Faculty of Resource Science and Technology

Preliminary Study on Seaweed Community from an Intertidal Area of Telok Melano, Sematan Sarawak

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°C	Degree Celsius
%	Percent
km	Kilometre
cm	Centimetre
UV	Ultraviolet
indiv.	Individuals
m^2	Square metre

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ABSTRACT

An assessment of seaweed composition in intertidal zones of Telok Melano was done to obtain more information on seaweeds in this study site. Seaweed plays an important role in providing habitat, maintaining overall biodiversity structure and act as primary producers in marine ecosystem. Seaweed samples were collected in 8 stations along the intertidal zones of the beach. Six genera namely *Enteromorpha, Neomeris, Udotea*, *Laurencia, Gracilaria* and *Padina* were identified based on their morphological characteristics. Based on the total number of the species, the Chlorophyta division has the highest percentage of composition compared to Phaeophyta and Rhodophyta divisions. The density and the frequency of species *Neomeris annulata* is the highest among the other five species with 81.11 indiv./m^2 and 0.4849 respectively. The highest species diversity (H' = 1.7802) was found in station 6 that comprised of rocky shore.

Key words: seaweeds, composition, density, species diversity, intertidal zone

ABSTRAK

Satu penilaian komposisi rumpai laut dalam zon pasang surut Telok Melano telah dilaksanakan untuk memperoleh lebih maklumat mengenai rumpai laut di tapak kajian ini. Rumpai laut memainkan peranan penting dalam menyediakan habitat, mengekalkan keseluruhan struktur biodiversiti dan menjadi pengeluar utama dalam ekosistem marin. Sampel rumai laut telah dikumpulkan dari 8 stesen sepanjang zon pasang surut pantai. 6 genera iaitu Enteromorpha, Neomeris, Udotea, Laurencia, Gracilaria dan Padina telah dikenal pasti berdasarkan dasar ciri-ciri morfologi. Berdasarkan jumlah spesies, bahagian Chlorophyta mempunyai peratusan komposisi yang tertinggi berbanding bahagian Phaeophyta dan Rhodophyta. Ketumpatan dan kekerapan spesies Neomeris annulata adalah yang paling tinggi berbanding lima species yang lain dengan nilai ketumpatan iaitu 81.11 indiv./m^2 dan nilai kekerapan iaitu 0.4849. Nilai kepelbagaian spesies tertinggi (H = 1.7802) didapati di stesen 6 yang terdiri daripada pantai berbatu. Perbezaan dalam jumlah bilangan spesies dari semua stesen menunjukkan bahawa perbezaan lokasi dan jenis substrata boleh membawa kepada kepelbagaian dalam komposisi dan kepelbagaian spesies rumpai laut.

Kata kunci: *rumpai laut, komposisi, ketumpatan, kepelbagain spesies, zon pasang surut*

1.0 Introduction

Seaweeds supply energy to aid the diverse marine life and provide habitat for the invertebrates and fish. Although seaweeds are traditionally only referred to as macroscopic, multicellular green, red, and brown algae however each of the groups has representatives with microscopic or unicellular characteristics. The life cycle of seaweeds has a unicellular state either as spores or gametes and zygotes, and they could be in the planktonic stage temporarily (Maximova and Sazhin, 2010). Seaweeds usually inhabit water bodies, but they also can be found in terrestrial environments, snow, and ice.

The intertidal zone or littoral zone is referred to as a seashore that is covered during high tide and exposed during the low tide which can be a rocky shore, sandy beach, or mudflat (Mohan and Swathi, 2020). The intertidal zone is an extreme ecosystem due to the drastic changes that happened in the area. The organisms that inhabit the intertidal zone must be able to survive the constant change in the salinity, temperature, moisture, UV radiation and withstand strong waves (Rawlings, 1999). The extreme condition of the intertidal zone made the organisms inhabit there has suitable and diverse adaptation to ensure their survivability.

The main division of seaweeds are Chlorophyta, Phaeophyta and Rhodophyta. Chlorophyta are mostly found in the upper intertidal zone to subtidal zone, while Phaeophyta are mostly in the mid-tidal areas and Rhodophyta are usually distributed in subtidal zone with low light intensity.

