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Analysis of vegetation of Rampara forest in Saurashtra region of Gujarat state of India

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Abstract: Rampara forest of Saurashtra region of Gujarat state of India was quantitatively analyzed. The total tree basal cover ranged from 180 to 3326 cm^2 100 m^{-2}. The composition of tree and shrub layers was markedly similar among various sites. Site 1 supported the largest shrub population, while site 2 was the poorest in this regard. Site 1 on density basis and site 2 on cover and IVI basis had maximum diversity of tree species. On the whole, the studied scrub forest has low species diversity. Population structure of different species indicates *Butea monosperma* at sites 2 and 3, *Prosopis cineraria* at site 2 and *Boswellia serrata* at sites 2 and 4 may disappear in near future. *Cordia gharaf* at site 1, *Acacia catechu* at sites 1, 2 and 4, *Boswellia serrata* and *Bauhinia racemosa* at site 3 are recent invaders and may become canopy dominants later on.

Resumen: Se hizo un análisis cuantitativo del bosque Rampara de la región Saurashtra del estado Gujarat, India. La cobertura basal total de los árboles fluctuó entre 180 y 3326 cm^2 100 m^{-2}. La composición de los estratos arbóreo y arbustivo fue marcadamente similar entre varios sitios. El sitio 1 sostiene la población más grande de arbustos, mientras que el sitio 2 fue el más pobre en este sentido. El sitio 1 con base en su densidad, y el sitio 2 con base en su cobertura y sus IVI, fueron los que tuvieron la máxima diversidad de especies arbóreas. En general, el matorral estudiado posee una baja diversidad de especies. Las estructuras poblacionales de diferentes especies indican que en un futuro próximo podrían desaparecer *Butea monosperma* de los sitios 2 y 3, *Prosopis cineraria* del sitio 2 y *Boswellia serrata* de los sitios 2 y 4. *Cordia gharaf* en el sitio 1, *Acacia catechu* en los sitios 1, 2 y 4, *Boswellia serrata* y *Bauhinia racemosa* en el sitio 3 son invasores recientes y en el futuro pueden llegar a ser dominantes del dosel.

Resumo: A floresta de Rampara na região de Saurashtra do Estado de Gujarat na Índia foi quantitativamente analisada. A cobertura basal total das árvores variou entre os 180 e os 3326 cm^2 100m^{-2}. A composição dos estratos arbóreos e arbustivos era marcadamente semelhante entre as várias estações. A estação 1 continha a maior população de arbustos, enquanto a estação 2 foi neste particular a pior. A estação 1, numa base de densidade, e a estação 2, na base da cobertura e IVI, apresentaram a diversidade máxima em espécies arbóreas. No seu conjunto, o estrato arbustivo da floresta apresentou a menor diversidade específica. A estrutura de população das diferentes espécies indica que a *Butea monosperma* na estação 2 e 3, a *Prosopis cineraria* na estação 2 e *Boswellia serrata* na estação 2 e 4 podem desaparecer num futuro próximo. A *Cordia gharaf* na estação 1, a *Acacia catechu* nas estações 1,2 e 4, a *Boswellia serrata* e a *Bauhinia racemosa* na estação 3 são invasoras recentes e podem vir a tornar-se as espécies dominantes do copado.

Key words: Diversity, phytosociology, population structure, Rampara forest, scrub forest.

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Introduction

Rampara forest, dominated by deciduous tree species during early part of twentieth century, served as a game reserve of the ex-ruler of the then Wankaner state in Saurashtra region of Gujarat state of India. Later the indiscriminate felling of trees resulted in the development of Savanna. However, because of protection provided by the Forest Department aggrading secondary forest has appeared which is dominated by thorny trees. Recently, in the year 1988 the forest was notified as a sanctuary. This scrub forest spreads in a small and isolated area of about 1500 ha and lacks quantitative details of its vegetation. As understanding of forest structure is pre-requisite to describe various ecological processes and also to model the functioning and dynamics of forest (Elouard *et al.* 1997; Sukumar *et al.* 1992), the aim of the present study is to generate quantitative information on analytical characters, tree diversity and regeneration status of Rampara scrub forest.

