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PHYTOSOCIOLOGICAL STUDY OF RIPARIAN FLORA OF SABARMATI RIVER IN PRANTIJ TALUKA OF SABARKANTHA DISTRICT, GUJARAT, INDIA

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Abstract: The main objective of this study was to record the floristic abundance in the riparian zone of Sabarmati river in Prantij taluka of Sabarkantha district of Gujarat state to highlight its current status. Transect-based quadrate surveys have been conducted in six sampling sites along the Sabarmati riverine stretch. A total of 197 plant species were recorded of which, trees represented 19 species, shrubs represented 27 species, and herb, grasses and sedges were represented by 120 species and 31 species were climbers. Among the tree species, *Prosopis juliflora* showed the highest density (166.67 ind./ha), whereas among the shrub species, *Cassia auriculata* showed the highest density (549.33 ind./ha). Regarding herb species, *Tephrosia purpurea* represented the highest density (2.353 ind./sq.m) and frequency (52 %). Moreover, the highest importance value index was measured in *Prosopis juliflora* (IVI-57.8) among trees, *Cassia auriculata* (IVI-27.86) among shrubs and *Tephrosia purpurea* (IVI-17.44) among herbs. The Abundance/Frequency ratio of trees species showed regular distribution pattern, shrub and climber species showed that 5 species (8%) had contagious distribution, 23 species (40%) had random distribution and 30 species (52%) had regular distribution, whereas herb species showed contagious distribution pattern within the study area. The present study also includes α diversity (Shannon diversity index, Simpson's Index, species richness, evenness index) of the riparian flora of Sabarmati river.

Key words: Phytosociological, Abundance/Frequency, α diversity, Riparian

INTRODUCTION

The small strips of land adjacent to streams, rivers, lakes, reservoirs, and wetlands are “Riparian regions” and biotic communities living along the shoreline of rivers are known as “riparian” (Vaheeda and Uma, 2013; Priyadarshana et al., 2009). Riparian regions are among the most complex, dynamic, and diverse, ecosystems on the mother earth (Malanson 1993, Naiman and Decamps 1997). Riparian ecosystems contain a rich array of important species and are called corridors of biodiversity (Corbacho et al., 2003).They are the transition area between terrestrial and aquatic environments. The riparian region provides many ecosystem services such as preventing soil erosion, flood prevention, enhancement of wildlife corridors, provide habitats for high number of species, etc. The ecological integrity of river ecosystems is directly related to the integrity of the plant communities that make up and surround the river catchments and their ecological characteristics. Riparian vegetation is the complex plant communities found in the Riparian region. It includes plant species that are substantially different from those in upland ecosystems, therefore, regional wealth around the globe is enhanced by riparian vegetation (Sabo et al., 2005). Under the influence of waterways such as rivulet banks or riverbanks, it links terrestrial and aquatic habitat, represented by a specific type of vegetation that grows along the sides of rivers, called the river's riparian zone (Dutta et al., 2011). The riparian vegetation mainly comprise of macrophytes, native grasses, sedges, climbers, shrubs and trees (Dutta et al., 2011). Riparian plant species exhibit a variety of morphological, physiological and life history adaptations in these variable and complex environments that allow them to survive (Capon, S. J., and Dowe, J. L. 2007). The riparian vegetation has many ecological roles, such as providing shelter and food to the terrestrial and aquatic animals, obstructing and isolating environmental contaminants, maintaining the water level and stabilizing the banks, balancing stream temperatures through canopy shadows, providing rich organic matter in the form of litter fall etc. The riparian areas are also reported as the most productive and species-rich ecosystem as well as at the same time vulnerable to human disturbances (Malanson, 1993). Intense usage of riparian zone for agriculture activities and other purposes have caused disturbance and spatial variation in the native species richness, composition and productivity (Corbacho et al. 2003; Aguiar and Ferreira 2005; Smakhtin, V. Y. 2006).

Gujarat is the western most maritime state in the country as well as seventh largest in terms of the area covered in India. The state is bestowed with various geomorphological features giving rise to a variety of habitats and consequently rich biodiversity. Gujarat has total 185 river basins, of which 17 major river basins in present in North and South Gujarat, 71 river basins occur in Saurashtra region and 97 river basins are in Kachchh (https://indiawris.gov.in/wiki/doku.php?id=gujarat). The Sabarmati is one of the major west flowing rivers of Gujarat and originates from the mountain range of Aravalli in the Udaipur District of Rajasthan state in India. The river holds both religious as well

as historical significance in the India's struggle for independence by establishing the Sabarmati ashram on river bank. Moreover, the river plays a major role in providing water for the cities surrounding it.

In past, different aspects of Riparian flora have been studied by many researchers (Bachan, 2003; Shah et al., 2015; Sankhwal et al., 2015; Maitreya B. B., 2015; Sunil et al., 2016; Jamtsho and Sridith, 2017). Though several reports on riparian flora are available but the entire floristic composition and quantification of riparian flora of Sabarmati river of Prantij Taluka of Sabarkantha District has not been done. As the riparian areas are rapidly changing and are most prone to devastation, there is a need to create information about the floristic diversity on and around the riparian areas. Because of a number of factors, species diversity can change over time and in different locations. Therefore, seasonal assessment is essential. The present study aims to generate such information of riparian flora of Prantij Taluka of Sabarkantha District, Gujarat.

STUDY AREA

A large part of the course of the Sabarmati flows through Gujarat state. The river passes from the range of Aravalli to the western sloping districts of Mehasana and Sabarkantha, and then flows through the sloping south ward of Gujarat's Kheda and Ahmedabad districts before emptying into the Gulf of Khambhat. This study was carried out in Indrajpur, Poyda, Oran, Sadodiya, Vaghpur and Ged, villages falling in the riparian zone of Sabarmati river of Prantij taluka, Sabarkantha district (Fig. 1). The soil of Prantij taluka of Sabarkantha district is Sandy loam to sandy in nature (http://www.gujenvis.nic.in/PDF/soil.pdf) and the taluka received an average rainfall of 825 mm during 1990 to 2019 (State Emergency Operation Centre, Revenue Department, 2020).

