

Quantitative Study of Coastal Flora of 'Bhal' Region in Gujarat

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Abstract: Gujarat state of India has a coastline of more than 1600 km. 'Bhal' region is situated on south-west border of saurashtra, it covers partly of the Ahmedabad and half of Bhavnagar district of Gujarat state. Basically this area is famous for saline conditions; the region is flat as forehead devoid of stones or gravel. Major rivers like bhogavo, ghelo and kalubhar passes from this region. Due to these rivers the estuarine habitat and marshy habitat are found in 'Bhal' region. Halophytes are dominant in marshy where as in coastal wetlands the species of grass from chenopodiaceae family found. Quantitative assessment of all the species growing in bhal region of Bhavnagar district are shown in this research. Phytosociological parameters of biodiversity (frequency, density, relative density and abundance) were calculated.

Keywords: Bhal, marshy habitat, wetland, phytosociology, halophytes

1. Introduction

Approximately 60% of the global population lives in coastal areas having high ecological and economic significance and values. 'Bhal' region is situated on the south-west border of Saurashtra, spreading in 2 revenue districts of Bhavnagar and Ahmedabad on the left border of the Gulf of Khambhat (Cambay). The term 'Bhal' in Sanskrit language means a forehead and as the hairs do not grow on the forehead, the natives here believe, plant species find difficult to grow in this area. The combination of freshwater and saline water is seen in this area hence, ecological diversity is reflected in flora and fauna of this region. It is an ecologically complex coastal belt having length of approximately 100 km and breadth of 25 km and low mean sea level; it receives an average annual rainfall about 650 to 700 mm and includes moderately big mouths of the rivers Sabarmati, Bhogavo and Bhadar and smaller ones of Keri, Ghelo and Kalubhar rivers.

This region can be classified as a ~ 15 kms wide coastal wetland comprising of marshy areas towards the Gulf of Khambhat and of freshwater bodies in a landward margin of ~ 10 kms, which remains flooded during monsoon. Because of this diversified edaphic conditions, the flora represents a combination of salt tolerant halophytes growing in marshy area, less salt tolerant species and aquatic plants occurring in inland 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 (BennoBöer, 2004). Prominent coastal ecosystems of the world have become highly fragile and considerable damage has been done to coastal and marine habitats resulting in an alarming loss of biodiversity in developed countries (IUCN, 2002). Earlier UNEP (1995) had also pleaded for conserving biodiversity of inland, marine and coastal habitats supporting rare plant communities.

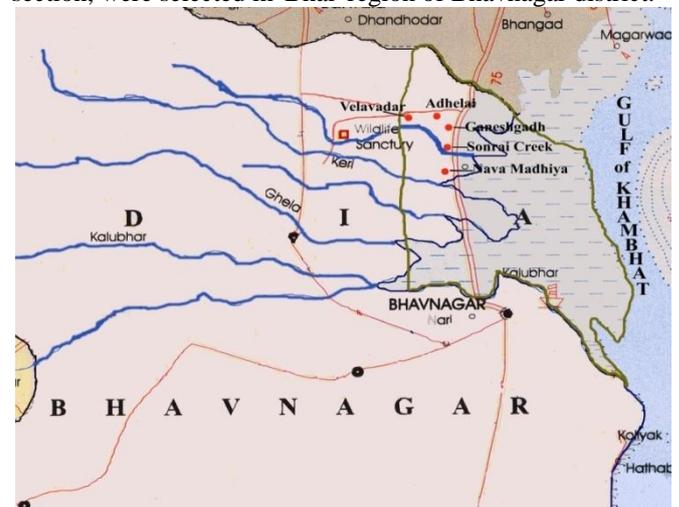
Marine phytoplankton and algae, seagrasses, mangroves and halophytes are major components of marine flora. While

marine phytoplankton, algae and seagrasses occur in oceanic waters, sub-tidal and intertidal zones in various parts of the world, mangroves grow in intertidal tropical and subtropical regions (Dawes, 1981). However, halophytes generally occur in habitats like salt marshes and salt desert across the globe (Mitsh and Gosselink, 2000; Nybakken, 2001). The coastal flora is getting degraded by various developmental activities, which eventually disturbs the whole marine ecosystem.