Sarawak has the lowest distribution of seaweed (Lian *et al.*, 2008) based on the spatial patterns of seaweed distribution research in Malaysia by using Geographic Information Studies. There is a lack of research studies on the seaweed community in Telok Melano. The latest study of seaweeds in Telok Melano which focused on the seaweed composition was carried out by Nurridan (2007). The study was focusing on the seaweed composition and identification of seaweed samples.

Telok Melano is located in the southwest of Borneo, Sematan, Sarawak, and intersected with the border of Indonesian Kalimantan Barat. On 26 January 2020, Pan Borneo Highway Kilometre Zero was ready to use for the convenience of Telok Melano residents mainly to facilitate the residents to travel to Sematan to obtain other facilities and open the access for visitors or tourists to visit Telok Melano. Telok Melano is located in the coastal water areas which hold up diverse flora and fauna including seaweeds.

The quantitative assessment of abundance was assess to obtain a realistic picture of the diversity and structure of seaweeds in the desired study sites (Dhalgalkar and Kavlekar, 2004). The statistical analysis includes the calculation of density, frequency and species diversity.

This study was conducted to determine the composition and species diversity of seaweeds at the intertidal zone of Telok Melano.

2.0 Literature Review

2.1 Structure of Seaweed

Seaweed's whole body structure is called a thallus. Thallus of the seaweed consists of holdfast, stipe, and blade. In comparison to terrestrial plants, seaweed does not have true roots, stems, or leaves. Holdfast which is similar to root is functioning in attaching to the substrate, unlike root that is for absorbing nutrients. The formation of holdfast such as discoidal, rhizoidal, bulbous, and branched is depending on the substrate it attaches on. The stem-like part on the thallus is known as the stipe. It gives structural support to the blade and overall thallus. Blade resembles leaves of the terrestrial plants which are responsible for photosynthesis and absorption of nutrients (Dhargalkar and Kavlekar, 2004). The blade may have various forms such as smooth, segmented, perforated, and dented. Figure 1 shows the structure of the seaweed.

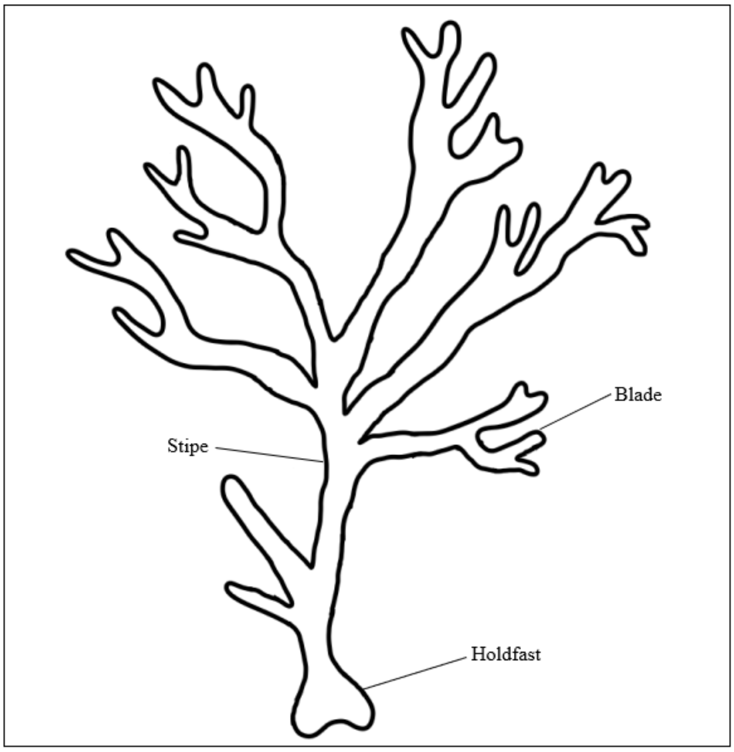

Figure 1: Structure of thallus.

2.2 Division of Seaweed

Seaweed has three main divisions: Rhodophyta, Chlorophyta, and Phaeophyta. Gracilariaceae under Rhodophyta division, Caulerpaceae under Chlorophyta division, and Sargassaceae under Phaeophyta division are the most dominant family of seaweeds in Sarawak (Nurridan, 2007). Telok Melano has recorded a few species of seaweed includes *Acetabularia sp., Avrainvillea erecta, Hypnea spinella,* and *Halimeda macroloba* (Nurridan, 2007).