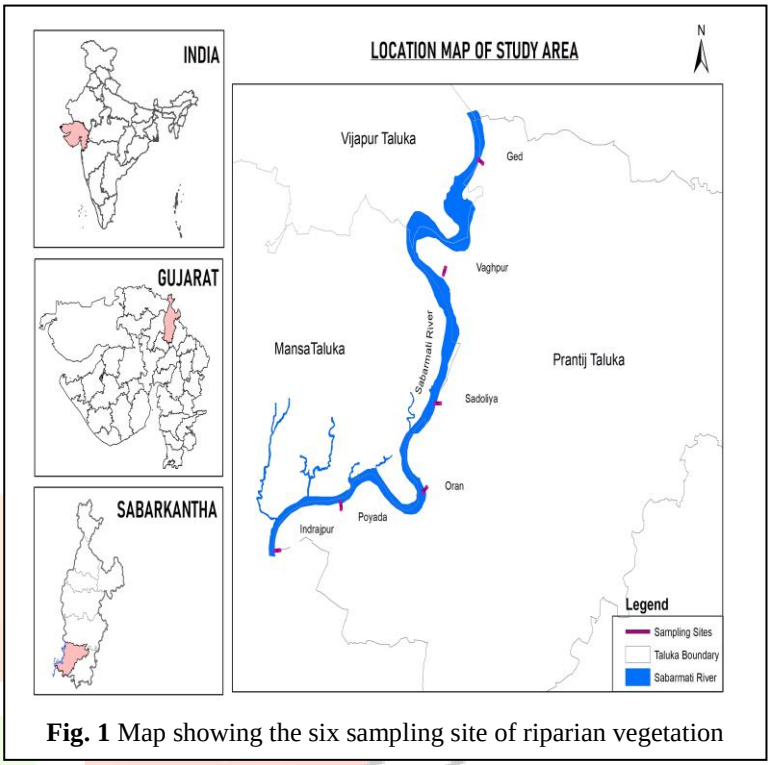

Fig. 1 Map showing the six sampling site of riparian vegetation

MATERIAL AND METHODOLOGY

Field data collection

The present work is based on the survey of vegetation occurring in riparian areas of Prantij Taluka of Sabarkantha district in the year 2020. For this study, random sampling method was followed and the area was surveyed on foot. In the riparine area, line transects were laid perpendicular to River bank towards landward side and distance of 5 km between two subsequent line intersects was maintained using Global Positioning System (GPS). Inside each transect, nested quadrates were laid at an interval of 50 m and the size of quadrates were 20m×20m for trees, 5m ×5m for shrubs and climbers, 1m×1m for herbs, grasses and sedges. Transects were started from the edge of the river and ended where the riparian vegetation subsided and agricultural land started. The riparian areas of Sabarmati river of Prantij taluka in Sabarkantha District were explored by laying a total of 06 transacts comprising of 150 quadrates of 1m×1m size, 150 quadrates of 5m×5m size and 30 quadrates of 20m×20m size. Within each sampling plot the number and name of all the trees, shrubs and herbs were counted and recorded. Documentation was done in the form of photographs as well as the plants were collected in the flowering and fruiting stages for identification using floristic keys of Cooke (1908), Santapau (1962), Santapau and Janardhanan (1967), Shah (1978) and Bhole and Pathak (1988).

Table 1. Brief description of study area

S.N.	Name of Sampling Sites	GPS Coordinates	Quadrate			Area Studied (sq.m)
			1 (sq.m)	5 (sq.m)	20 (sq.m)	
1	Indrajpur	N23 23 16.4 E72 43 26.1	25	25	5	2000
2	Poyada	N23 24 22.7 E72 45 36.0	25	25	5	2000
3	Oran	N23 24 36.8 E72 48 15.1	25	25	5	2000
4	Sadodiya	N23 26 33.0 E72 48 37.3	25	25	5	2000
5	Vaghpur	N23 29 21.4 E72 48 51.1	25	25	5	2000
6	Ged	N23 31 52.0 E72 49 55.6	25	25	5	2000

Data Analysis

Phytosociological characters such as Density (D), Relative Density (RD), Frequency (F), Relative Frequency (RF), Abundance (A), Relative Abundance (RA) and Importance Value Index (IVI) were calculated through Shukla and Chandel (2000) and abundance frequency ratio (A/F) for tree, shrub and herb species were also calculated through distribution patterns of Whitford (1948). Moreover, plant biodiversity of the study area was calculated by using different standard equations of Michael 1990 (Shannon- Wiener diversity index), Simpson 1949 (Simpson's index), Pielou 1966 (Evenness index) and Margalef, 1958 (Species richness index).

RESULTS AND DISCUSSION

A. Qualitative analysis

Riparian area of the Sabarmati river in Prantij taluka of Sabrkantha district were found predominantly covered with shrubby and herbaceous species including grasses. A total 196 Angiosperm and 1 Pteridophyte species belonging to 147 Genera and 58 Families were recorded (Table-2)

Angiosperm plant diversity includes 169 Dicot and 27 Monocot species. The ratio of Monocots to Dicots was 1:13.3 Families, 1: 6 Genera and 1:6.3 Species. The ratio of Family to Genera and Species was 1: 2.5: 3.4.

Among 169 dicot species sub-class Polypetalae exhibited the highest number of species (81 species), followed by Gamopetalae (70 species) and Monochlamydeae (18 species). Within Polypetalae, Calyciflorae group was represented with the maximum number of species (44), followed by Thalamiflorae (27 Species) and Disciflorae (10 Species). Ratio of subclasses, Polypetalae to Gamopetalae to Monochlamydae was 1:0.9:0.2 and in the subclass Polypetalae, ratio of groups Thalamiflorae to Disciflorae to Calyciflorae was 1:0.4:1.6, Gamopetalae distribution of groups Inferae to Heteromarae to Bicarpellate was 1:0.1:3.0, Monochlamydeae distribution of groups Curvembryeae to Unisexuales was 1:1 (Fig.-2).

Among 27 Monocot plant species, a total 15% species belongs to Coronarieae, 85% belongs to Glumaceae. Distribution of series, Coronarieae to Glumaceae was 1:5.75.

