



STUDY OF DIVERSITY INDICES AND ECOLOGICAL CHARACTERISTIC OF COASTAL FLORA IN 'BHAL' REGION (GUJARAT)

Suhas J. Vyas* and A. J. Joshi[#]

*Department of Earth & Environmental science, K.S.K.V. Kachchh University, Bhuj- Kachchh

[#]Department of Life Science, Bhavnagar University, Bhavnagar

ABSTRACT: Gujarat is the state which has two gulfs in its 1600 km (approximately) area of coast out of 7517 km (approximately) coast line of India. Much work on diversity of mangroves and microbial diversity has been done in this area, but research on diversity of halophytes has not been much done. Attention was paid to listing, distribution and ecological aspects of plants growing in coastal areas. An attempt was made to study the diversity indices like Shannon's index, Simpson index and Pielou's index of coastal flora at 3 different habitats viz., marshy, fresh wetland and inland saline habitat during 3 seasons in Bhal region falling under Bhavnagar district (Gujarat). Results showed little variations for the indices for marshy locations (Sonrai Creek) during monsoon, winter and summer. In contrast, these measures of diversity marginally fluctuated at freshwater, saline and grassland localities.

Key words: Distribution, coastal habitats, Bhal region, diversity indices, temporal variations

INTRODUCTION

Intensive researches on biodiversity its values, uses, loss, conservation and management during last two decades has made a spectacular *niche* in the field of environmental science. Today's plant communities in the world are the result of long term interactions between vegetation and site factors including man-made impacts. Current species diversity reflects historical as well as environmental factors, which affect variations in species composition [1].

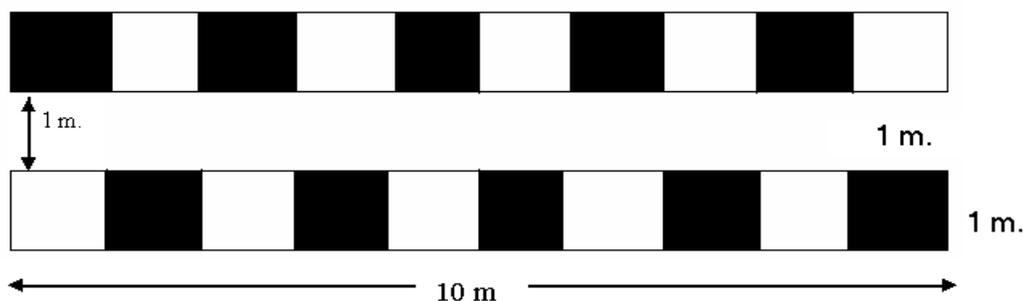
While quoting important studies on Indian coastal flora made during the last century i.e., between the year 1901-2000, Banerjee *et al.* [2] observed that limited attempts had been made in the first half of century. Later on, attention was paid to listing, distribution and ecological aspects of plants growing in coastal areas. Halophytes, as integral parts of many marine, coastal and terrestrial ecosystems are believed to play an important future role for biosaline agriculture, aquaculture and habitat restoration [3].

The present study was undertaken to determine, Shannon's, Simpson's, its reciprocal and Pielou's indices were calculated for diversity, species richness and evenness for plant species, of coastal flora occurring at 5 locations in a unique 'Bhal' ecoregion falling under revenue district of Bhavnagar (Fig. 1 & 2). Twin belt transects method was used for recording floristic data.

Methodology

Five locations, details of which are fully described in section, were selected in 'Bhal' region of Bhavnagar district.

Design of Twin Transects



3 twin belt transects (10 x 1 m) were laid down at right angle to the wetlands at selected locations. Plant species were counted in five alternative segments (1x1 m) of either of the twin belt transects.

Following measures were used for studying diversity of plants:

Shannon Index for Diversity [4]:

$$\text{Diversity } H' = - \sum_{i=1}^S pi \log_{10} pi$$

Where S = Number of species

Pi = Proportion of individuals of the abundance of the ith species expressed as a proportion of total cover.

log₁₀ = log base₁₀

Simpson Index for species richness [4]:

$$D = \sum (n/N)^2$$

Where n = The total number of a particular species.