2.2.1 Chlorophyta

Chlorophyta is also known as green algae possessed pigments which are mainly chlorophyll a and b including some accessory pigments such as carotenes and xanthophylls with starch as the major food storage similar to terrestrial plants (Bold and Wynne, 1985). Chlorophyta can be distinguished from other eukaryotic algae by having two membranes of chloroplast a stellate structure of flagellated transition region (Hoek *et al.,* 1995). They are mainly abundant in freshwater environments including ponds, lakes, wetlands, and streams (John *et al.,* 2002; Wehr and Sheath, 2003). Under division Chlorophyta, the classes include Prasinophyceae, Trebouxiophyceae, Charophyceae, and Chlorophyceae.

Chlorophyta is one of the most diverse eukaryotes by showing different forms of morphology from flagellated unicells, coccoids, filamentous branched or unbranched form to multinucleated macrophytes with parenchymatic tissues (Proschold and Leliaert, 2007) (Figure 1).

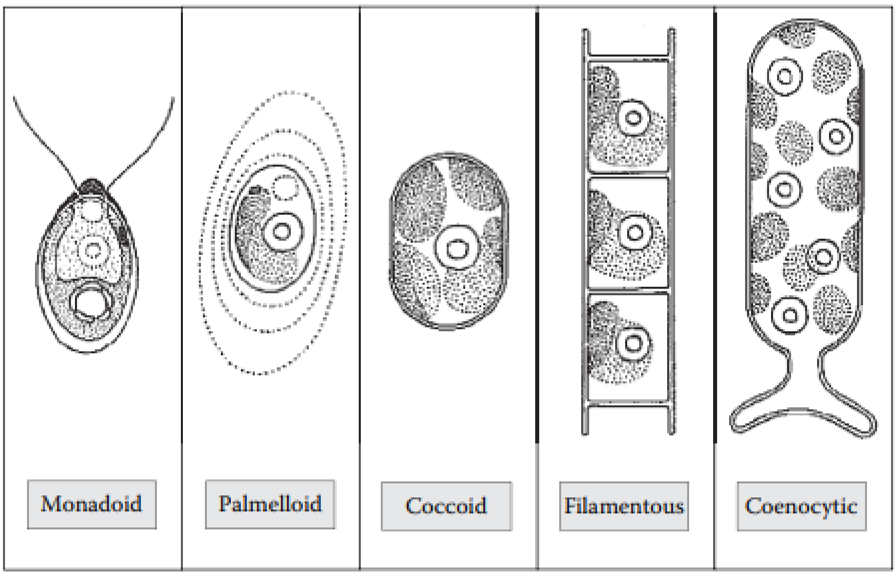

Figure 2: Morphological organization in green algae, parenchymatous and siphonocladous organization are not illustrated (Proschold and Leliaert, 2007).

Neomeris annulata is one of the species under the Chlorophyta division. This species is small with 1 to 3 cm high and has white colour on the lower part and green colour on the upper part of the thallus due to the calcification of the plant. It is widely distributed from the intertidal zone to a depth of 30 m and usually grows in solitary and does not form any colonies and associations. (Ohba *et al.*, 2017).

2.2.2 Rhodophyta

Rhodophyta or red algae possessed chlorophyll a, and phycobiliprotein pigments (red and blue) including phycoerythrin, phycocyanin, and allophycocyanin as the accessory pigments with floridean starch as the storage product. Rhodophyta can be distinguished from other eukaryotic algae by having unstacked thylakoids in plastids, the chloroplasts are lacking external endoplasmic reticulum and absence of eukaryotic flagella as well as the presence of cellulosic cell wall and mucopolysaccharides agar and carrageenan (Woelkerling, 1990). Most

Rhodophyta is distributed in the marine environment, with only approximately 3% of the more than 5000 species occurring in freshwater habitats (Sheath, 1984).

Rhodophyta morphology range from unicellular forms to more complex parenchymatous and non-parenchymatous thallus (Goff and Coleman, 1986). The morphological structures include filamentous, branched, feathered, and sheetlike thalli.