During study, it was revealed that Poaceae was the largest family in Monocotyledons represented by 19 Species and 16 Genera, whereas Fabaceae was the largest family among Dicotyledons represented by 19 Species and 13 Genera. Out of 57 Angiospermic families, only 27 families were represented with more than half of the species recorded and 30 families were represented with single species.

Table 2. Floral richness in Riparian zone of Sabarmati river of Prantij taluka, Sabarkantha district of Gujarat state

	Family	Genera	Species
A. Angiosperms			
Dicotyledons	53	125	169
Monocotyledons	4	21	27
B. Pteridophytes	1	1	1
Total	**58**	**147**	**197**

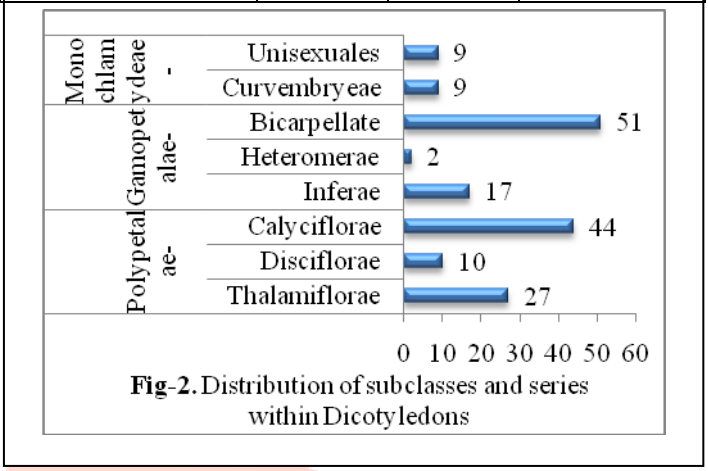

Fig-2. Distribution of subclasses and series within Dicotyledons

The genera *Ipomoea* had the highest number of species i.e. 6 followed by *Indigofera* genera represented with 5 species, *Acacia* and *Cassia* genera both represented with 4 species. Among recorded 147 genera, 7 genera were represented by three species, 21 genera were represented by two species and 115 genera were represented with single species.

Habit wise distribution of angiosperms is illustrated in Fig.-3. Among 197 recorded species, herbs were represented by the highest number of species (97), followed by climber (31), shrubs (27), grasses & sedges (23) and trees (19) species. Among 6 villages, the highest species diversity was found in Indrajpur and Sadodiya (107 species) from each, followed by Poyda (95), Oran (87), Vaghpur (77) and Ged (66) species. (Fig.-4)

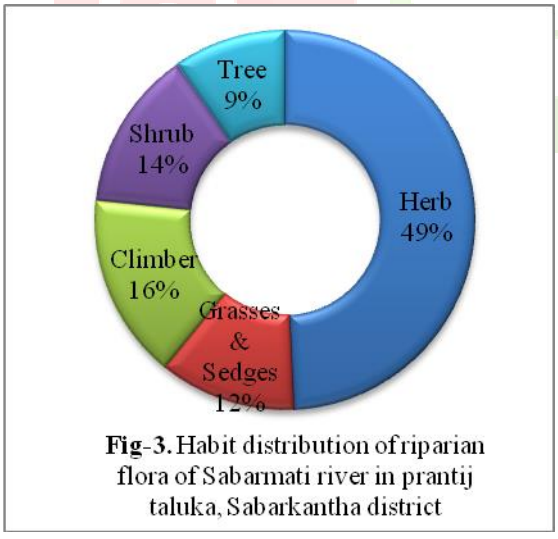

Fig-3. Habit distribution of riparian flora of Sabarmati river in prantij taluka, Sabarkantha district

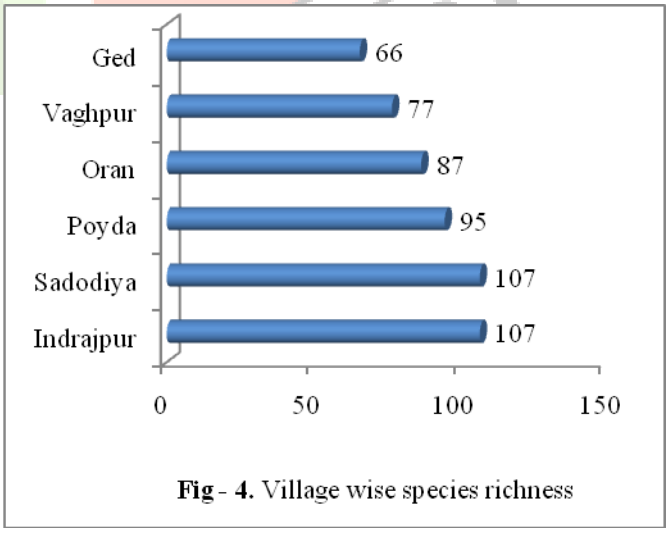

Fig - 4. Village wise species richness

B. Quantitative analysis

The density, abundance and distribution of individual species are measurable indicators of plant diversity (Wattenberg and Breckle, 1995).

Trees:

During the study, 19 tree species were recorded in the quadrate sampling plot. Among the tree species, the highest density was measured in *Prosopis juliflora* (166.67 ind./ha) followed by *Balanites aegyptiaca* (70.00 ind./ha), *Acacia senegal* (60.83 ind./ha). On the other hand, the lowest density (0.83 ind./ha) was observed in *Cordia gharaf* and *Moringa oleifera* (Table-3). The highest frequency was calculated in *Prosopis juliflora* (80.00 %) followed by *Acacia senegal* (60.00 %) and *Acacia leucophloea* (44.17 %). The lowest frequency (3.3 %) was calculated in *Flacourtia indica, Cordia gharaf* and *Moringa oleifera* (Table-3).