N = The total number of all species.

Pielou's Index for species evenness [4]:

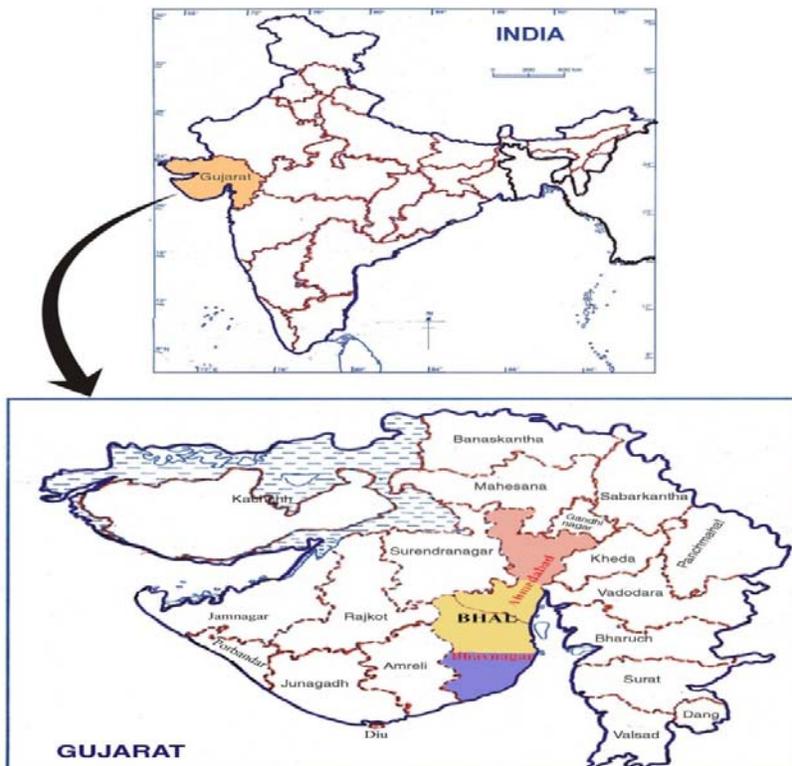
$$J = \frac{H'}{H'_{\max}} = \frac{- \sum_{i=1}^S pi \log_{10} pi}{\log_{10} S}$$

Where S = the number of species

Pi = the proportion of individuals of the ith species or the abundance of the ith species expressed as a proportion of total cover.

Log₁₀ = Log base 10

Study area:



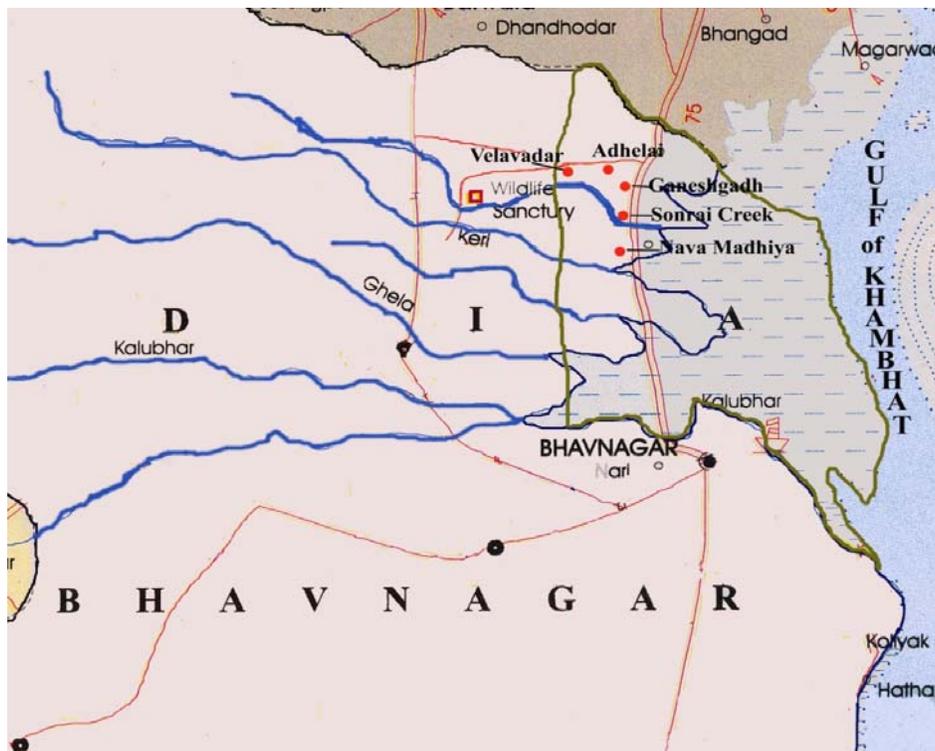


Figure 1. Location of study area in the 'Bhal' region.

RESULTS

As mentioned in previous section, 10 (1 m × 1 m) sample units from each of 3 twin belt transects laid down at 3 locations were considered for determining diversity in coastal belt of 'Bhal' region. Important diversity indices viz., Shannon index (H'), Simpson index (D), its reciprocal index ($1/D$) and Pielou's evenness index (J) were worked out, as they provide vital information about diversity, rarity and commonness of the species in a community. These measures also elucidate richness and evenness of species growing at selected habitats.

Internationally accepted approach of interpreting high values for the Shannon index reflecting greater diversity at particular location; zero Simpson's index representing infinite richness and 1 indicating no richness; Simpson's reciprocal index ($1/D$), starting with 1, as the lowest possible figure indicative of low richness and its maximum number that is, equal to total number of species, denoting high degree of species richness; Pielou's index (J) 1 showing similar portion and less values indicative of unequal proportion of all species in area was followed for the present study [4].

Location 1 Nava Madhiya

Although total number of individuals of *Suaeda nudiflora* were 95, 97 and 67 during monsoon, winter and summer, diversity indices (Shannon index $H' = 0$; Simpson index D as well as its reciprocal index $1/D = 1$; Pielou's index $J = 0$) reflected low diversity, species richness and evenness (Table 1). This was simply because of occurrence of only one species (*S. nudiflora*) at this location.

Location 2 Sonrai creek

This marshy habitat supported 2 plant species viz., *S. nudiflora* and *Aeluropus lagopoides* and collectively 630 (monsoon), 639 (winter) and 491 (summer) individuals were recorded in sample units. Monsoon value of Pi^2 for *S. nudiflora* (0.024) was less than that of *A. lagopoides* (0.713) suggesting less individuals of the former species in the habitat.

Shannon index was noted between 0.181 to 0.188 (Table 1); Simpson's index and its reciprocal index fluctuated between 0.735 to 0.749 and 1.355 to 1.359, respectively; Pielou's index for evenness varied from 0.602 to 0.626. These observations were indicative of low diversity, moderately high degree of species richness and evenness distribution of 2 species at this marshy site.

Table 1. Diversity indices for coastal flora growing in 'Bhal' region during 3 seasons.

Locations	Seasons	S*	H'	D	1/D	J
Nava Madhiya	Monsoon	1	0	1	1	0
	Winter	1	0	1	1	0
	Summer	1	0	1	1	0
Sonrai creek	Monsoon	2	0.1875	0.7371	1.3566	0.6229
	Winter	2	0.1813	0.7490	1.3551	0.6023
	Summer	2	0.1885	0.7353	1.3599	0.6262
Ganeshgad	Monsoon	3	0.3862	0.4455	2.2446	0.8094
	Winter	3	0.3348	0.4834	2.0686	0.7017
	Summer	3	0.3950	0.4345	2.3014	0.6279
Adhelai	Monsoon	3	0.4660	0.4089	2.4455	0.9767
	Winter	3	0.3998	0.4374	2.2862	0.8379
	Summer	3	0.4238	0.4038	2.4764	0.8882
Velavadar	Monsoon	3	0.4684	0.3467	2.8843	0.9817
	Winter	3	0.3994	0.4400	2.2727	0.8371
	Summer	3	0.4283	0.4053	2.4673	0.8977