Genus *Gracilaria* is one of the genera in the Rhodophyta division. *Gracilaria arcuata* has a reddish-brown colour with a discoid holdfast. The branches of this species are cylindrical, irregular, and arcuate and could grow up to 120 mm tall. Every branching of this species is constricted, and the terminal branch gives rise to two or three short stubby spinose branchlets at their distal parts. (Ruhana *et al.,* 2019).

Laurencia is a genus of red algae in the order of Ceramiales and the family Rhodomelaceae which grows in a variety of habitats including intertidal and subtidal zones, tidepools, reef flats and rocky substrates. Laurencia species mainly can be found in warm water and distributed at the tropical and subtropical areas. (McDermid, 1988).

2.2.3 Phaeophyta

Phaeophyta or brown algae possessed chlorophyll a, and β-carotene including fucoxanthin of the carotenoid pigment as the main accessory pigment which provides brown colour characteristics to Phaeophyta (Graham *et al.,* 2009) with laminarin and mannitol as the main storage (Wehr, 2015). Fewer than 1 % of the brown algae with 1836 species with 285 genera (Reviers *et al.,* 2007; Guiry and Guiry, 2021), inhabit freshwater environments, while some of the marine species colonized brackish waters (West and Kraft, 1996).

Phaeophyta does not have unicellular or colonial in their vegetative stage and their cell walls are composed of cellulose which is often supplemented with alginic acid (Wehr, 2015).

The simplest morphology in Phaeophyta division is a branched filament that can be found in the lower orders such as Ectocarpales.

Padina is one of the genera in Phaeophyta that mainly grows on the flat or shallow inclined surfaces or attached directly the rock (Price *et al.*, 1979). Based on Phang (2006), *Padina* are the most frequently found species in Malaysia which mainly inhabits different types of substratum including sandy areas, mudflats, rocky shores, coral reefs and mangroves.

2.3 Distribution of Seaweeds in Sarawak

Seaweeds are restricted in their division at the intertidal to the shallow subtidal zone in the marine environments, but a few species of seaweeds may be found in the supratidal zone or spray zone. The difference in the distribution pattern is due to their capabilities in adapting to the different ecological situations in their habitat surroundings. Some species of the seaweeds may only be found in the protected bays and covers the reef flat while some species may only distribute in the rocky wave-exposed areas along the shores or near the reef side (Nurridan, 2007). The species that inhabit different habitats depending on their capability to adapt to the different environmental factors in the surroundings.

The vegetation in the ocean is dominated by algae. There are no mosses, ferns, or gymnosperms that are found in the oceans, and only a few angiosperms such as seagrasses inhabit the marine environment. The few populations of angiosperms may be due to the difficulty in adapting in the marine environments including ion regulation and pollination (Ackerman, 1998). Seaweed micro stages may grow on and within larger seaweeds due to ecological relationships where the seaweed surfaces themselves and are colonized by the benthic microalgae and bacteria (*Hurd et al.*, 2014). In muddy and sandy areas, seaweeds are fewer as the environments make most of the species unable to anchor in the areas, though some siphonous green algae such as *Caulerpa* and *Udotea* produce penetrating, root-like holdfast which also serves in the uptake of nutrients (Littler *et al.*, 1988). Multicellular algae often grow away from substrate vertically which allows them to go closer to the light, grow larger without facing competition for spaces, and enable them to gain nutrients in a large volume of water (Hurd *et al.*, 2014).

2.4 Environmental Factors Interactions

Seaweed and marine creatures may associate with each other and their physicochemical environment if the algae live attached to the substrate located between the top of the intertidal zone and the maximum depth that the light is able to penetrate. The major environmental or abiotic factors affecting the algae are light, temperature, availability of nutrients, salinity, and the motion of the water. Biological interactions of biotic factors include the interaction between the seaweed and epiphytic bacteria, algae, fungi, and sessile animals; interaction between seaweeds and herbivores including both macroalgae and epiphyte; and the predators' impact including human to the seaweed (Hurd *et al.*, 2014).

Each propagule contains the genetic information that will enable the maturing seaweed to form a phenotype that is well suited to the surroundings of the environment. A high degree of phenotypic plasticity can even occur in the genetically identical population in the same condition of the environment (Hurd *et al.*, 2014). For example, the variation of the cap morphologies of *Acetabularia acetabulum* grew in the same experimental conditions (Figure 2).