Distribution of species is one of the important aspects of ecological studies, which has attracted attention of a number of ecologists (Frackler and Brischle, 1944; Cole, 1946; Whitford, 1948 and Ashby, 1948). A value of abundance and frequency ratio below 0.025 was

considered as regular distribution, between 0.025 to 0.050 as random and more than 0.050 represented as contagious distribution pattern (Cottam and Curtis, 1956). In the present study, A/F values for different tree species revealed that all the species had regular distribution pattern in the riparian zone of Sabarmati river (Table-3). A similar observation was found for 107 tree species of tropical forest of Eastern Ghats, India, which showed regular distribution pattern (Reddy and Ugle, 2008).

It is said that species with the greatest importance value are the leading dominant of the particular vegetation. Importance Value Index (IVI) determines the extent of dominance of a species in the structure of a forest stand (Curtis and McIntosh, 1951). Accordingly, the leading dominant tree species from riparian zone of Sabarmati river in Prantij taluka was *Prosopis juliflora* (IVI-57.8) followed by *Balanites aegyptiaca* (IVI-30.8) and *Acacia senegal* (IVI-28.1). On the other hand, the least dominant species with 2.5 IVI value were *Cordia gharaf* and *Moringa oleifera* (Table-3).

Table 3 Phytosociological attributes of tree species recorded in Riparian zone of Sabarmati river of Prantij Taluka, Sabarkantha district, Gujarat state

S N	Botanical Name	D (ind./ha)	F (%)	A	A/F	RD (%)	RF (%)	RA (%)	IVI
1	*Prosopis juliflora*	166.67	80.0	0.021	0.0003	29.33	13.4	15.1	57.8
2	*Balanites aegyptiaca*	70.00	50.0	0.014	0.0003	12.32	8.4	10.1	30.8
3	*Acacia senegal*	60.83	60.0	0.010	0.0002	10.70	10.1	7.3	28.1
4	*Anogeissus latifolia*	45.00	33.3	0.014	0.0004	7.92	5.6	9.8	23.3
5	*Acacia leucophloea*	44.17	56.7	0.008	0.0001	7.77	9.5	5.6	22.9
6	*Azadirachta indica*	30.00	56.7	0.005	0.0001	5.28	9.5	3.8	18.6
7	*Holoptelea integrifolia*	30.00	43.3	0.007	0.0002	5.28	7.3	5.0	17.6
8	*Acacia nilotica*	29.17	40.0	0.007	0.0002	5.13	6.7	5.3	17.1
9	*Diospyros cordifolia*	26.67	33.3	0.008	0.0002	4.69	5.6	5.8	16.1
10	*Salvadora oleoides*	25.83	60.0	0.004	0.0001	4.55	10.1	3.1	17.7
11	*Prosopis cineraria*	13.33	26.7	0.005	0.0002	2.35	4.5	3.6	10.4
12	*Acacia tortilis*	6.67	13.3	0.005	0.0004	1.17	2.2	3.6	7.0
13	*Ziziphus mauritiana*	5.83	10.0	0.006	0.0006	1.03	1.7	4.2	6.9
14	*Nyctanthes arbor-tristis*	4.17	6.7	0.006	0.0009	0.73	1.1	4.5	6.4
15	*Salvadora persica*	4.17	10.0	0.004	0.0004	0.73	1.7	3.0	5.4
16	*Wrightia tinctoria*	2.50	6.7	0.004	0.0006	0.44	1.1	2.7	4.3
17	*Flacourtia indica*	1.67	3.3	0.005	0.0015	0.29	0.6	3.6	4.5
18	*Cordia gharaf*	0.83	3.3	0.003	0.0008	0.15	0.6	1.8	2.5
19	*Moringa oleifera*	0.83	3.3	0.003	0.0008	0.15	0.6	1.8	2.5
	Total					**100.00**	**100.00**	**100.00**	**300.00**

D (ind./ha)= Density (Individual/hector), F (%)= Frequency (Percent), A= Abundance, A/F= Abundance/Frequency, RD (%)= Relative Density (Percent), RF(%)= Relative Frequency (Percent), RA (%)= Relative Abundance (Percent) , IVI= Importance Value Index

Shrubs and Climbers:

During quadrate study a total of 58 shrub and climber species were recorded. Among the shrub and climber species, the highest density was measured in *Cassia auriculata* (549.33 ind./ha) followed by *Ziziphus nummularia* (450.67 ind./ha) and *Maytenus emarginata* (346.67 ind./ha). On the other hand, the lowest density (2.67 ind./ha) was calculated in *Adhatoda vasica*, *Cissampelos pareira*, *Clitoria ternatea*, *Cuscuta reflexa*, *Hemidesmus indicus*, *Ipomoea eriocarpa*, *Trichosanthes cucumerina* and *Wattakaka volubilis* (Table 4).

However, the highest frequency was found in *Cassia auriculata* (56.00 %) followed by *Grewia tenax* (42.00 %), *Ziziphus nummularia* (39.33%) whereas the lowest frequency (0.67 %) was showed by 21 plant species such as *Ipomoea fistulosa*, *Plumbago zeylanica*, *Abrus precatorius*, *Alhagi pseudalhagi*, *Clerodendrum multiflorum* etc. (Table 4).

In the present study, A/F values for different shrub and climber species revealed that, out of the 58 shrub and climber species encountered, 5 species (8%) showed contagious distribution, 23 species (40%) had random distribution and 30 species (52%) had regular distribution (Table 4). In general, a regular distribution pattern is indicated by higher frequency and lower abundance, while a contagious distribution is indicated by the opposite. In general, regular distribution occurs where severe competition exists between individuals; random distribution is found in very uniform environment and contagious distribution is common in nature (Odum, 1971). Sobuj and Rahman (2011) discovered both contagious and random distribution of shrub species in Bangladesh's Khadimnagar National Park during their research.

The leading dominant shrub and climber species of the study area was *Cassia auriculata* (IVI-27.86) followed by *Ziziphus nummularia* (IVI-22.24) and *Grewia tenax* (IVI-19.31). The least dominant species with IVI-1.14 were *Adhatoda vasica*, *Cissampelos pareira*, *Clitoria ternatea*, *Cuscuta reflexa*, *Hemidesmus indicus*, *Ipomoea eriocarpa*, *Trichosanthes cucumerina* and *Wattakaka volubilis* (Table 4).

