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# Seaweed and Associated Invertebrates at Iture Rocky Beach, Cape Coast, Ghana

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## Abstract

In this study, the various floral species of Iture beach were surveyed for seaweed composition, floral zonation and diversity of associated epifauna. No such study has been conducted for specific Ghanaian rocky shores such as Iture beach, although more generalized studies are available concerning the coastal ecology of Ghana as a whole. Iture beach has been the subject of ecological studies, however these have focused primarily on the mollusk and bivalve populations independent of the floral communities. Quadrat sampling was done to determine seaweed composition and distribution within three equally spaced shore zones. Floral zonation was studied to investigate a discernable gradient in ecological health from the upper shore neighboring Iture village to the lower shore bordering the ocean. Twelve distinct species of macro-algae in three phyla were recorded as *Chaetomorpha anteninna*, *Chondria bernardii*, *Cladophora ruhengeri*, *Enteromorpha flexuosa*, *Galaxaura marginata*, *Gelidium arbuscula*, *Hypnea musciformis*, *Jania rubens*, *Padina durvillaei*, *Sargassum vulgare* and *Ulva fasciatta* as well as one unidentified species. Additionally, at least twenty species of invertebrates in four phyla were found to inhabit the various algal species. They are *Alaba culliereti*, *Littorina punctatta*, *Natica marochiensis*, *Nereis sp.*, *Perna perna*, *Petricola pholadiformis*, *Polyapthalmus pictus*, *Semifusis morio*, *Sphaeroma rugirauda*, *Thais haemastoma*, Amphitohoidae (family), Cirratulidae (family), Cumacea (family), Haustoriidae (family), Spionidae (family), Syllidae (family) and Ophiuroidae (Class) as well as juveniles of two unknown species. Zonation was distinct in species of green and red alga types and diversity and richness of algal species was found to decrease with shore height. Species of red alga were found to harbor a relatively more diverse and rich community of invertebrates compared to green and brown types of algae. Diversity and richness of epifauna were found to increase with shore height, a reverse of the trend shown by the algae. Further, a significant number of individuals found within the algal samples were in early stages of development, suggesting the importance of the seaweed of this isolated rocky beach as a nursery environment. These observations provide a basis for future studies in determining conservation strategies for Iture beach, which sits adjacent to a small community and between the two tourists centers of Elmina and Cape Coast.

## Introduction

The general ecology of the West African coast and its various microenvironments have been intensively studied in the past (Lawson 1965; John et al. 2001; Yankson et al. 2001). Those specific to Ghana have received ample amount of attention as well (Lawson 1956; Boughey 1957; Biney 1990). These studies have all equally acknowledged the presence of two main categories of West African marine beaches: those of the overwhelmingly dominant steep sandy beaches and those of the scarce and intermittent interruptions of rocky outcrops. Only one study, to my knowledge, has attempted to assess the ecology of an isolated rocky shore with respect to growing human populations and tourist attractions as well as recent global climate fluctuations, which may be influencing the ecology of the area (Yankson and Akpabey, 2001). That work consisted of a preliminary ecological survey of the macro-invertebrate population immediately visible within the intertidal and supra-tidal zones of Iture rocky beach, complete with species diversity and richness indices to form the basis for comparison with future studies. This study is meant as a corollary to the above work. However, the focus of this survey is on the various floral species of Iture rocky beach and the associated epifauna.

Numerous studies have shown evidence of the mutualistic relationship between seaweed and associated invertebrates (Parker et al. 2001; Stachowicz 2005; Bracken et al. 2007) and the importance of these relationships in maintaining species richness and diversity within a community (Lubchenco 1978; Schreider 2003). Therefore, conservation of the flora and associated epifauna at Iture rocky beach may be essential in maintaining the health of the ecosystem. Hence, the relevance of periodic floral and fauna surveys.