Study area

Rampara forest (22° 31′ 82″ to 22° 34′ 88″ N lat. and 70° 55′ 54″ to 70° 58′ 59″ E long.) is located in Rajkot district of Saurashtra region of Gujarat (Fig. 1.). The terrain is undulating and soil is residual derived from basalt rocks. There is considerably thick soil in troughs, whereas elevated tops constituting greater proportion of the forest area have thin soil mixed with pebbles. The mean maximum temperature at Rampara ranges between 28.5°C (January) and 40.6°C (May) and mean minimum between 10.9°C (January) and 25.8°C (June). The mean monthly rainfall varies from 2.3 (May) to 224.9 mm (July). Annual rainfall averages at 521 mm, out of which 95% occurs during the rainy season (Fig. 2). In general, the ecoclimate of the forest locality is of semi-arid type (Pandeya *et al.* 1977).

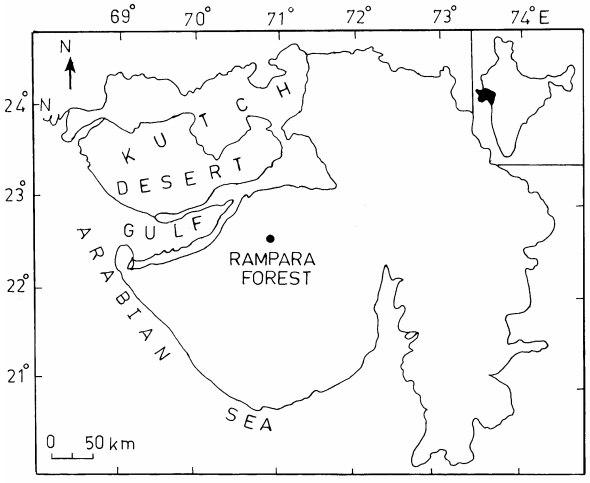

Fig. 1. Map of Gujarat state of India showing location of study area. The inset is map of India.

Methods

On the basis of preliminary reconnaissance, four study sites (1 ha each) were demarcated based on topographic variation and named as site 1, 2, 3 and 4. The phytosociological analysis of each site of forest was conducted by using twenty five randomly placed, 10 x 10 m, quadrats. The size and the number of quadrats were determined by the species area curve (Misra 1968) and the running mean method (Kershaw 1973), respectively. In each quadrat, trees with ≥31.5 cm cbh (Circumference at breast height, i.e., 1.37 m from the ground) were individually measured for cbh. The cbh of shrubs was measured at 50 cm height. Individuals of 10.5 to 31.4 cm cbh were recorded either as saplings or as shrubs (as the case may be) and those of <10.5 cm cbh were considered as seedlings following Ralhan *et al.* (1982). The above cbh classes for demarcation of trees, shrubs, saplings and seedlings are arbitrary and widely used by the foresters.

The vegetational data were quantitatively analyzed for density, abundance and frequency following Curtis & McIntosh (1950). The relative values of frequency, density and dominance were deter-

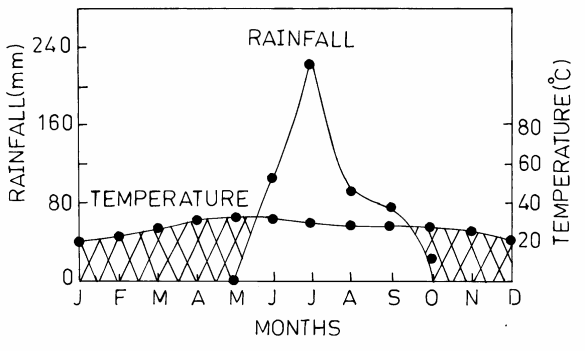

Fig. 2. Ombrothermic diagram for the study area based on rainfall and temperature data for ten years from 1989 to 1998.

mined following Phillips (1959). These values were summed to estimate IVI of individual species (Curtis 1959). The ratio of abundance to frequency for different species was determined for eliciting the distribution patterns. This ratio indicates regular (<0.025), random (0.025 to 0.05) and contagious (>0.05) distributions (Curtis & Cottam 1956).

Sorenson's similarity measure (Cs) for tree layer and shrub layer between different sites were calculated following Magurran 1988).

$$Cs = 2j/a+b$$

where, a = number of species at site A, b = number of species at site B, j = number of species common to both the sites.

The tree species diversity for different sites was determined by using Shannon-Wiener information function ($\overline{H}$) (Shannon & Wiener 1963).

$$\overline{H} = -\sum_{i=1}^{S}(Ni/N)\log_e(Ni/N)$$

where, Ni is the importance value of each species, and N is the total importance value of all the species in a stand. The tree species diversity was calculated by using the values of density, total basal cover and IVI, separately.