Table 4 Phytosociological attributes of shrub and climber species recorded in Riparian zone of Sabarmati river of Prantij Taluka, Sabarkantha district, Gujarat state

S N	Botanical Name	D (ind./ha)	F (%)	A	A/F	RD (%)	RF (%)	RA (%)	IVI
1	*Cassia auriculata*	549.33	56.00	0.098	0.002	13.70	11.88	2.28	27.86
2	*Ziziphus nummularia*	450.67	39.33	0.115	0.003	11.24	8.35	2.66	22.24
3	*Maytenus emarginata*	346.67	38.67	0.090	0.002	8.64	8.20	2.08	18.93

S N	Botanical Name	D (ind./ha)	F (%)	A	A/F	RD (%)	RF (%)	RA (%)	IVI
4	*Grewia tenax*	341.33	42.00	0.081	0.002	8.51	8.91	1.89	19.31
5	*Capparis decidua*	325.33	38.67	0.084	0.002	8.11	8.20	1.95	18.27
6	*Dichrostachys cinerea*	258.67	29.33	0.088	0.003	6.45	6.22	2.05	14.72
7	*Commiphora wightii*	248.00	25.33	0.098	0.004	6.18	5.37	2.27	13.83
8	*Calotropis procera*	157.33	16.00	0.098	0.006	3.92	3.39	2.28	9.60
9	*Tinospora cordifolia*	106.67	13.33	0.080	0.006	2.66	2.83	1.86	7.35
10	*Barleria prionitis*	101.33	11.33	0.089	0.008	2.53	2.40	2.08	7.01
11	*Pavonia zeylanica*	101.33	12.00	0.084	0.007	2.53	2.55	1.96	7.03
12	*Rhynchosia minima*	88.00	13.33	0.066	0.005	2.19	2.83	1.53	6.56
13	*Pergularia daemia*	82.67	12.67	0.065	0.005	2.06	2.69	1.52	6.26
14	*Pentatropis spiralis*	61.33	12.00	0.051	0.004	1.53	2.55	1.19	5.26
15	*Rivea hypocrateriformis*	61.33	8.67	0.071	0.008	1.53	1.84	1.64	5.01
16	*Capparis sepiaria*	58.67	8.00	0.073	0.009	1.46	1.70	1.70	4.86
17	*Abutilon ramosum*	56.00	5.33	0.105	0.020	1.40	1.13	2.44	4.97
18	*Asparagus racemosus*	50.67	9.33	0.054	0.006	1.26	1.98	1.26	4.50
19	*Crotalaria burhia*	45.33	5.33	0.085	0.016	1.13	1.13	1.97	4.24
20	*Cocculus hirsutus*	42.67	6.67	0.064	0.010	1.06	1.41	1.49	3.97
21	*Datura metel*	42.67	5.33	0.080	0.015	1.06	1.13	1.86	4.05
22	*Grewia villosa*	40.00	5.33	0.075	0.014	1.00	1.13	1.74	3.87
23	*Dalechampia scandens*	37.33	4.00	0.093	0.023	0.93	0.85	2.17	3.95
24	*Securinega virosa*	37.33	6.00	0.062	0.010	0.93	1.27	1.45	3.65
25	*Ipomoea triloba*	32.00	4.00	0.080	0.020	0.80	0.85	1.86	3.51
26	*Grewia flavescens*	29.33	4.67	0.063	0.013	0.73	0.99	1.46	3.18
27	*Mukia maderaspatana*	26.67	4.67	0.057	0.012	0.66	0.99	1.33	2.98
28	*Vernonia cinerascens*	26.67	3.33	0.080	0.024	0.66	0.71	1.86	3.23
29	*Abutilon indicum*	18.67	2.67	0.070	0.026	0.47	0.57	1.63	2.66
30	*Ctenolepis garcinii*	18.67	3.33	0.056	0.017	0.47	0.71	1.30	2.47
31	*Euphorbia neriifolia*	13.33	1.33	0.100	0.075	0.33	0.28	2.32	2.94
32	*Ipomoea pes-tigridis*	13.33	2.00	0.067	0.033	0.33	0.42	1.55	2.31
33	*Aerva javanica*	10.67	1.33	0.080	0.060	0.27	0.28	1.86	2.41
34	*Ipomoea fistulosa*	10.67	0.67	0.160	0.240	0.27	0.14	3.72	4.12
35	*Cardiospermum halicacabum*	8.00	1.33	0.060	0.045	0.20	0.28	1.39	1.88
36	*Coccinia grandis*	8.00	1.33	0.060	0.045	0.20	0.28	1.39	1.88
37	*Mucuna Prurita*	8.00	2.00	0.040	0.020	0.20	0.42	0.93	1.55
38	*Plumbago zeylanica*	8.00	0.67	0.120	0.180	0.20	0.14	2.79	3.13
39	*Telosma pallida*	8.00	1.33	0.060	0.045	0.20	0.28	1.39	1.88
40	*Abrus precatorius*	5.33	0.67	0.080	0.120	0.13	0.14	1.86	2.13
41	*Alhagi pseudalhagi*	5.33	0.67	0.080	0.120	0.13	0.14	1.86	2.13
42	*Cadaba fruticosa*	5.33	0.67	0.080	0.120	0.13	0.14	1.86	2.13
43	*Cayratia carnosa*	5.33	0.67	0.080	0.120	0.13	0.14	1.86	2.13
44	*Clerodendrum multiflorum*	5.33	0.67	0.080	0.120	0.13	0.14	1.86	2.13
45	*Cocculus pendulus*	5.33	0.67	0.080	0.120	0.13	0.14	1.86	2.13
46	*Cucumis callosus*	5.33	0.67	0.080	0.120	0.13	0.14	1.86	2.13
47	*Ipomoea biflora*	5.33	0.67	0.080	0.120	0.13	0.14	1.86	2.13
48	*Luffa acutangula*	5.33	0.67	0.080	0.120	0.13	0.14	1.86	2.13
49	*Momordica balsamina*	5.33	0.67	0.080	0.120	0.13	0.14	1.86	2.13
50	*Ziziphus oenoplia*	5.33	0.67	0.080	0.120	0.13	0.14	1.86	2.13
51	*Adhatoda vasica*	2.67	0.67	0.040	0.060	0.07	0.14	0.93	1.14
52	*Cissampelos pareira*	2.67	0.67	0.040	0.060	0.07	0.14	0.93	1.14
53	*Clitoria ternatea*	2.67	0.67	0.040	0.060	0.07	0.14	0.93	1.14
54	*Cuscuta reflexa*	2.67	0.67	0.040	0.060	0.07	0.14	0.93	1.14
55	*Hemidesmus indicus*	2.67	0.67	0.040	0.060	0.07	0.14	0.93	1.14
56	*Ipomoea eriocarpa*	2.67	0.67	0.040	0.060	0.07	0.14	0.93	1.14
57	*Trichosanthes cucumerina*	2.67	0.67	0.040	0.060	0.07	0.14	0.93	1.14
58	*Wattakaka volubilis*	2.67	0.67	0.040	0.060	0.07	0.14	0.93	1.14
	Total					**100.00**	**100.00**	**100.00**	**300.00**

