Chapter-VI

Quantitative Studies of Mangroves
QUANTITATIVE STUDIES OF MANGROVES

Introduction:

Mangrove of India has been studied earlier for various aspects (Chapman 1976; Macnae, 1968). Earlier several attempts were made to survey the mangroves areas and the distribution of species along the Indian coast (Methuda, 1975; Quereshi, 1975). The remote sensing techniques such as aerial photographs and satellite imageries have been found to be effective in the study of various fields (Chaudhry, 1973; Iyer, 1974). However, the FSI report of 1999 using remote sensing technology has put the mangrove area of Goa as 5 sq km but fact is that mangrove area is more as satellite imageries cannot take into account very small areas, which are in form of narrow strips along the river banks and khazan fields in Goa. The total area covered by mangrove forests in Goa has been estimated to be 2000 ha (Jagtap, 1985). However department of forest Goa Government has estimated the total mangrove cover in Goa to be total 5000 ha which does not include areas like saleri, pallolem along the coast of Goa.

Also composition and structure of the mangrove forest along 10 estuaries and a canal of Goa was studied.

Methods:

The mangrove swamp area was studied by using Quadrate method, Total 18 quadrates were studied from each station, out of which 6 quadrates were studied at each sub-station, proportionally on the map and identified in the field. Each quadrate size of 20x20 mt was marked with help of peg, to which rope is tied to differentiate area. Quadrates were taken in such a way that position of each quadrate is independent of the other Quadrate. All the mangrove species and individuals of mangrove in the Quadrate were counted.

Number of Taxas: This is considered as one for each species irrespective of their numerical strength in one sampled plot.
Total number of individuals: This is considered as one for each tree, which when added together from total strength in our sampled plot.

Dominance: Ranges from 0 (all taxa are equally present) to 1 (one taxon dominates the community completely).

\[ D = \sum \left( \frac{n_i}{n} \right)^2 \]

Where \( n_i \) is number of individuals of taxa.

Shannon Weiner's index of diversity \( H' \): Diversity indexes, taking into account the number of individuals as well as number of taxa. Varies from 0 for communities with only single taxon to high values (up to about 5.0) for communities with many taxa, each with few individuals.

Shannon Weiner's index of diversity \( H' = -\sum (ni/N + \log ni/N) \)

Where \( ni \) is the total number of individuals of species “a”

\( N \) is the total number of all the species.

Frequency: The frequency of species is the measure chance of finding at with any throw of the quadrat given area. Frequency refers to the degree of dispersion in terms of percentage accordance.

Frequency: \[ \text{Total No of Quadrats in which the species occur} \times 100 \]

Total number of quadrat

(Shukla and Chandel 1972)

Density: Density is the count of number of individuals within an area. It is usual to count the number of individuals within a series of randomly distributed quadrats by the calculating the average number of individual relative to the size of the area under study & number of quadrats.

Density = \[ \frac{\text{Total no of individuals of species}}{\text{Total no of quadrats}} \]

(Shukla & Chandel 1972)
Abundance: The estimate of the number of individual of a species per unit area is referred to as Abundance.

\[
\text{Abundance} = \frac{\text{Total No of individual of species in all quadrates}}{\text{Total number of quadrats in which the species occured}}
\]

(Shukla & Chandel, 1972)

Index of similarity: To discuss the compositional similarity between the habitats (Johnson and brinkhurst, 1971) Index of similarity (j) was applied. The similarity index refers to the ratio of number of species shared to the total species number among the various entities compared.

\[
\text{Index of similarity} = \frac{C \times 100}{A + B - C}
\]

Where 'A' and 'B' are the number of taxa in two stations being compared and 'C' equal number of taxa held in common by both the stations. The value indicate simple percentage

Brilliouin (HB): Sample randomness could not be guaranteed and because of this reason the total number of individuals in a sample as well as the number of individuals per species is used here. Brilliouin diversity statistic was used to compare change in diversity for the whole study area with the mean diversity of individual site in succession data series analyses.

\[
\text{HB} = \ln(N!) - \sum \ln(n_i)
\]

\[
N
\]

Where HB is the Brilliouin index, N is the total number of individuals in the sample, ni is the number of individual of species and N! Means the factorial of N=1*2*3*4*....*N, ln(x) =natural logarithm of x(or logarithm base)
is the natural logarithm of $x$ (or logarithm base $e$)

**Margalef's species richness index:** It is a measure of species present, representing with numerical estimation of species richness. But completely ignores the composition along with the information of common and rareness of species (Margalef, 1958)

Species richness index (Margalef's) $d = S-1/ (\log N)$

Where $S$ is the total number of taxa in a station

$N$ is the number of Individuals of all the species of the station.

**Equitability:** Shannon diversity is divided by the logarithm of number of taxa. This measures the evenness with which individuals are divided among the taxa present.