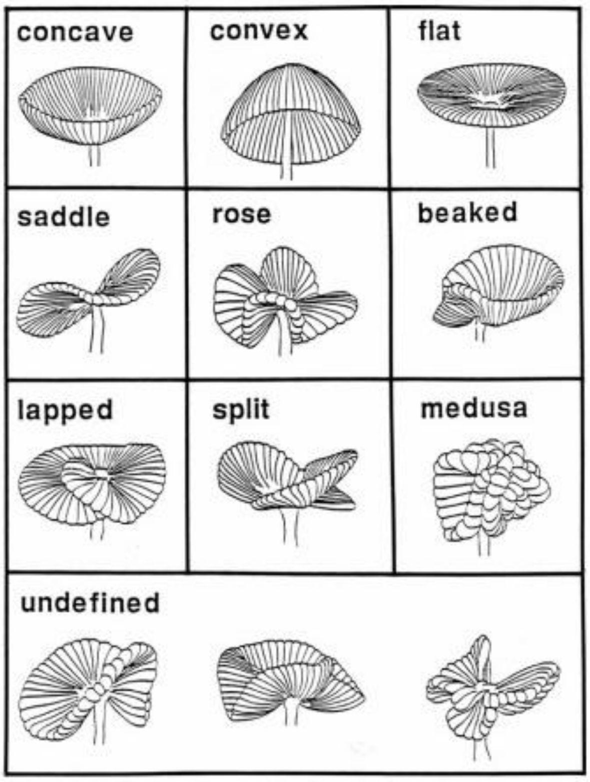

Figure 3: Variation in cap morphologies of *Acetabularia acetabulum* (Nishimura and Mandoli, 1992).

The climate of the Sarawak coastal area is tropical monsoon with a high temperature, high humidity, and heavy seasonal rainfall. The average daily temperature of the coastal ranges from 22 °C to 31 °C with very little seasonal dissimilarity (Nurridan, 2007). Along the Sarawak coast, the tidal range is usually large which can arise to 6 metres. Coastal areas of Sarawak are bound with warm waters and the sun shines all year round allow the nurturing of seaweeds in the water bodies.

2.5 Uses of Seaweed

Seaweeds are rich in minerals, vitamins, polyunsaturated fatty acids, have a low lipids content and a high content of bioactive molecules. Seaweeds have been applied in different fields including food, industrial use, medicine, and agriculture.

Seaweed has been used in agriculture for the farm animals as complimentary food to the farm animals. Seaweed is a good choice for complimentary food for the animals as seaweed build disease resistance by ensuring a complete balance of micronutrients. The fat level and iodine content in milk and the yield of milk products also will be improved from the consumption of seaweed. Seaweed enhances the fertility and birth rate of the farm animals and the yolk colour of the eggs can be improved (Chapman and Chapman, 1980). The fish and prawn culture feed from the species *Gracilaria, Gelidiella, Hypnea,* and *Sargassum* provides enrichment of minerals, amino acids, and carbohydrates that help in maintaining the water quality of the aquaculture (Kaladharan *et al.,* 1998). Seaweed may also assist in disinfecting water in aquaculture as it recycles the fish waste that polluted the water environment (Dhargalkar and Neelam, 2005).

Agar is being applied as the solid substrate to grow bacteria and fungi. The production of agar involved different genera of seaweeds including *Gelidium, Gelidiella, Gracilaria,* and *Pterocladia*. The usage of agar in the modern microbiological laboratory is very important to assist in the laboratory works as other alternatives to replace the agar have not yet been found. Agarose which is under red algae in the family Gelidiaceae is the highest quality of agar. Seaweed hydrocolloids that are used as gelation and thickening agents in different food, pharmaceutical, and application in biotechnology can be extracted from seaweeds from the categories of alginates, agars, and carrageenans. Alginates can only be extracted from the brown seaweeds and agars and carrageenans can be extracted from red seaweed.

According to Alwarsamy and Ravichandran (2014), Kappa carrageenan from *Kappaphycus alvarezii* under the class Rhodophyceae is cultivated and commercially essential as phycocolloid. Phycocolloid is beneficial for its polysaccharide cell wall as a thickening and stabilizing agent that is widely used for food, pharmaceutical, and cosmetic industries. In addition, *Kappaphycus alverezii* has been used for producing healthy beverages and anticancer nutraceuticals as it contained antioxidant and other nutritive compounds (Phang *et al.,* 2010; Cornish and Garbary, 2010). In Malaysia, *Kappaphycus alverezii* is the main seaweed species and is largely cultivated in the coastal areas of Sabah and commercialized in local markets (Ahemad *et al.,* 2006). Different products have been produced from this species including healthy, drinks, cordials, and chili sauce.