D (ind./ha)= Density (Individual/hector), F (%)= Frequency (Percent), A= Abundance, A/F= Abundance/Frequency, RD (%)= Relative Density (Percent), RF(%)= Relative Frequency (Percent), RA (%)= Relative Abundance (Percent) , IVI= Importance Value Index

Herbs:

With respect to the herb species, a total of 120 species were enumerated during quadrate study. The highest density was measured in *Tephrosia purpurea* (2.35 ind./sq.m), followed by *Apluda mutica* (1.87 ind./sq.m) and *Oropetium thomaeum* (1.73 ind./sq.m). On the other

hand the lowest density (0.007 ind./sq.m) was calculated in 14 species such as *Argemone mexicana, Chloris virgata, Citrullus colocynthis, Cyperus difformis* and *Digera muricata* etc. (Table 5).

However, the highest frequency was measured in *Tephrosia purpurea* (52 %), followed by *Justicia simplex* (48 %) and *Apluda mutica* (46 %). On the otherhand, the lowest frequency (0.67 %) was calculated in 29 species such as *Marsilea quadrifolia, Aerva lanata, Caesulia axillaris, Catharanthus pusillus, Eclipta prostrata* and *Indigofera oblongifolia* etc. (Table 5).

The A/F ratio of herb species in the riparian zone of Sabarmati river indicated contagious distribution pattern as ratio is higher than 0.05 (Table 5). A similar observation was found for herb species of a deforested area in Bangladesh which showed contagious distribution (Al-Amin et al., 2004). According to Odum (1971), the study area was not completely uniform because several species showed contagious distribution. Contagious distribution depends on local habitat, seasonal weather changes and reproductive processes.

Based on IVI, *Tephrosia purpurea* (IVI-17.44) was most dominant species followed by *Apluda mutica* (IVI-14.56) and *Justicia simplex* (IVI-12.73). On the other hand, 14 species were least dominant with IVI-0.49 such as *Argemone mexicana, Chloris virgata, Citrullus colocynthis, Cyperus difformis* and *Digera muricata* etc. (Table-5)

Table 5 Phytosociological attributes of herbaceous species recorded in Riparian zone of Sabarmati river of Prantij Taluka, Sabarkantha district, Gujarat state