**Fisher's alpha:** A diversity index, defined implicitly by the formula $S = a \ln(1 + n/ a)$, where $S$ is number of taxa, $n$ is number of individuals and $a$ is the Fisher's alpha. This index refers to a parameter in a logarithmic abundance model.

**Relative Mangrove Diversity (RMD)** of each study station was calculated as

$$RMD = 100 \frac{X \cdot (F_n + G_n + S_n)}{N}.$$  

Where, $F_n$, $G_n$, and $S_n$ are Number of Families, Number of genera, Number of species of a habitat respectively.

$N$ = Sum of reported number of Families, Generas, Species of the habitats.
RESULTS

The diversity indexes of 15 species belonging to 10 genera under 8 families reported from different study stations were estimated and the result is as follow.

Diversity measures

A total of 23,065 individual were counted belonging to 15 species, 10 genera, 7 families from 10 estuaries and one canal of Goa region. Highest individual were reported from Galgibaga estuary (Fig 14). The maximum numbers of taxa were reported from Cumbarjua canal, Mandovi and Zuari estuaries and least from Tolpona estuary (Fig 12). Rare mangrove Lumnitzera racemosa was recorded for first time from pallolem estuary (Fig 13). Simpson, Shannon, and Brillouin diversity indices showed that the highest diversity value were obtained by Cumbarjua canal, Terekhol Mandovi and Zuari estuaries (Fig 16, 17, 19). The maximum value for Margalef and Fisher-alpha diversity indices were obtained by Pallolem estuary (Fig 21, 23). Maximum Equitability value of 0.956 and 0.9543 were obtained by Terekhol and Tolpona estuaries (Fig 22). The 100% Index of similarity was obtained by Cumbarjua canal and Zuari estuary (Fig 24) and least of 64.28% was obtained by Tolpona estuary when compared with mandovi estuary (Table 17).

The maximum Relative mangrove density (RMD) of 90.62% was obtained by Cumbarjua canal, Mandovi and Zuari estuaries and least 68.75% was obtained by Tolpona estuary (Fig 25).

The station wise maximum density of 36.77 was recorded for Rhizophora mucronata and Avicennia officinalis from Galgibaga estuary and minimum 0.27 was recorded for B. gymnorrhiza from baga estuary.

The station wise maximum frequency percentage of 94.44 was recorded for Avicennia officinalis, Rhizophora apiculata and Exocaricia agallocha from cumbharjua canal, terekhol and sal estuaries and minimum 0.33 percent was recorded for Lumnitzera racemosa from pallolem estuary.
The station wise maximum abundance of 66.2 was recorded for *Rhizophora mucronata* from Galgibaga estuary and minimum 1 was recorded for *A. alba* from pallolem estuary.

When overall density, frequency and abundance of Goa state for each species was calculated irrespective of river of estuaries (Table 18). The highest density of 18.97 was recorded for *Rhizophora mucronata* and minimum 0.26 was recorded for *Lumnitzera racemosa* (Fig 26). The highest frequency of 68.18 was recorded for *Rhizophora apiculata* and minimum 0.03 was recorded for *Lumnitzera racemosa* (Fig 27). The highest abundance of 29.35 was recorded for *Rhizophora mucronata* and minimum 8.66 was recorded for *Lumnitzera racemosa* (Fig 28).