## STUDY AREA

The location of Iture rocky beach as described by Yankson and Akpabey (2001) is about 6 km west of Cape Coast and 3 km East of Elmina ($5^{o}$N, $1^{o}$ 10'W). It is a relatively narrow beach measuring not more than 60 meters from the mean low water mark (MLWM) to the uppermost limit and lies adjacent to an estuary formed by the Kakum-Sweet river confluence. The general slope of the beach is gentle – about $9^{o}$ and the layout is closest to that described by Lawson (1956) as a moderately sheltered rocky shore. This scheme describes a more horizontal, rather than vertical layout of rocks along the shore with those closest to the sea taking most of the wave force and thus sheltering the rocks further in. Although a small isolated section of vertically projecting rock is present at the western edge, the overall layout of Iture rocky beach and the area sampled for this study is horizontal. The intertidal zone, which is subjected to daily submergence and exposure due to the tide was divided into three equal sections of 15 meters each, with the lower shore being 0-15 meters from the MLWM followed by the middle shore at 15-30 meters and the upper shore at 30-45 meters. The remaining 15 meters of beach constitute the supratidal zone, a mix of sand and rock that is scarcely submerged and contains no algae.

## Materials and Methods

Quadrat surveying of the seaweed population and sampling of seaweed specimens for epifauna analysis were done separately. Sampling was done along the whole length of the intertidal zone, from the fringe of the lower shore to that of the upper. Intertidal pools within this area were examined for the presence of various seaweed species. No quantitative measure of sample size was taken. A single hand "scoop" was used as a consistent measure of sample size throughout the study. In most cases, this "scoop" merely represented one individual of the floral species, however, for species such as *Chaetomorpha anteninna* and *Cladophora ruhengeri*, which grow in mats consisting of multiple individuals, a scoop was taken as that amount which could be obtained from a handful. In any case, a relatively equal amount of material was collected for each scoop sample.

Surveying was done with the use of a $0.25m^2$ quadrat. The quadrat was placed randomly in three separate tidal pools within each of the three shore zones. All seaweed within the quadrat were counted. Again, for species such as *Cladophora ruhengeri*, *Chaetomorpha anteninna* and *Jania rubens*, which grow in mats consisting of multiple individuals, one was taken as the amount which could be obtained from a handful.

Because a distinct floral zonation scheme is present along this shore, individuals of most species occur more frequently within the lower shore and in some cases, very scarcely along the upper shore. Alternatively, some species were found to occur only in the upper shore. Therefore, the sampling method used resulted in more samples obtained for some species within one particular shore zone. For these reasons, the results presented are averaged over the number of samples taken for each individual floral species within each shore zone so as to obtain a standard of comparison.

All collected seaweed specimens were stored in 4% formaldehyde preservative to maintain as much natural color and identifiable morphological features as possible. Most were identified using a West African seaweed identification manual (John et al. 2001). Upon examination, the specimens were carefully washed of any invertebrates contained within the seaweed and further inspected for any remaining individuals. These invertebrates were then examined under a microscope and identified to the lowest possible taxonomic level using various reference sources on coastal fauna (Edmunds 1978; Schneider 1990; Yankson et al. 2001). However, within the amphipoidae and polychaete groups, accurate identification was possible only up to the level of order or family.

The Shannon-Weiner and Margalef's indices for species diversity and richness, respectively, were determined. These indices range from zero to four, zero being void of both diversity and richness and four being extremely diverse and rich. The equations for relative abundance (RA), species diversity (H') and species richness (d) indices are shown below.

(Click image for larger version)

Where
$n$ = the number of individuals in a sample from a population,
$n_i$ = the number of individuals in a species i of a population,
s = the number of species in a sample.

Temperature and salinity of all surveyed and sampled tidal pools were recorded using a mercury-in-glass thermometer and a refractometer, respectively.