This study is basically to monitor and provide scientific data on diversity of flora of with respect to its habitat in selected sites at coastal area of 'Bhal' region situated in Bhavnagar district of Gujarat, India. Moreover, negligible work is done on the quantitative study of different halophytic species in this area. Quantitative parameters like frequency, density, relative density and abundance have been done in present study. Twin belt transects method was used for recording floristic data.

2. Methodology

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



3 twin-belt transects (10 x 1 m) (Figs.1 and 2) 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.

Thus, ten sample units from each of belt transect as indicated above and thereby total of 30 sample units admeasuring 30 m² at each location weretaken into

$$\text{Frequency} = \frac{\text{Number of units in which the species occurred}}{\text{Number of units studied}} \times 100$$

$$\text{Density} = \frac{\text{Total number of individuals of a species in all the sample units}}{\text{Total number of sample units studied}}$$

$$\text{Relative Density} = \frac{\text{Number of individuals of the specie sin all the sample units}}{\text{Number of individuals of all species in all the sample units}} \times 100$$

$$\text{Abundance} = \frac{\text{Number of individual in all sample units}}{\text{Number of sample units in which species occurred}}$$

Mean value of 10 sample units of each of twin belt transects were used for calculating all phyto-sociological parameters.

3. Results

Selected locations

As mentioned earlier, 5 locations in Bhal area falling in the district of Bhavnagar were selected for the present investigation. Their varying characteristics are described in this section.

Location 1 Nava Madhiya

Nava Madhiya is located at 32 km North of Bhavnagar. This intertidal marshy habitat supported a monoculture of a halophytic succulent species, *Suaedanudiflora* Moq.

Location 2 Sonrai Creek

This location is 5 km away from Nava Madhiya. It is also a part of salt marsh, wherein of two halophytic species namely, *Suaedanudiflora* Moq. and *Aeluropuslagopoides* Trin. were found.

Location 3 Ganeshgad

Ganeshgad is situated 4 km away from location 2 and is a freshwater site flooded by rain waters for about 4-5 months during and after monsoon. This location included species like *Dichanthiumannulatum* Stapf (forssk), *Echinochloacrussgalli* Beauv. (syn. *Panicumcolonum*, L.) and *Schoenoplectusmaritimus* Lye.

Location 4 Adhelai

This loation is a dry inland saline habitat and is located 5 km way from Ganeshgad. It supported a halophytic succulent species (*S. nudiflora*), an annual shrub (*D. annulatum*) and a salt tolerant shrub (*Prosopischilensis* Stunz.).

Location 5 Velavadar

This habitat is 7 km away from location 4 and it is just on the border of the Velavadar National Park protecting a population of Black bucks. It presents a typical grassland flora, comprising of less or no salt tolerant species *Sporoboluscoromandellianus*, Link., *S. maritimus* and *Echinopsechinatus*, Roxb.

Allied diversity measures

Forgoing observations show that the 'Bhal' region comprises of tidal and freshwater marshes and support 3 major groups of plant communities having different habits as

consideration. Preliminary observations were recorded in data sheets – as shown above for further calculation of other parameters.

Usual formulae for calculating Frequency, Density, Relative Density and Abundance were used :

well as variable diversity. This section describes closely related aspects of species diversity such as, frequency, density, abundance and relative density for further understanding plant diversity in a coastal belt. All floristic data are for 10 sample units (1 m × 1 m) from each of the 3 belt transects laid down at selected habitats.