### Table 17: Diversity indices of different study stations of Goa.

<table>
<thead>
<tr>
<th>Species(S)</th>
<th>Tk</th>
<th>Cp</th>
<th>Bg</th>
<th>Md</th>
<th>Cj</th>
<th>Zr</th>
<th>Sl</th>
<th>Se</th>
<th>Pi</th>
<th>Tp</th>
<th>Gb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individuals(N)</td>
<td>1943</td>
<td>1369</td>
<td>673</td>
<td>3240</td>
<td>3744</td>
<td>3014</td>
<td>1522</td>
<td>432</td>
<td>792</td>
<td>1656</td>
<td>4680</td>
</tr>
<tr>
<td>Dominance(D)</td>
<td>0.095</td>
<td>0.1156</td>
<td>0.1566</td>
<td>0.109</td>
<td>0.096</td>
<td>0.0997</td>
<td>0.1698</td>
<td>0.1403</td>
<td>0.118</td>
<td>0.1313</td>
<td>0.1204</td>
</tr>
<tr>
<td>Simpson(1-Lambda)</td>
<td>0.905</td>
<td>0.8844</td>
<td>0.8434</td>
<td>0.891</td>
<td>0.904</td>
<td>0.9003</td>
<td>0.8302</td>
<td>0.8597</td>
<td>0.882</td>
<td>0.8687</td>
<td>0.8796</td>
</tr>
<tr>
<td>Shannon(H')</td>
<td>2.451</td>
<td>2.344</td>
<td>2.199</td>
<td>2.415</td>
<td>2.46</td>
<td>2.414</td>
<td>1.973</td>
<td>2.131</td>
<td>2.311</td>
<td>2.097</td>
<td>2.261</td>
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<tr>
<td>Brillouin(HB)</td>
<td>2.431</td>
<td>2.318</td>
<td>1.954</td>
<td>2.401</td>
<td>2.448</td>
<td>2.399</td>
<td>1.952</td>
<td>2.074</td>
<td>2.27</td>
<td>2.081</td>
<td>2.253</td>
</tr>
<tr>
<td>Margalef(d)</td>
<td>1.585</td>
<td>1.662</td>
<td>1.536</td>
<td>1.608</td>
<td>1.58</td>
<td>1.623</td>
<td>1.501</td>
<td>1.648</td>
<td>1.798</td>
<td>1.079</td>
<td>1.302</td>
</tr>
<tr>
<td>Equitability(J')</td>
<td>0.956</td>
<td>0.914</td>
<td>0.8306</td>
<td>0.9149</td>
<td>0.9322</td>
<td>0.9145</td>
<td>0.7939</td>
<td>0.8885</td>
<td>0.901</td>
<td>0.9543</td>
<td>0.91</td>
</tr>
<tr>
<td>Fisher-alpha</td>
<td>1.872</td>
<td>1.989</td>
<td>1.868</td>
<td>1.878</td>
<td>1.837</td>
<td>1.9</td>
<td>1.777</td>
<td>2.055</td>
<td>2.209</td>
<td>1.252</td>
<td>1.49</td>
</tr>
<tr>
<td>Index of similarity</td>
<td>92.85</td>
<td>92.85</td>
<td>78.57</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>85.71</td>
<td>78.57</td>
<td>92.85</td>
<td>64.28</td>
<td>85.71</td>
</tr>
<tr>
<td>Relative mangrove density(RMD)</td>
<td>87.5</td>
<td>84.37</td>
<td>78.12</td>
<td>90.62</td>
<td>90.62</td>
<td>90.62</td>
<td>81.25</td>
<td>78.12</td>
<td>87.5</td>
<td>68.75</td>
<td>81.25</td>
</tr>
</tbody>
</table>
Table 18: Density, frequency and abundance of different mangrove species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Density</th>
<th>Frequency</th>
<th>Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.m</td>
<td>18.97</td>
<td>64.64</td>
<td>29.35</td>
</tr>
<tr>
<td>R.a</td>
<td>12.39</td>
<td>75.55</td>
<td>16.46</td>
</tr>
<tr>
<td>B.g</td>
<td>3.09</td>
<td>24.24</td>
<td>12.75</td>
</tr>
<tr>
<td>B.c</td>
<td>1.82</td>
<td>17.17</td>
<td>10.61</td>
</tr>
<tr>
<td>C.t</td>
<td>2.85</td>
<td>14.14</td>
<td>20.17</td>
</tr>
<tr>
<td>K.c</td>
<td>3.25</td>
<td>23.73</td>
<td>13.72</td>
</tr>
<tr>
<td>E.c</td>
<td>7.29</td>
<td>58.58</td>
<td>12.44</td>
</tr>
<tr>
<td>A.a</td>
<td>3.91</td>
<td>20.7</td>
<td>18.85</td>
</tr>
<tr>
<td>A.m</td>
<td>12.36</td>
<td>46.46</td>
<td>26.61</td>
</tr>
<tr>
<td>A.o</td>
<td>16.86</td>
<td>70.28</td>
<td>20.12</td>
</tr>
<tr>
<td>S.a</td>
<td>7.006</td>
<td>38.38</td>
<td>18.06</td>
</tr>
<tr>
<td>S.c</td>
<td>2.91</td>
<td>16.16</td>
<td>18.06</td>
</tr>
<tr>
<td>L.r</td>
<td>0.26</td>
<td>0.03</td>
<td>8.66</td>
</tr>
<tr>
<td>A.i</td>
<td>11.63</td>
<td>68.18</td>
<td>17.06</td>
</tr>
<tr>
<td>E.a</td>
<td>11.73</td>
<td>57.07</td>
<td>20.55</td>
</tr>
</tbody>
</table>
Fig. 12: Total number of species present in each estuaries

Fig. 13: Each species present in number of estuaries.

Fig. 14: Total individual of each estuary.
Fig. 15: Dominance of mangroves in different estuaries.

Fig. 16: Simpson index of mangroves in different estuaries.

Fig. 17: Shannon index of mangrove in different estuaries.

Fig. 18: Species Evenness of mangrove in different estuaries.
Fig. 19: Brillouin index of mangrove of different estuaries.

Fig. 20: Menhinick index of mangrove of different estuaries.

Fig. 21: Margalef index of mangrove of different estuaries.

Fig. 22: Equitability index of mangrove of different estuaries.
Fig. 23: Fisher-alpha index of mangrove of different estuaries.

Fig. 24: Index of Similarity of mangrove of different estuaries.

Fig. 25: Relative Mangrove Diversity percentage of different estuaries.
Fig. 26: Density of different mangrove species.

Fig. 27: Frequency of different mangrove species.

Fig. 28: Abundance of different mangrove species.