S*= No. of plant species

Location 3 Ganeshgad

Freshwater location of Ganeshgad was inhabited by 3 species and their total number during monsoon, winter and summer reached to 280, 294 and 194, respectively. Values of Pi^2 of *Schoenoplectus maritimus* (0.264, 0.314 and 0.270) were greater than that of either *Echinochloa crusgalli* (0.173, 0.163 and 0.173) or *Dichanthium annulatum* (0.003, 0.001 and 0.003) during all seasons reflecting dominance of the first species.

Shannon index (0.335 to 0.395) indicated low diversity of species (Table 1); Simpson index (0.434 to 0.483); and its reciprocal (2.068 to 2.301) were indicative of high species richness and Pielou's index (0.627 to 0.809) showed that distribution of species was even at this site.

Location 4 Adhelai

3 plant species grew at this site. Total number of individuals growing at this study area was 182, 156 and 129 at different times during a year. Maximum value of Pi^2 for *D. annulatum* (0.310) and for *S. nudiflora* (0.015) was observed during monsoon and winter; whereas that of *Prosopis chilensis* (0.209) was noticed in summer.

Shannon index was noted between 0.399 to 0.466; Simpson index and its reciprocal index ranged between 0.403 to 0.437 and 2.286 to 2.476; while Pielou's evenness index fluctuated from 0.837 to 0.976 (Table 1). These observations were indicative of a low degree of diversity and moderately good richness and even distribution of plant species at this inland dry saline habitat.

Location 5 Velavadar

Collective numbers of 3 plants occurring at this site were 1115, 252 and 239, respectively in monsoon, winter and summer. Values of Pi^2 for *Sporobolus coromandellianus* (0.27 to 0.36) recorded in monsoon were greater than that of two other species viz., *S. maritimus* and *Echinops echinatus* growing here.

Shannon index (0.399 to 0.468) suggested low diversity; Simpson's index varying from 0.346 to 0.440; and its reciprocal index (2.272 to 2.884) were suggestive of high species richness (Table 1). Pielou's index nearing to 1 in all three seasons, reflected highly even distribution of 3 species.

From what has been said above, it becomes clear that 'Bhal' area is characterized by quite low plant diversity, but species richness and their distribution as indicated by Simpson's and Pielou's indices were moderately good.

Temporal and spatial variations

Temperature in summer (~ 43°C) and in winter (~10°C) in 'Bhal' area varies and precipitation during monsoon is about ~ 650 mm. Similarly, edaphic conditions, either freshwater or marshy, differ remarkably. Therefore attempts were made to determine temporal and spatial variations in Shannon's, Simpson's and Pielou's indices calculated for coastal plant communities growing in the region.

These results showed little variations for the indices for marshy locations (Sonrai Creek) during monsoon, winter and summer. In contrast, these measures of diversity marginally fluctuated at freshwater, saline localities. Thus, it can be inferred that climatic changes had little or poor impact on plant diversity.

On the other hand, spatial variations for species diversity (H') were noticeable for different habitats, though diversity of plant species *per se* was quite low. Furthermore, values for species richness and species evenness were moderately high and variations for 5 selected habitats were noticeable. These observations justify a conclusion that vegetation on microhabitats in the same ecoregion exhibit different diversity characteristics.

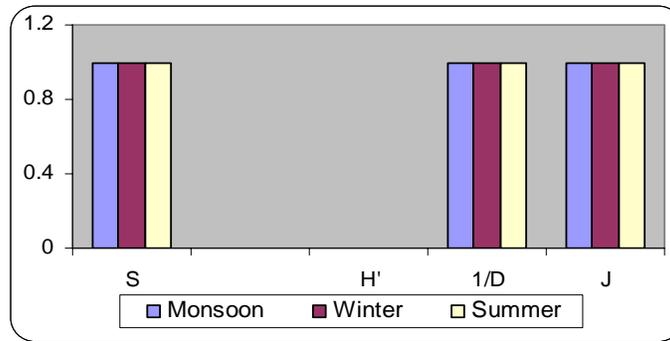


Fig.2. Temporal variations in diversity indices at location 1 (Nava Madhiya).