## Results

The results of this study highlight the distributions of individuals as well as groups of floral and faunal species within shore zones and within other species at Iture beach. Tables 1-3 present the distribution of floral species at Iture rocky beach. Table 1

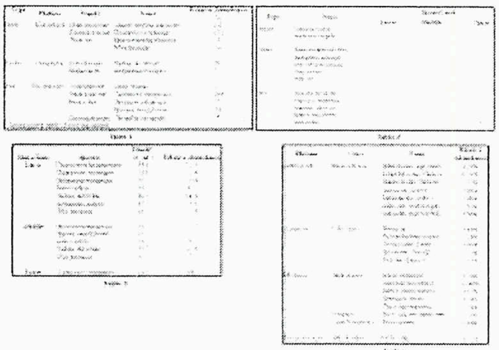


*Table 1. Relative abundance of algae species found at Iture rocky beach.*
*Table 2. Alga species distribution at Iture rocky beach.*
*Table 3. Algal abundance and density with respect to shore height as a result of quadrat sampling.*
*Table 4. Invertebrate relative abundance within all algal samples.*
(Click image for larger version)

shows the relative abundance of each species throughout the whole shore, irrespective of shore height. Table 2 shows where each species can be found, regardless of their presence in the quadrats. Table 3 shows results from quadrat sampling in which the relative abundance of species in each shore zone are shown. Table 4 presents the relative abundance of each species of invertebrate found within all of the seaweed samples collected, irrespective of algal species or shore zone. Figures 1

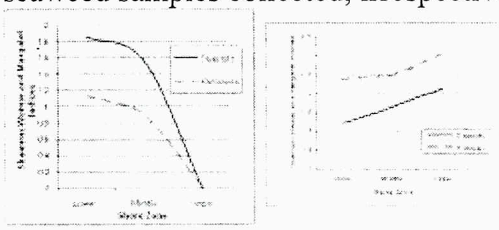
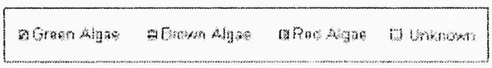


Figure 1 Figure 2

*Figure 1. Seaweed diversity and richness as related to shore height at Iture rocky beach*
*Figure 2. Epifauna diversity and richness as related to shore height at Iture rocky beach* (Click image for larger version)

and 2 present the change in species richness and diversity indices with shore height. Figure 1 shows this change for seaweed while figure 2 shows this for epifauna. Figures 3-10




*Legend for Figures 3-10* (Click image for larger version)

show species richness and diversity index values for the epifaunal communities found within each alga species at each of the three shore zones as well as for the whole shore. Figures 3

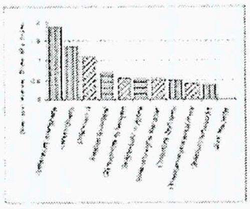


Figure 3

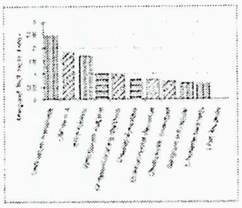



Figure 4

*Figure 3. Lower shore epifaunal diversity of present algal*
*Figure 4. Lower shore epifaunal richness of present algal species* (Click image for larger version)
and 4 present these indices for the lower shore, Figures 5

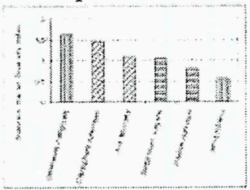


Figure 5

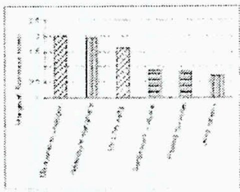



Figure 6

*Figure 5. Middle shore epifaunal diversity of present algal species*
*Figure 6. Middle shore epifaunal richness of present algal species* (Click image for larger version)
and 6 for the middle shore, figures 7

