brown, 2002). Diatoms has been reported to contain more fatty acids than other green microalgae and cyanobacteria because diatom cells accumulate lipids while other microalgae and blue green microalgae do not accumulate lipids (Hoek et al., 1995). Since survival rate and growth rate of aquatic animals are related with the fatty acids content of their feeds (Tamtin et al., 2004), most aquatic animals tend to consume food sources rich in fatty acid such as diatoms. It has also been reported that diatoms such as *Nitzchia* spp. are capable of processing of all the three highly unsaturated fatty acids(HUFAs), C20:4n-6, C20:5n-3 and C22:6n-3 (Pratoomyot et al., 2005), which serve as good nutritional sources for aquatic animals and hence used in aquaculture (Brown, 2002). Cyanophyceae are known to be deficient in HUFA, therefore, may be poorly consumed by zoobenthos, this may have accounted for their poor representation in the fecal matter of *P. aurita.*

The relatively poor digestibility of diatoms may also account for their occurrence in large numbers compared to blue green algae in the fecal matter of *P. aurita.* Impregnation of the cell **w**all of diatoms with silica and the overlapping of the two halves of the cell wall (Castro and Huber, 2005) make it difficult for the simple digestive system of the animal to cope with. However, it has been reported that some benthic species of gastropods are able to puncture and suck out the content of diatom cells (Dillon, 2000).

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