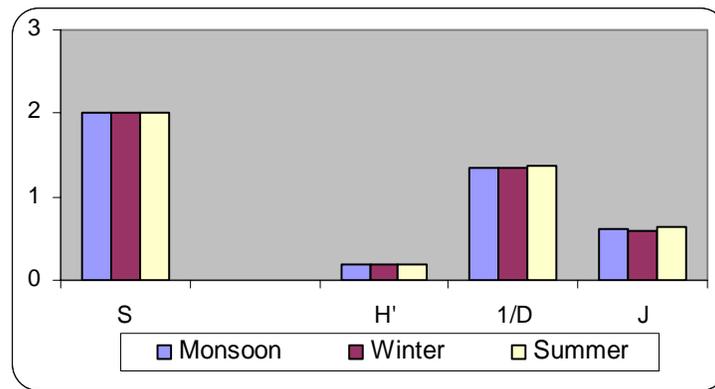


Fig.3. Temporal variations in diversity indices at location 2 (Sonrai creek).

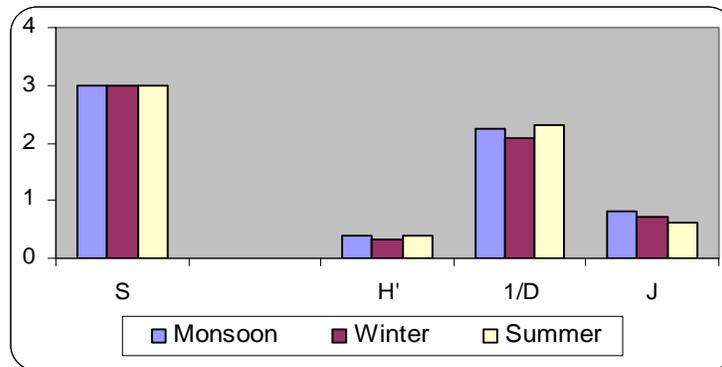


Fig.4. Temporal variations in diversity indices at location 3 (Ganeshgadh).

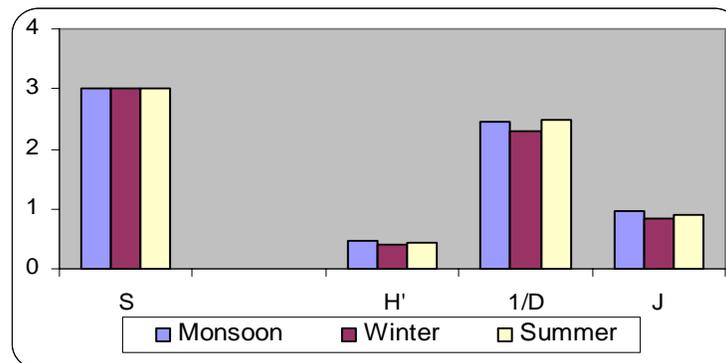


Fig.5. Temporal variations in diversity indices at location 4 (Adhelai).

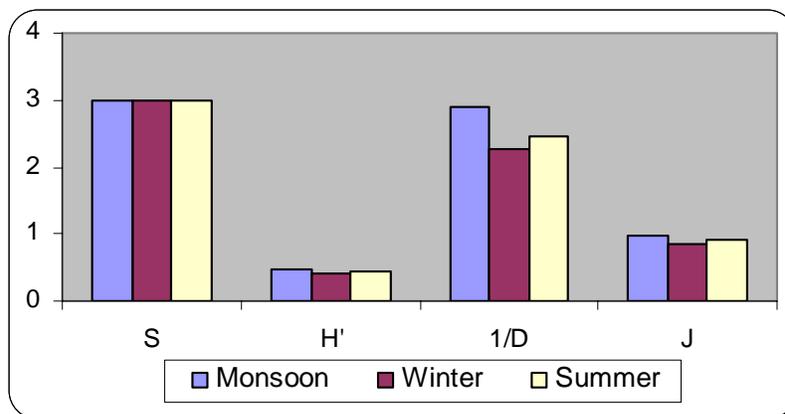


Fig.6. Temporal variations in diversity indices at location 5 (Velavadar).