Location 1 Nava Madhiya

Frequency of only one species (*Suaedanudiflora*, Moq.), occurring at this marshy location was noticed between 80 to 100 % (Table 1) and it marginally decreased in summer. Density and abundance (1.3 to 4.3) were low because of spreading habit of this halophyte. Furthermore, number of plants per unit area decreased during summer. Due to occurrence of only one species, its relative density was 100 %. Seasonal changes reflected minor decrease in phyto-sociological parameters in summer. Similar trend was also noticed for the belt transect laid down at an elevated level of the habitat.

Table 1: Quantitative parameters of floral biodiversity at Nava madhiya during 3 seasons

Plant species	Twin belt transect	Freq. (%)	Density	Abundance	Relative Density (%)
<i>S. nudiflora</i>	Monsoon	100	3.16	3.16	100
	Winter	93.33	3.03	3.27	100
	Summer	86.67	2.23	2.52	100
	Mean	93.33	2.81	2.98	100

Location 2 Sonrai creek

100 % frequency of *S. nudiflora* was noted here (Table 2). On other hand, frequency of *Aeluropuslagopoides*, Trin. (50 to 90 %) suggested its greater occurrence in transects away from creek. Density as well as abundance of *S. nudiflora* varied from 2.4 to 4.2 and less number of plants were noticed in transects laid down away from the creek. Negligible differences in these parameters were noted in summer. Density of a halophytic grass (*A. lagopoides*) was recorded between 12.5 to 22.8. It was further observed that its density in monsoon and winter progressively increased in belt transects further away from the creek. In contrast, the reverse trend was noted during summer. Abundance values of *A. lagopoides* varying between 15.1 to 28.5 also strengthened observations recorded for density.

Seasonal changes further indicated decreasing order of relative density (21.4 to 11.2) and (23.3 to 9.8) of *S. nudiflora* in belt transects 2 and 3 during monsoon and

winter; while no such trend was noticed in summer. On the other hand, relative density of *A. lagopoides* was recorded between 73.2 to 89.9 % and it was much greater than that of *S. nudiflora*, obviously due to small and upright habit of the former grass species.

Table 2: Quantitative parameters of floral biodiversity at Sonrai Creek during 3 seasons

Plant species	Twin belt transect	Freq. (%)	Density	Abundance	Relative Density (%)
<i>S. nudiflora</i>	Monsoon	100	3.26	3.26	15.81
	Winter	100	3.13	3.13	15.67
	Summer	100	2.57	2.57	15.77
	Mean	100	2.98667	2.98667	15.75
<i>A. lagopoides</i>	Monsoon	73.33	17.75	24.11	84.18
	Winter	70	18.17	25.83	84.29
	Summer	80	13.8	17.35	84.22
	Mean	74.44	16.57	22.43	84.23

Location 3 Ganeshgad

100 % frequency was noted for *Schoenoplectusmaritimus*, Lye. and *Echinochloacrussgalli* Beauv. (syn. *Panicumcolonum*, L) within 3 belt transects laid down here (Table 3). However, frequency of *Dichanthiumannulatum*, (Forssk.) stapf. varied between 20 to 70 % and it was not recorded in the third belt transect. No seasonal impact was noticed on frequency of 3 species growing at this location. Because of occurrence of *S. maritimus* and *E. crussgalli* in all sampling units, their density and abundance fluctuated uniformly between 3.2 to 5.9 and 2 to 5.2, respectively in 3 belt transects. Nevertheless, low values for density (0.4 to 1.0) and abundance (1.2 to 2.0) were noted for *D. annulatum*. Relative density between 46.2 to 62.8 % was observed for *S. maritimus*, whereas in case of *E. crussgalli* it ranged from 37.1 to 43.5 % (Table 3). Due to absence of the third species, their relative density in the third belt transect were noticeably high. *D. annulatum* occurred with low relative density (3.9 to 12.0 %) in first two belts transects. This characteristic was not affected by seasonal changes.