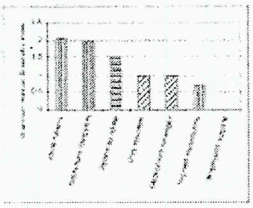


Figure 7

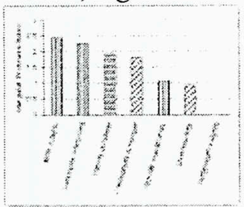



Figure 8

*Figure 7. Upper shore epifaunal diversity of present algal species*
*Figure 8. Upper shore epifaunal richness of present algal species* (Click image for larger version)
and 8 for the upper shore and figures 9

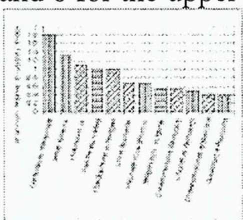


Figure 9

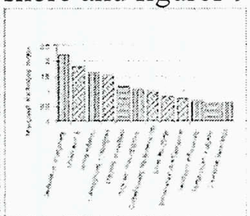



Figure 10

*Figure 9. Whole shore mean epifauna diversity of all algal species*
*Figure 10. Whole shore mean epifauna richness off all algal species* (Click image for larger version)
and 10 as mean values for the whole shore.

## Discussion

### Floral Species Composition and Distribution

It is important to note that the following account on floral observations is meant only as a general guide to the species of Iture rocky beach. An intensive study of the shore's floral distribution was not carried out. Rather, only generalized observations of the most obvious and dominant species in the intertidal rock pools and on the rock surfaces were made. Therefore, species inhabiting specific micro ecological settings like the crevices of rocks were not covered.

*Floral composition*

The floral species encountered represent green, brown and red color types of macro-algae. Three phyla representing seven families were found and twelve species in the same number of genera (Table 1).

Six of the genera found were observed by Lawson (1956) as important ecological organisms on the rocky shores of Ghana. They are *Chaetomorpha, Enteromorpha*, *Hypnea, Padina*, *Sargassum* and *Ulva*. Of these six, *Hypnea musciformis*, *Sargassum vulgare* and *Ulva fasciatta* are also of the same species noted by Lawson. Five of the remaining species: *Cladophora ruhengeri*, *Gelidium arbuscula*, *Jania rubens*, *Galaxaura marginata* and *Chondria bernardii* were noted either by Lawson or by John et al. (2001) to inhabit Ghanaian rocky shores.

*Cladophora ruhengeri* accounts for more than a quarter of the seaweed individuals at Iture beach. This is undoubtedly due to the dominance of this species in the upper portions of the beach, where it is the uniform species in nearly every tidal pool. The high abundance of *Galaxaura marginata* can be explained by the presence of this species on the exposed tops of rocks of the lower shore, where it is able to compete through periods of intense sun and wave forces when others are not. The absence of *Galaxaura marginata* in Lawson's description of ecologically important organisms is peculiar considering its high relative abundance on Iture beach (Table 1) where it was found to harbor a profoundly diverse and rich community of invertebrates as shown in the later sections. Further, *Padina durvillaei*'s relatively high abundance is most likely due to its even distribution throughout the sand bottomed tidal pools of the lower and middle shore, where it is able to anchor itself and is safe from the force of breaking waves.

*Floral Distribution*

The zonation at Iture rocky beach is closest to that described by Lawson (1956) of moderately sheltered rocky shore already mentioned in the "study area" section of this paper. This sheltering scheme allows for a unique distribution of floral species, with more hardy species observed in the lower shore where they can endure the force of breaking waves and reap the benefits of competition. Less durable species can then be found in the upper shore where they are sheltered from the waves, however, these individuals must instead endure periods of high temperatures and salinity levels when the tide recedes and the sun and evaporation take effect. Environmental measurements such as temperature and salinity in those pools of the upper beach were indeed found to be higher (+2oC, +3% NaCl).

Green and red algal types characterize floral zonation at Iture rocky beach. Green algae species *Chaetomorpha anteninna*, *Enteromorpha flexuosa* and unknown were found exclusively in the lower shore, as were red algae *Chondria bernardii* and *Gelidium arbuscula* while *Hypnea musciformis* was found only in the middle and upper shores (Table 2).