An attempt has been made to determine whether temporal variations had any impact on the biodiversity indices at different locations or not.

Table 2: 2-way ANOVA assessing biodiversity indices of 5 locations during 3 seasons.

Diversity Indices	Seasons	Locations
H'	282.53***	5.05*
D	498.82***	3.88 ^{ns}
J	187.82***	4.46*

The values indicate *F* values calculated and * indicate the level of significance. (^{ns}= non-significant; *= significant at $P \leq 0.05$; and ***= very highly significant at $P \leq 0.001$)

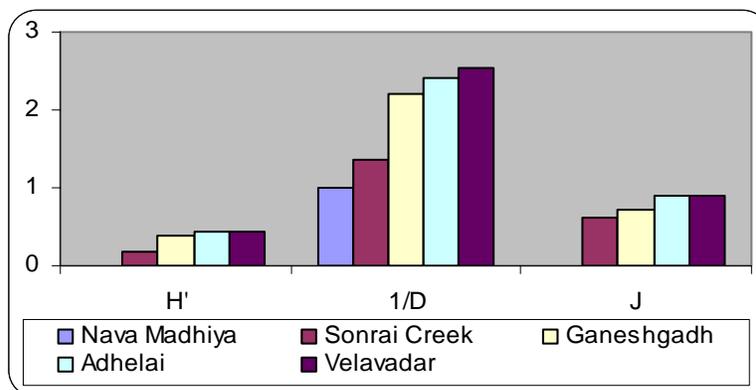


Fig.7. Spatial variations in diversity indices recorded for 5 locations

DISCUSSION

It is widely accepted that biodiversity of coastal flora is depended on hydrological regime, geological and climatic conditions. Green [5] further suggested that although hydrology – whether it be frequency of inundation or water source – was the most important factor, remaining criteria such as, wetland morphology, vegetation type and geographical locations were equally important for managing coastal ecosystems. Earlier Gopal and Sah [6], too, had suggested that the various growth forms of wetland vegetation can be used as indicators as of different hydrological regimes in India.

Pollock *et al.* [7] also concluded that heterogeneity in the physical environment (e.g. substrate, nutrients, soil moisture and structure) was positively and linearly correlated with diversity at a number of spatial scales.

The present study indicated that 2 halophytic species viz, *Suaeda nudiflora* and *Aeluropus lagopoides* grew at marshy locations; freshwater habitat supported a sedge plant and 2 grasses; inland saline habitat supported a mixed vegetation of a halophyte, 1 grass and 1 shrub; while grassland location was dominated by a grass and 2 other species.

It was noticed that temporal variations did not affect the diversity indices of present communities of marshy locations, but opposite trend was observed for freshwater, saline and grassland vegetation. This important observation supports a conclusion that plant diversity at a level of microhabitats differed in the same ecoregion of 'Bhal'.

From what else has been said above, it becomes evidently clear that findings of this study appear to be highly relevant from the view point of biodiversity of coastal flora. Furthermore, species like *Suaeda nudiflora*, *Aeluropus lagopoides*, *Salvadora persica* have been classified amongst 20 coastal plants, as endangered species by the IUCN [8]. As if this is not enough, the Gulf of Kutch and Khambhat have been identified amongst 20 most seriously threatened wetlands in India.

A specific mention should be made here about most valuable report on flora of Sunderban by Naskar [9]. It may be concluded that the present investigation contributes only a small part of a major and important task of examining biodiversity of coastal vegetation and that sustained efforts in this direction would enrich this fascinating area of research in plant sciences.

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