Table 3: Quantitative parameters of floral biodiversity at Ganeshgad during 3 seasons

Plant species	Twin belt transect	Freq. (%)	Density	Abundance	Relative Density (%)
<i>E. crussgalli</i>	Monsoon	100	3.9	3.9	41.52
	Winter	100	3.97	3.97	40.31
	Summer	100	2.7	2.7	41.42
	Mean	100	3.52	3.52	41.08
<i>D. annulatum</i>	Monsoon	70	0.95	1.36	10
	Winter	30	0.5	1.75	4.75
	Summer	50	0.6	1.21	8.52
	Mean	50	0.68	1.44	7.76
<i>S. maritimus</i>	Monsoon	100	4.8	4.8	51.8
	Winter	100	5.5	5.5	56.49
	Summer	100	3.37	3.37	62.26
	Mean	100	4.56	4.56	56.85

Location 4 Adhelai

Frequency of a succulent halophyte *S. nudiflora* was recorded between 10 to 60 % (Table 4) with low value being observed for belt transect No.3 in winter. *D. annulatum* occurred with high frequency of 80-100 % and

Prosopischilensis, Stuntz. was most frequent (90 -100 %) at this site. These primary data did not reflect any remarkable seasonal effects on frequency of the plant species. Density of *S. nudiflora* (0.1 to 0.8), *D. annulatum* (1.6 to 4.3) and of *P. chilensis* (1.6 to 2.6) showed less number of plants per unit area. This was further supported by low abundance values i.e., 1.0 to 1.6 for *S. nudiflora*, 1.8 to 4.3 for *D. annulatum* and 1.7 to 2.6 for *P. chilensis* (Table 4). Relative density of a halophytic species *S. nudiflora* (4.6 to 16.6 %) was comparatively less than that of a grass *D. annulatum* (38.1 to 63.2 %) or a shrub species *P. chilensis* (27.9 to 48.8 %). Seasonal changes did not have any noteworthy effects on this parameter.

Table 4: Quantitative parameters of floral biodiversity at Adhelai during 3 seasons

Plant species	Twin belt transect	Freq. (%)	Density	Abundance	Relative Density (%)
<i>S. nudiflora</i>	Monsoon	53.33	0.73	1.39	12.3
	Winter	36.67	0.47	1.2	8.27
	Summer	40	0.5	1.2	11.74
	Mean	43.33	0.567	1.26	10.77
<i>D. annulatum</i>	Monsoon	86.67	2.97	3.35	47.94
	Winter	93.33	2.9	3.05	54.57
	Summer	90	1.83	2.03	42.93
	Mean	90	2.57	2.81	48.48
<i>P. chilensis</i>	Monsoon	100	2.37	2.37	39.74
	Winter	96.67	1.83	1.89	37.13
	Summer	100	1.97	1.97	46.08
	Mean	98.89	2.06	2.08	40.98

Location 5 Velavadar

This location is situated just near Velavadar Blackbuck National Park grassland in Bhavnagar district. *Sporoboluscoromandellianus*, Link. dominated this grassland site with simultaneous presence of *S. maritimus* and *Echinopsechinatus*, Roxb. *S. coromandellianus* occurred with 100 % frequency in all 3 belt transects and in 3 seasons followed by *E. echinatus* having frequency between 70 to 100 % (Table 5). Moderate to high frequency (70- 100%) was recorded for *S. maritimus*. No remarkable seasonal effects on this character were noticed.

Table 5: Quantitative parameters of floral biodiversity at Velavadar during 3 seasons

Plant species	Twin belt transect	Freq. (%)	Density	Abundance	Relative Density (%)
<i>S. coromandellianus</i>	Monsoon	100	22.46	22.43	59.07
	Winter	100	4.73	4.73	60.11
	Summer	100	4.2	4.2	55.12
	Mean	100	10.4633	10.4533	58.1
<i>S. maritimus</i>	Monsoon	76.67	6	7.4	15.22
	Winter	70	1.25	1.7	12.86
	Summer	60	1.27	1.82	13.78
	Mean	68.89	2.84	3.64	13.95
<i>E. echinatus</i>	Monsoon	100	8.7	8.7	25.66
	Winter	86.67	2.83	3.09	31.27
	Summer	86.67	2.5	2.81	31.06
	Mean	91.11	4.68	4.87	29.33

From the above data of frequency, density, abundance and relative density at different locations of 'Bhal' region during monsoon, winter and summer it indicated that availability number of species at Ganeshgad was more in number (4)

compared to that of other locations. Moreover, Ganeshgadhi is a freshwater location in 'Bhal' region. One marshy (Nava Madhiya) location had the lowest number of species (1) which was highly saline habitat (Table 6).