Although the top portions of rocks in the lower shore are exposed at low tide, they receive constant spray and washover from the breaking waves. This keeps them amply moist, allowing for the growth of algae where it is otherwise not found. It also keeps them constantly battered by significant wave forces, meaning the species here must be able to obtain strong holds on either rock or sand to keep from washing away. The dominant seaweeds here are *Sargasssum*, *Galaxaura* and *Padina*. The *Sargassum* and *Padina* individuals are found anchored to the sand covered bottoms of tidal pools. *Galaxaura* grows as individual plants anchored to the rocks and can be found to cover significant portions of them. It can also be found in less numbers below the water line in rock pools.

The intertidal pools of the upper shore are almost completely dominated by *Cladophora ruhengeri* and devoid of most other species, however, other individuals can scarcely be found. This exclusivity as well as the limiting of *Chaetomorpha anteninna*, *Chondria bernardii*, *Gelidium arbuscula*, *Enteromorpha flexuosa* and unknown to the lower shore is most likely due to the sensitivity of these organisms to the more extreme environment of the upper shore where temperature and salinity levels were found to be elevated. It may as well be due to the presence of Iture village, which sits directly adjacent to the uppermost rocks and allows for significant human traffic. The effects of shore height and human traffic on macro-algae diversity in tropical rocky shores have in fact been found to be significant (Danwei et al. 2006).

**Epifaunal Species Composition**

A complete breakdown of the algae from each shore zone and the encountered invertebrates within each specimen, complete with density (# / sample) and percent composition of each sample, can be found in the appendix

*Appendix*
(Click image for larger version)
.

Four separate phyla were present containing six classes and at least twenty different species (Table 4). Due to limitations in identification resources, many of the arthropods and annelids were not identified past the order or family of their taxonomic level. Therefore, individuals in all such cases are taken to be of the same species, as seemed to be the case, and so the analysis of species diversity and richness may very well be underestimating the true values as some of these individuals may be of very similar but different species.

**Species Richness and Diversity**
It is apparent that both algae and epifauna diversity and richness vary with shore height (Figures 1 & 2). It is also apparent that epifauna diversity and richness vary within algal species and also within the same algal species of different shore heights (figures 3-10).

*Floral richness and diversity with respect to shore height*
A trend of decreasing richness and diversity of floral species with shore height was initially visually discernable and later quantified from the data (Figure 1). This is consistent with studies of the effects of shore height on floral diversity and richness in tropical rocky shores (Danwei et al. 2006). As discussed earlier, the reasons for this significant decrease is most likely due to the elevated temperature and salinity levels within the rock pools of the upper beach, where the blue-green algae, *Cladophora ruhengeri* is the only species able to thrive. Human traffic from the adjacent Iture village may also be a factor.

*Epifauna richness and diversity with respect to shore height*
A strong positive influence of shore height on epifauna diversity and richness could not be immediately observed but is clearly present from the data (Figure 2). This is surprising, considering the scarcity of highly diverse algal species such as *Galaxaura marginata* and *Jania rubens* and the domination of the relatively non-diverse *Cladophora ruhengeri* in the upper shore. Additionally, experimental studies on the effects of shore height on epifauna diversity and richness in a temperate climate have shown epifauna to favor the lower shore and thus being more abundant there (Schreider et al, 2003). Observations of a similar study on a tropical rocky shore also showed epifauna diversity and richness to decrease with shore height (Danwei et al 2006). Therefore, the relationship at Iture rocky beach is noted as particularly peculiar. Reasons for this deviation from the reported experimental results may be due to the difference in climactic conditions between the temperate, Australian climate of the experiment and the tropical climate of the Ghanaian coast. If so, the aforementioned escalated temperatures recorded in the pools of the upper shore may be forcing invertebrates to seek refuge within the algae, where this was not a factor of the experimental conditions. Comparatively, deviations from the results of observations on the tropical rocky shore may be due to the presence of significantly more human traffic at the present study site. Further, the epifauna recorded in this study are small invertebrate organisms which seem to favor the less turbulent rock pools in the upper intertidal zone.