3.0 Materials and Methods

3.1 Study area

The study was conducted in Telok Melano (Figure 4) located in Sematan, Sarawak. It is one of the tourist attractions in Sematan. The study was conducted on 18, 30 and 31 March 2022.

Figure 4: Eight stations are shown in blue marks on the Telok Melano map (Google Earth, 2022).

Table 1: Global Positioning System (GPS) coordinates of sampling stations

Stations	GPS coordinate	Location description
1	N02º00’30.2” E109º38’37.5”	Sandy beach and rocky shore
2	N02º00’28.2” E109º38’49”	Sandy beach
3	N02º00’25.6” E109º38’38.5”	Sandy beach
4	N02º00’22.2” E109º38’51.2”	Sandy beach
5	N02º00’19.5” E109º38’42.4”	Sandy beach and rocky shore
6	N02º00’17.9” E109º38’42.8”	Sandy beach and rocky shore
7	N02º00’15.6” E109º38’43.9”	Sandy beach and rocky shore
8	N02º00’14.5” E109º38’44.5”	Sandy beach and rocky shore

3.2 Transect Quadrat Method

Eight sampling stations were chosen randomly along approximately 1 km of the intertidal area of Telok Melano with a distance of 0.1 km between each sampling station. The coordinates of each sampling station were measured using Global Positioning System (GPS) (Model 62s, GARMIN, USA). Each sampling site were labeled with Station 1, 2, 3, 4, 5, 6, 7 and 8. Three transect was laid perpendicular to the shore at every site. At every 5 m of the transect line, 50cm × 50cm quadrat were placed randomly. The quadrats were subdivided into 25 small quadrats of 10cm × 10cm (Uddin *et al.,* 2007).

3.3 Seaweed Sampling

The data collections of seaweeds were carried out along the intertidal zone during low tide. The representative of seaweed species was collected by using a knife or scalpel. The identification of seaweeds was based on the whole thallus that was taken out from the substrate. Seaweeds were identified and counted. Other relevant information on the samples including nature of the habitat, size, and aspect of the seaweed species, major association, and type of substrate were recorded (Abbott and Dawson, 1978).

3.4 Preservation

Seaweed specimens were washed and cleaned to remove any foreign material including epiphytes, sand, and soil. The specimens were sorted based on their species and kept in polyethylene bags containing seawater to maintain their freshness. Representatives of each species were taken back for further identification. The specimens then were preserved as herbarium (Nurrida, 2007).

3.5 Identification and Documentation

Each species was photographed for the record. Samples were identified following Teo and Wee (1983), Littler *et al.* (1989), Ahmad (1995), Dhargalkar and Kavlekar (2004), Nurridan (2007), and Wells (2010). The important characteristics for thallus identification are based on the morphology of size, form, branch, and type of holdfast (Uddin *et al.*, 2007).

3.6 Quantitative Assessment of abundance

Based on Dhargalkar and Kavlekar (2004), quantitative assessment of the abundance is a statistical consideration that includes the density, frequency, and species diversity. Statistical considerations were used to provide a more realistic idea of seaweeds in Telok Melano.

Density is the measure of the total number of individual species and the total area sampled. The calculations were based on the formula suggested by Dhargalkar and Kavlekar (2004):

$$D = n/A$$

where

D = density,

n = total number of individuals of the species

A = total area sampled

Frequency is the number of samples in which species occur and the total number of samples taken (Dhargalkar and Kavlekar, 2004):

$$F = j/k$$

where

F = frequency

j = number of samples in which species occur

k = total number of samples

Species diversity is a measure of the number of species and the relative abundance of the individual of each species. The formula used for this was Shannon – Weiner Index (Dhargalkar and Kavlekar, 2004):

$$H = - \Sigma (Pi) (\log_2 Pi)$$

where

H = Shannon - Weiner Index of species Diversity

I = ith species

Pi = proportion of ith species calculated as total no. of individuals of species ‘i’/ total no. individuals of all the species.