Table 6: Presence of species at all locations in 'Bhal' region

Species	Locations				
	Nava madhiya	Sonrai Creek	Ganeshgadhi	Adhelai	Velavadar
<i>S. nudiflora</i>	√	√	-	√	-
<i>A. lagopoides</i>	-	√	-	-	-
<i>E. crusgalli</i>	-	-	√	-	-
<i>D. annulatum</i>	-	-	√	√	-
<i>S. maritimus</i>	-	-	√	-	√
<i>P. chilensis</i>	-	-	√	-	-
<i>S. coromandellinus</i>	-	-	-	-	√
<i>E. echinatus</i>	-	-	-	-	√

4. Discussion

The Gujarat coast is bounded by the Arabian sea and by the Gulf of Kutchh and Khambhat. 'Bhal' region is situated on left side of the Gulf of Khambhat. It is ~100 km long and ~25 km wide belt extending from near Bhavnagar to the northern end of the Gulf. Annual rainfall is about 650mm; low temperature in winter (~ 10⁰C) and high in summer (~ 43⁰C) result in sharp temporal variations. Tidal inundations from the Gulf of Khambhat and freshwater flows in river mouths, make the 'Bhal' region very unique and fascinating for botanical studies. Plant communities comprising of highly, moderately and less or no salt tolerant annuals and perennial dicot and monocot species occur in the region.

Classification of Indian coastal flora into 2 distinct types named as (1) Dry (2) Wet Coastal Plant Communities (Banerjee, L. K. *et al.*, 2002). According to them, dry coastal communities are of 2 types – sandy strand vegetation and rocky strand vegetation –, whereas wet coastal communities comprises of coral reefs, sea weeds, sea grasses, mangroves and salt marsh vegetation. Often repeated excursions to the region showed that the coastal vegetation included communities of salt tolerant, moderately salt tolerant and aquatic plants. A salt tolerant halophyte *Suaeda nudiflora* occurred at 3 marshy locations and was absent at 2 inland habitats. Its phytosociology varied in habitats and also in different seasons (Tables 1, 2 & 4). Another salt tolerant grass, *Aeluropus lagopoides* was located at only one location and high values of its frequency, density, abundance and relative density were due to its upright small habit (Table 2).

In contrast, to forgoing 2 species, *Echinochloa crusgalli* was recorded at freshwater location only. Its frequency was 100% but its density and abundance were low (Table 3). It was associated with *Dichanthium annulatum* and *Schoenoplectus maritimus* and its relative density was 40%.

It should be noted here that *Dichanthium annulatum* grew at freshwater as well as at saline location. It occurred with remarkably high frequency (Table 4), but its density and abundance were low. Nevertheless, its relative density in saline habitat was noticeably greater than that at freshwater location.

Schoenoplectus maritimus was found at freshwater and grassland location having much greater frequency level in freshwater condition (Tables 3 & 5). Its density and abundance in both the habitats fluctuated in a close range, but its relative density was evidently high in freshwater condition. *Sporobolus coromandellianus* was noticed at grassland location with 100% frequency. Its density and abundance were high in monsoon but declined in winter and summer (Table 5). High relative density showed its dominance over to other species occurring at locations. *Echinopsechinatus* grew at grassland location with quite high frequency but with low density and abundance (Table 5). Moreover, its relative density was half of the dominant species *S. coromandellianus* in the habitat. A shrubby plant *Prosopis chilensis* having 100% frequency was located at inland saline locality. Its density and abundance were low but relative density was moderately high (Table 4).