*Epifauna richness and diversity with respect to algal species*
Figures 3-10 highlight the relationship between algal species and epifauna diversity and richness. It can be seen from the figures that some algal species harbor significantly more diverse and rich communities of epifauna than others. In some cases, this trend is evident in only two of the three shore zones and therefore only suggests the possibility of an important or equally unimportant algae species. Such incomplete trends are seen for species such as *Jania rubens* and *Ulva fasciatta*. *Jania* displays high index values for diversity and richness in both the lower and upper shores but scores lowest in these values for the middle shore. Comparatively, *Ulva fasciatta* displays the lowest values within the lower shore and average values within the middle and upper shores. Such inconsistent patterns are difficult to explain but may suggest irregular variations in the conditions of the rock pools from which the samples were taken. It also calls for the need for more intensive studies of this shore.
For the case of *Galaxaura marginata*, however, a trend of very high diversity and richness values is evident in all three shore zones and may very well be taken as significant evidence of the importance of this species. *Galaxaura marginata* is an alga of regular dichotomous branching, round at the base and flattening out towards the top. Its large amount of surface area could be the reason for its containment of diverse and rich invertebrate communities. However, the surface area of this species relative to the other algae is not known to be much greater and studies have shown epifauna diversity to be more strongly influenced by plant composition rather than surface area (Parker et al. 2001).

**Evidence of Important Nursery Environment**
Many invertebrate individuals were found to be in the early development stages of their respective life cycles. Most notably, all bivalves observed were of juvenile development. In all, forty-four individuals of *Petricola pholadiformis* and seventeen of *Perna perna* were in the juvenile stage, 7.3% and 2.8% of all 601 faunal individuals observed, respectively. Adult individuals of both of these species are absent from this study area. Further, three crab individuals were found to be in the megalop stage and three also in the juvenile stage of development. Again, adult individuals of these organisms were absent from the observed algae. These observations may suggest the importance of the algae at Iture beach in providing essential nursery environments for invertebrate species otherwise not associated with these algae. If so, the importance of Iture rocky beach and its contained seaweed communities, especially in the rock pools, may have implications not only to the immediately surrounding environment but also to the supply of seafood harvested elsewhere.

## Conclusions

The seaweed at Iture rocky beach is distributed in patterns pertaining to species of green and red algae only. Green algae species *Chaetomorpha anteninna*, *Enteromorpha flexuosa* and unknown were found exclusively in the lower shore, as were red algae *Chondria bernardii* and *Gelidium arbuscula* while *Hypnea musciformis* was found only in the middle and upper shores. Both species of brown algae could be found along the whole shore. The blue-green alga *Cladophora ruhengeri* was found to be the almost uniform species of the upper shore.

The epifaunal communities of these seaweeds were found to vary within floral species as well as shore zones. Red algae such as *Galaxaura marginata* and *Jania rubens* seemed to harbor more diverse and rich populations of invertebrates than other algal types. Further, richness and diversity of epifauna in general increased with shore height but the reverse was true for the flora. *Jania rubens* exhibited a sharp fluctuation in epifauna diversity and richness from one shore zone to another. Amphipods overwhelmingly dominated these communities, followed distantly by the gastropod *Littorina punctatta*.

The presence of multiple invertebrate individuals in various young stages of their respective life cycles found within the algal samples, suggests that these algae provide important nursery conditions for otherwise un-associated adult invertebrates. This may mean that the importance of the algal communities of Iture beach may have far reaching implications in terms of the seafood supply harvested elsewhere.

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