Concentration of dominance (cd) was computed by Simpson's index (Simpson (1949).

$$cd = \sum_{i=1}^{S}(Ni/N)^2$$

where, Ni and N are the same as for Shannon-Wiener information function. The calculations for the species diversity and concentration of dominance were made on tree individuals.

For representing the population structure of trees the following arbitrary cbh classes were established: A, 0 to 10.4 (Seedlings); B, 10.5 to 31.4 (Saplings); C, 31.5 to 51.5; D, 52 to 72; E, 72.5 to 92.5; F, 93 to 113; G, 113.5 to 133.5; H, 134 to 154; and I, 154.5 to 174.5 cm. The total number of individuals belonging to individual girth class was calculated for each species on each site. The number of individuals in each girth class, for each species, was divided by the total number of individuals in all girth classes of that species on a site. The resultant value was multiplied by 100 to yield percent density for each girth class of a species.

Results and discussion

Analytic characters

Borassus flabellifer had maximum value of mean basal cover (MBC), total basal cover (TBC) and Importance Value Index (IVI) on site 1 (Table 1). On the basis of IVI value, *Butea monosperma* appeared next dominant species. *Balanites aegyptiaca* had lowest value of IVI among all species. *Acacia senegal* had lower value of MBC than *B. aegyptiaca*, but due to high values of relative density (RD) and relative frequency (RF), it assumed an IVI value higher than *B. aegyptiaca*. *Acacia nilotica* exhibited greater dominance than other species of the genus *Acacia* such as *A. senegal* and *A. leucophloea*.

At site 2, *A. senegal* had maximum IVI, due to high values of RD and RF, although MBC was lowest for this species. *A. leucophloea* had minimum IVI. *Boswellia serrata* exhibited maximum value for MBC, but because of its lower RD and RF, it had an IVI lower than *A. senegal, B. aegyptiaca* and *A. nilotica*.

At site 3, *A. nilotica* had maximum IVI, whereas *A. catechu* exhibited minimum IVI among all species. *B. monosperma* had higher MBC, but due to low values of RD and RF, it assumed an IVI lower than *A. nilotica, A. senegal, A. leucophloea* and *B. aegyptiaca*.

At site 4, though *B. serrata* exhibited maximum MBC, due to low values of RD and RF, its IVI was lowest among all species. *A. senegal* had lower MBC, but due to high values of RD and RF, it assumed an IVI higher than any other species.

The TBC was maximum for site 1 and minimum for sites 2 and 4. The total density was maximum at site 1 and minimum at site 2. The data on MBC per tree for these sites indicated that the forest on site 4 was younger or with poor growth of trees among all forest sites.

The values for TBC and density in several temperate forests as reported by different authors vary from 1560 to 5930 cm^2 100 m^{-2} and from 3.5 to 20.8 trees 100 m^{-2}, respectively. While in tropical forests (except for tropical rain forest) the same ranges from 1073 to 3062 cm^2 100 m^{-2} and from 5.5 to 11.7 trees 100 m^{-2} (Saxena 1979). The values for TBC and density of forests at Rampara ranged from 180 to 3326 cm^2 100 m^{-2}, and from 0.88 to 5.0 trees 100 m^{-2}, respectively. Therefore, these values were not in the range reported for the temperate and tropical forests. The studied scrub forest in dry region of Saurashtra has sparse and slender trees. The poor growth of trees in dry regions is generally attributed to water deficit and poor soil.

Table 2. Similarity index of tree species for different sites.

	Site 1	Site 2	Site 3	Site 4
Site 1	100.00	85.70	76.92	66.66
Site 2		100.00	76.92	83.32
Site 3			100.00	72.72
Site 4				100.00

Table 3. Similarity index of shrub species for different sites.

	Site 1	Site 2	Site 3	Site 4
Site 1	100.00	70.00	66.66	50.00
Site 2		100.00	80.00	71.42
Site 3			100.00	66.66
Site 4				100.00

The tree and shrub layer composition was much similar among all the sites (Tables 2 & 3). The values of similarity index (tree layer) varied between 66 to 85% and for shrub layer between 50 to 80%.

Variation in populations at the study sites is presented (Fig. 3a,b,c). Considering shrubs population, site 1 supported the largest population and site 2 the smallest. *Zizyphus nummularia* was dominant at sites 1, 2 and 3 while *Abutilon indicum* was dominant at site 4.