From what has been said above, it becomes evidently clear that plant species preferred specific microhabitats, which can be classified as salt marshes, freshwater and inland saline and grassland type. Furthermore, density and abundance of annual and perennial grasses were adversely affected during summer. While studying plant communities of coastal zones, occurrence of 5 plant communities viz., (i) *Cyperus conglomeratus*, (ii) *Halophyrum mucronatum*, (iii) *Hydrophylax maritima*, (iv) *Ipomoea pes-caprae*, (v) *Leptadenia pyrotechnica* along Gujarat coast. Likewise, they reported 6 communities namely, i) *Avicennia marina*, ii) *Suaeda nudiflora*, iii) *Aeluropus lagopoides*, iv) *Fimbristylis cymosa*, v) *Scirpus maritimus*, vi) *Urochondra setulosa* in salt marshes (Rao, T. A and Aggarwal K. R., 1966).

Of the above mentioned 11 plant communities, following communities were observed in 'Bhal' area during this study: i) *Schoenoplectus maritimus*, ii) *Suaeda nudiflora*, and iii) *Aeluropus lagopoides*. While synthesizing semi-quantitative data of plant communities along Gujarat coast, noted that occurrence of 3 species of *Cyperus* varied from 20 to 80 %, whereas that of *Suaeda* and *Aeluropus* was more than 80 %. Strand habitats along the Konkan, Malbar and Coromandal also support the *Cyperus* communities (Banerjee, L. K. *et al.*, 2002). A report combining the visits to different parts of country and literature available then showed the presence of various species belonging to genera *Cyperus*, *Fimbristylis*, *Aeluropus*, *Prosopis*, *Suaeda*, *Sesuvium*, *Sporobolus*, *Sclerodendron* in strand habitats in Maharashtra, Kerala, Tamilnadu, Andhra Pradesh and Orissa. He also attempted to explain zonations of coastal vegetation (Blasco, F., 1975). It may be mentioned here that Rao and Suresh (2001) have given exhaustive data of soil analysis and composition of mangrove flora occurring at 52 selected localities along the Karnataka coast (Rao, T. A. and Suresh, P. V., 2001). They further stressed the need of preparing a separate inventory on coastal wetlands. The present investigation, which rigorously deals with floristic data of 3 belt transects held during 3 seasons at each of 5 different locations generates a vital conclusion that *S. nudiflora*, *A. lagopoides*, *S. maritimus* communities dominated the vegetation in coastal sites in 'Bhal' ecoregion.

5. Acknowledgement

The project was funded by Ministry of Environment & Forest, Government of India, New Delhi.

6. Conclusion

The phyto-sociological parameters of coastal flora in 'Bhal' region shows varied habitat like marshy, freshwater and inland dry in the region. Total of 8 species were growing in the selected 5 location of 'Bhal' region. Marshy habitat of Nava Madhiya supported a monoculture of a halophytic succulent species, *Suaedanudiflora*, Moq. Occurrence of a halophytic grass (*Aleuopuslagopoides*, Trin.) along with *Suaedanudiflora* was recorded at another marshy habitat. Typical aquatic plants *Echinochloacrusgalli*, Beauv. (syn. *Panicumcolonum*, L), *Schoenoplectusmaritimus*, Lye. and one grass *Dicanthiumannulatum*, Stapf (forssk.) grew at freshwater location of Ganeshgadh. Inland saline habitat supported a vegetation comprising of *S. nudiflora*, *D. annulatum* and a salt tolerant shrub *Prosopischilensis*, Stuntz. Grassland site near Velavadar Black Buck National Park was inhabited by *Sporoboluscoromandellianus*, Link., *S. maritimus* and *Echinopsechinatus*, Roxb. Thus, coastal vegetation of 'Bhal' region included 3 major groups of plants, namely highly salt tolerant halophytes, moderately salt tolerant species and aquatic plants.

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