S N	Botanical Name	D (sq. m)	F (%)	A	A/F	RD (%)	RF (%)	RA (%)	IVI
1	*Tephrosia purpurea*	2.353	52.00	4.53	0.09	9.68	6.03	1.73	17.44
2	*Apluda mutica*	1.867	46.00	4.06	0.09	7.68	5.33	1.55	14.56
3	*Oropetium thomaeum*	1.727	28.00	6.17	0.22	7.10	3.25	2.36	12.70
4	*Justicia simplex*	1.460	48.00	3.04	0.06	6.00	5.56	1.16	12.73
5	*Cynodon dactylon*	1.220	27.33	4.46	0.16	5.02	3.17	1.71	9.89
6	*Neuracanthus sphaerostachyus*	0.853	27.33	3.12	0.11	3.51	3.17	1.19	7.87
7	*Indigofera cordifolia*	0.793	25.33	3.13	0.12	3.26	2.94	1.20	7.40
8	*Lindenbergia muraria*	0.787	32.00	2.46	0.08	3.23	3.71	0.94	7.88
9	*Chloris barbata*	0.733	26.00	2.82	0.11	3.02	3.01	1.08	7.11
10	*Cassia tora*	0.620	20.00	3.10	0.16	2.55	2.32	1.19	6.05
11	*Lepidagathis trinervis*	0.607	24.67	2.46	0.10	2.49	2.86	0.94	6.29
12	*Blepharis maderaspatensis*	0.560	19.33	2.90	0.15	2.30	2.24	1.11	5.65
13	*Enicostemma hyssopifolium*	0.533	19.33	2.76	0.14	2.19	2.24	1.06	5.49
14	*Triumfetta rotundifolia*	0.447	16.00	2.79	0.17	1.84	1.85	1.07	4.76
15	*Dactyloctenium scindicum*	0.420	12.67	3.32	0.26	1.73	1.47	1.27	4.46
16	*Vernonia cinerea*	0.407	24.67	1.65	0.07	1.67	2.86	0.63	5.16
17	*Dipteracanthus patulus*	0.393	19.33	2.03	0.11	1.62	2.24	0.78	4.64
18	*Tridax procumbens*	0.393	20.00	1.97	0.10	1.62	2.32	0.75	4.69
19	*Pulicaria wightiana*	0.353	16.67	2.12	0.13	1.45	1.93	0.81	4.20
20	*Indigofera linnaei*	0.320	8.67	3.69	0.43	1.32	1.00	1.41	3.73
21	*Borreria stricta*	0.313	8.00	3.92	0.49	1.29	0.93	1.50	3.71
22	*Goniogyna hirta*	0.313	12.00	2.61	0.22	1.29	1.39	1.00	3.68
23	*Dichanthium annulatum*	0.307	12.00	2.56	0.21	1.26	1.39	0.98	3.63
24	*Peristrophe bicalyculata*	0.307	13.33	2.30	0.17	1.26	1.55	0.88	3.69
25	*Triumfetta rhomboidea*	0.300	12.67	2.37	0.19	1.23	1.47	0.91	3.61
26	*Ocimum canum*	0.293	15.33	1.91	0.12	1.21	1.78	0.73	3.72
27	*Blepharis repens*	0.287	12.67	2.26	0.18	1.18	1.47	0.87	3.51
28	*Justicia quinqueangularis*	0.227	5.33	4.25	0.80	0.93	0.62	1.63	3.18
29	*Sida cordata*	0.227	12.00	1.89	0.16	0.93	1.39	0.72	3.05
30	*Achyranthes aspera*	0.213	10.67	2.00	0.19	0.88	1.24	0.76	2.88
31	*Cenchrus ciliaris*	0.193	6.67	2.90	0.44	0.79	0.77	1.11	2.68
32	*Sporobolus coromandelianus*	0.187	4.00	4.67	1.17	0.77	0.46	1.78	3.02
33	*Xanthium strumarium*	0.180	10.00	1.80	0.18	0.74	1.16	0.69	2.59
34	*Heteropogon contortus*	0.160	6.00	2.67	0.44	0.66	0.70	1.02	2.37
35	*Boerhaavia diffusa*	0.153	10.00	1.53	0.15	0.63	1.16	0.59	2.38
36	*Evolvulus alsinoides*	0.153	7.33	2.09	0.29	0.63	0.85	0.80	2.28
37	*Melanocenchris jacquemontii*	0.153	3.33	4.60	1.38	0.63	0.39	1.76	2.78
38	*Digitaria ciliaris*	0.140	4.67	3.00	0.64	0.58	0.54	1.15	2.26
39	*Alternanthera sessilis*	0.127	6.00	2.11	0.35	0.52	0.70	0.81	2.02
40	*Borreria articularis*	0.120	7.33	1.64	0.22	0.49	0.85	0.63	1.97
41	*Corchorus aestuans*	0.120	7.33	1.64	0.22	0.49	0.85	0.63	1.97
42	*Senna uniflora*	0.113	4.67	2.43	0.52	0.47	0.54	0.93	1.94
43	*Convolvulus prostratus*	0.107	5.33	2.00	0.38	0.44	0.62	0.76	1.82
44	*Phyla nodiflora*	0.107	4.67	2.29	0.49	0.44	0.54	0.87	1.85
45	*Euphorbia hirta*	0.100	6.00	1.67	0.28	0.41	0.70	0.64	1.74
46	*Phyllanthus maderaspatensis*	0.100	5.33	1.88	0.35	0.41	0.62	0.72	1.75
47	*Acanthospermum hispidum*	0.093	6.00	1.56	0.26	0.38	0.70	0.59	1.67
48	*Ammannia baccifera*	0.093	4.67	2.00	0.43	0.38	0.54	0.76	1.69
49	*Blumea mollis*	0.093	3.33	2.80	0.84	0.38	0.39	1.07	1.84
50	*Launaea procumbens*	0.087	4.67	1.86	0.40	0.36	0.54	0.71	1.61

S N	Botanical Name	D (sq. m)	F (%)	A	A/F	RD (%)	RF (%)	RA (%)	IVI
51	*Trichodesma indicum*	0.087	5.33	1.63	0.30	0.36	0.62	0.62	1.60
52	*Dactyloctenium aegyptium*	0.073	3.33	2.20	0.66	0.30	0.39	0.84	1.53
53	*Dicoma tomentosa*	0.073	3.33	2.20	0.66	0.30	0.39	0.84	1.53
54	*Fimbristylis dichotoma*	0.073	2.00	3.67	1.83	0.30	0.23	1.40	1.94
55	*Pupalia lappacea*	0.073	4.67	1.57	0.34	0.30	0.54	0.60	1.44
56	*Tephrosia strigosa*	0.073	4.67	1.57	0.34	0.30	0.54	0.60	1.44
57	*Brachiaria ramosa*	0.067	2.67	2.50	0.94	0.27	0.31	0.96	1.54
58	*Dinebra retroflexa*	0.067	1.33	5.00	3.75	0.27	0.15	1.91	2.34
59	*Crotalaria medicaginea*	0.060	3.33	1.80	0.54	0.25	0.39	0.69	1.32
60	*Cyperus rotundus*	0.060	2.00	3.00	1.50	0.25	0.23	1.15	1.63
61	*Echinochloa colonum*	0.060	2.67	2.25	0.84	0.25	0.31	0.86	1.42
62	*Waltheria indica*	0.060	4.00	1.50	0.38	0.25	0.46	0.57	1.28
63	*Marsilea quadrifolia*	0.053	0.67	8.00	12.0	0.22	0.08	3.06	3.36
64	*Solanum surattense*	0.053	2.67	2.00	0.75	0.22	0.31	0.76	1.29
65	*Cenchrus biflorus*	0.047	2.67	1.75	0.66	0.19	0.31	0.67	1.17
66	*Indigofera tinctoria*	0.047	2.00	2.33	1.17	0.19	0.23	0.89	1.32
67	*Leucas aspera*	0.047	3.33	1.40	0.42	0.19	0.39	0.54	1.11
68	*Parthenium hysterophorus*	0.047	3.33	1.40	0.42	0.19	0.39	0.54	1.11
69	*Urginea indica*	0.047	2.00	2.33	1.17	0.19	0.23	0.89	1.32
70	*Alysicarpus monilifer*	0.040	2.00	2.00	1.00	0.16	0.23	0.76	1.16
71	*Eragrostis tremula*	0.040	2.67	1.50	0.56	0.16	0.31	0.57	1.05
72	*Merremia gangetica*	0.040	2.67	1.50	0.56	0.16	0.31	0.57	1.05
73	*Pentatropis capensis*	0.040	3.33	1.20	0.36	0.16	0.39	0.46	1.01
74	*Physalis minima*	0.040	2.67	1.50	0.56	0.16	0.31	0.57	1.05
75	*Tribulus terrestris*	0.040	2.00	2.00	1.00	0.16	0.23	0.76	1.16
76	*Andrographis echioides*	0.033	2.00	1.67	0.83	0.14	0.23	0.64	1.01
77	*Atylosia scarabaeoides*	0.033	2.00	1.67	0.83	0.14	0.23	0.64	1.01
78	*Cassia occidentalis*	0.033	2.00	1.67	0.83	0.14	0.23	0.64	1.01
79	*Ipomoea obscura*	0.033	2.00	1.67	0.83	0.14	0.23	0.64	1.01
80	*Merremia aegyptia*	0.033	2.67	1.25	0.47	0.14	0.31	0.48	0.92
81	*Pedalium murex*	0.033	1.33	2.50	1.88	0.14	0.15	0.96	1.25
82	*Chenopodium album*	0.027	1.33	2.00	1.50	0.11	0.15	0.76	1.03
83	*Indigofera linifolia*	0.027	1.33	2.00	1.50	0.11	0.15	0.76	1.03
84	*Commelina benghalensis*	0.020	1.33	1.50	1.13	0.08	0.15	0.57	0.81
85	*Commelina diffusa*	0.020	1.33	1.50	1.13	0.08	0.15	0.57	0.81
86	*Corchorus tridens*	0.020	1.33	1.50	1.13	0.08	0.15	0.57	0.81
87	*Croton bonplandianus*	0.020	1.33	1.50	1.13	0.08	0.15	0.57	0.81
88	*Merremia tridentata*	0.020	2.00	1.00	0.50	0.08	0.23	0.38	0.70
89	*Phyllanthus amarus*	0.020	2.00	1.00	0.50	0.08	0.23	0.38	0.70
90	*Polygala erioptera*	0.020	1.33	1.50	1.13	0.08	0.15	0.57	0.81
91	*Aerva lanata*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
92	*Caesulia axillaris*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
93	*Cassia pumila*	0.013	1.33	1.00	0.75	0.05	0.15	0.38	0.59
94	*Catharanthus pusillus*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
95	*Corchorus depressus*	0.013	1.33	1.00	0.75	0.05	0.15	0.38	0.59
96	*Eclipta prostrata*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
97	*Hibiscus caesius*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
98	*Indigofera oblongifolia*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
99	*Leucas urticifolia*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
100	*Ludwigia perennis*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
101	*Mollugo nudicaulis*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
102	*Nothosaerva brachiata*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
103	*Oldenlandia corymbosa*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
104	*Oplismenus burmannii*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
105	*Sida cordifolia*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
106	*Stylosanthes fruticosa*	0.013	0.67	2.00	3.00	0.05	0.08	0.76	0.90
107	*Argemone mexicana*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49
108	*Chloris virgata*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49
109	*Citrullus colocynthis*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49
110	*Cyperus difformis*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49
111	*Cyperus michelianus*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49
112	*Digera muricata*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49
113	*Elephantopus scaber*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49