The total density of saplings and seedlings was maximum at sites 2, 3 and 4 and minimum at site 1 (Fig. 3a,b,c). *A. senegal* was dominant in sapling

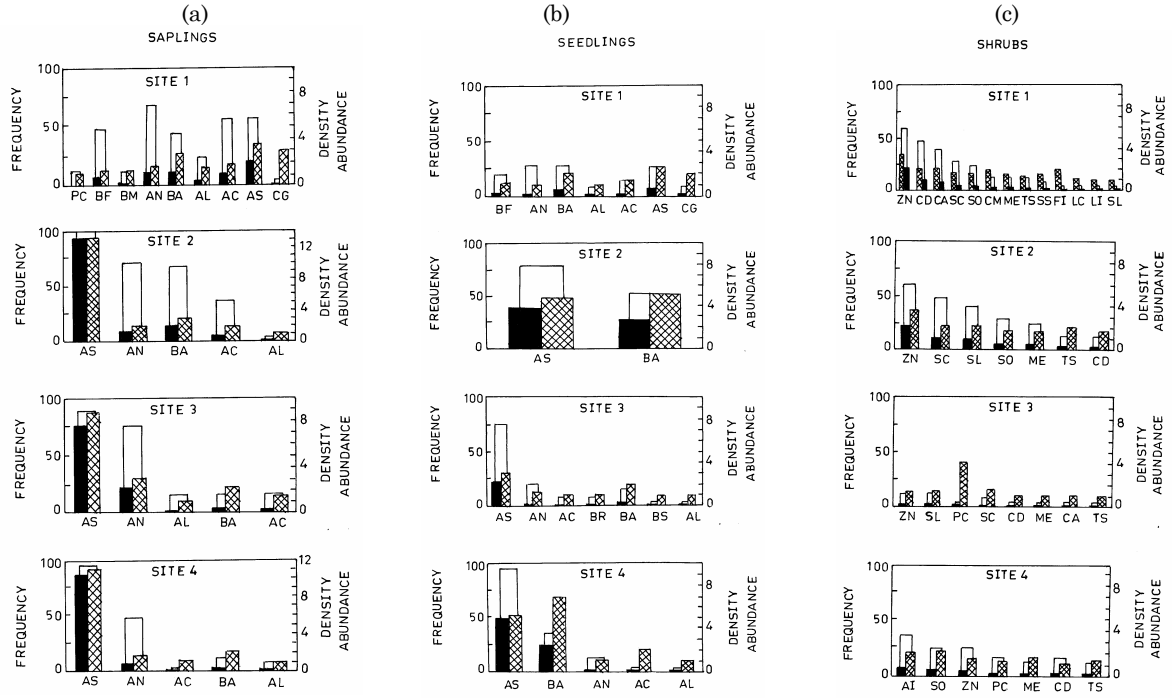

Fig. 3. Frequency, abundance and density of saplings (a), seedlings (b) and shrugs (c). Open bars = frequency, hatched bars = abundance and solid black bars = density, frequency values are in percentage and abundance and density in plants 100 m^{-2}. **Code:** *Shrubs*, *ZN* = *Zizyphus nummularia* (Burm.f) wt. & Arn., *CD* = *Capparis deciduas* (Forsk.) Edgew., *CA* = *Cassia auriculata*, L., *SC* = *Sida cordifolia* L., *SO* = *Sida ovata* Forsk., *CM* = *Clerodendrum multiflorum* (Burm. f.) O.Ktze., *ME* = *Maytenus emarginata* (Willd.) Ding Hou, *TS* = *Tephrosia senticosa* (L.) Pers., *SS* = *Salvia santolinaefolia* Boiss., *FI* = *Flacourtia indica* (Burm. f.) Merr, *LC* = *Lantana camera* Linn., *LI* = *Lantana indica* Roxb., *SL* = *Securinega leucopyrus* (Willd.) Muell. Arg., *PC* = *Prosopis chilensis* (Molina) Stuntz, *AI* = *Abutilon indicum* (L.) SW.; *Saplings and seedlings*: *PC* = *Prosopis cineraria* (Linn.) Druce, *BF* = *Borassus flabellifer* L., *BM* = *Butea monosperma* (Lam.) Taub., *AN* = *Acacia nilotica* (L.) Del., *BA* = *Balanites aegyptiaca* (L.) Del., *AL* = *Acacia leucophloea* (Roxb.) Willd., *AC* = *Acacia catechu* Willd., *AS* = *Acacia senegal* (L.) Willd., *CG* = *Cordia gharaf* (Forsk.) E. & A., *BR* = *Bauhinia racemosa* Lam., *BS* = *Boswellia serrata* Roxb.