S N	Botanical Name	D (sq. m)	F (%)	A	A/F	RD (%)	RF (%)	RA (%)	IVI
114	*Heliotropium indicum*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49
115	*Launaea resedifolia*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49
116	*Martynia annua*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49
117	*Phyllanthus fraternus*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49
118	*Sesbania cannabina*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49
119	*Sida spinosa*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49
120	*Trianthema portulacastrum*	0.007	0.67	1.00	1.50	0.03	0.08	0.38	0.49
	Total					**100**	**100**	**100**	**300**

D (ind./sq.m)= Density (Individual/square meter), F (%)= Frequency (Percent), A= Abundance, A/F= Abundance/Frequency, RD (%)= Relative Density (Percent), RF(%)= Relative Frequency (Percent), RA (%)= Relative Abundance (Percent) , IVI= Importance Value Index

PLANT SPECIES DIVERSITY

The biodiversity assessment on the species level is one of the most important indices for assessing ecosystems at various scales (Ardakani, 2004). To assess which community is more diverse, the Shannon-Wiener Index (H') and Simpson's index (c) were used. A high H'Index value indicates a diverse ecosystem with many species, while a low H'Index value indicates a diverse ecosystem with few species (Samantha, 2009). According to Barbour and Burk (1999), an ecosystem with an H' value of more than 2 is considered medium to large in terms of species diversity. The Simpson's Index measures the likelihood that two individuals selected at random will be of the same species. As a consequence, the Simpson's Index (c) has a scale of zero to one. With this index, zero represents the least diverse situation and one represents the most diverse situation (Samantha, 2009). In the present study Shannon-Wiener diversity (H') index and Simpson's index (c) was 4.583 and 0.9849, respectively. Thus the riparian area of Sabarmati river of Prantij Taluka, Sabarkantha District has rationally high species diversity.

The study came with index of dominance of 0.01512 for the riparian area of Sabarmati river of Prantij Taluka, Sabarkantha District. The greater value of index of dominance exhibits the lower species diversity and vice versa in the scale of 0 to 1 (Misra, 1989).

Species richness and evenness are two distinct concepts in heterogeneity, hence it is logical to calculate these two aspects separately. Lloyd and Ghelardi (1964) were the first to suggest that the evenness component of diversity be calculated separately (Krebs, 1989). Evenness refers to the distribution of individuals within a species. Pielou's evenness index (e) was 0.496 and Margalef (1958) species richness index (d) was 25.5 in the study area.

CONCLUSION

Floristic diversity must be evaluated at the local and regional levels in order to acquire information about the current situation for establishing successful conservation management strategies. The results in the present study clearly show that, riparian area of Sabarmati river of Prantij Taluka, Sabarkantha District are rich in phytodiversity. A record of 197 species during the study period reflects that the riparian area of Sabarmati river of Prantij Taluka, Sabarkantha District have the potential to harbour rich species diversity with various ecological services. The present research work provides an evaluation of floral diversity, density, frequency, and important value index, which will assist in the development of a long-term management strategy of riparian flora. Moreover the study results will serve as a primary input towards monitoring and sustaining the phytodiversity of the riparian area of Sabarmati river of Prantij Taluka, Sabarkantha District in the Gujarat state.

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