Table 4. Number of species, diversity index ($\overline{H}$) and concentration of dominance (cd) for different sites of scrub forest.

Site	No. of species	Diversity index ($\overline{H}$)			Concentration of dominance (cd)		
		On density basis	On basal cover basis	On IVI basis	On density basis	On basal cover basis	On IVI basis
1	7	2.029	1.378	2.052	0.333	0.525	0.328
2	7	1.855	2.470	2.239	0.429	0.220	0.300
3	6	1.974	1.985	2.035	0.303	0.313	0.295
4	5	1.940	2.133	2.034	0.308	0.254	0.285

and seedling population at all the four study sites in the forest.

This forest was characterized by a preponderance of contagious distribution and rarity of random distribution. In general, preponderance of contagious distribution in natural vegetation has been reported by several workers (Kershaw 1973; Ralhan *et al.* 1982; Singh & Yadav 1974; Visalakshi 1995). According to Odum (1971), clumped (contagious) distribution is the commonest pattern in nature, random distribution is found only in very uniform environment, and the regular distribution occurs where severe competition between the individuals exists. Contagious distribution depends on the (i) local habitat differences, (ii) daily and seasonal weather changes and (iii) reproductive processes. The tree species which grow in clumps are, in general, better adapted for intraspecific competition than for inter specific competition. Therefore, the management of such forest requires a special attention that the introduction of tree species from out side should not be allowed without an understanding of competitive potential of the tree species to be introduced.

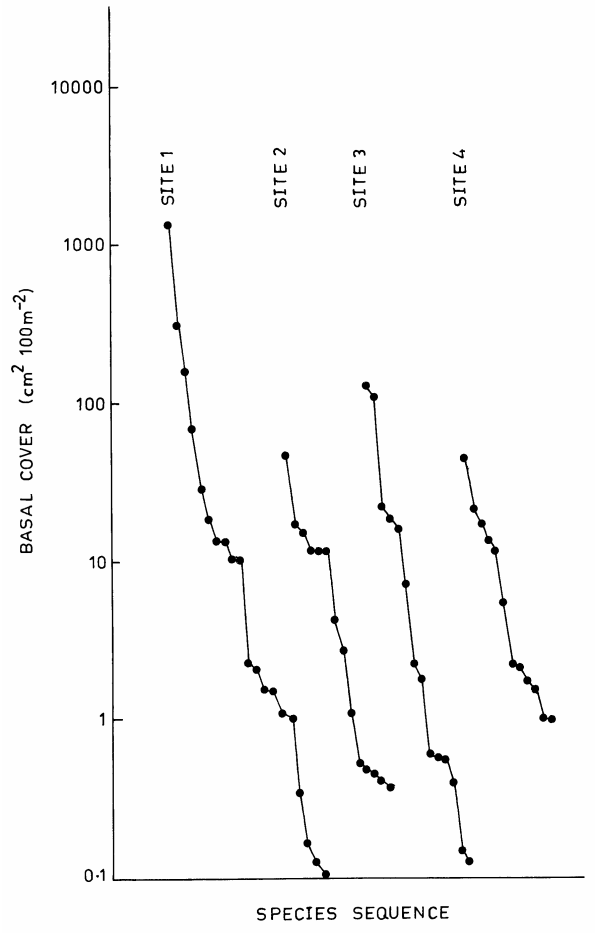

Fig. 4. Dominance diversity curves for woody species (trees + shrubs).

Tree species diversity

The number of species varied from 5 to 7 among the sites. The variations in Shannon and Wiener diversity index and concentration of dominance as computed on different quantitative values, are presented (Table 4). Monk (1967) and Risser & Rice (1971) obtained 2.3 as the highest values for diversity index to temperate forests. In an eastern deciduous forest of North America, Braun (1950) reported tree species diversity 1.69 and 3.40. On the other hand, tropical forests indicate higher diversity as calculated by Knight (1975) for young ($\overline{H}$ = 5.06) and old ($\overline{H}$ = 5.40) stands. The diversity index for different sites of the scrub forest in the present study falls in the range of values, between 1.8 and 2.0 on density basis, 1.4 and 2.5 on cover basis and 2.0 and 2.2 on IVI basis. These values were more than 50% lower than those for tropical forests reported by Knight (1975).

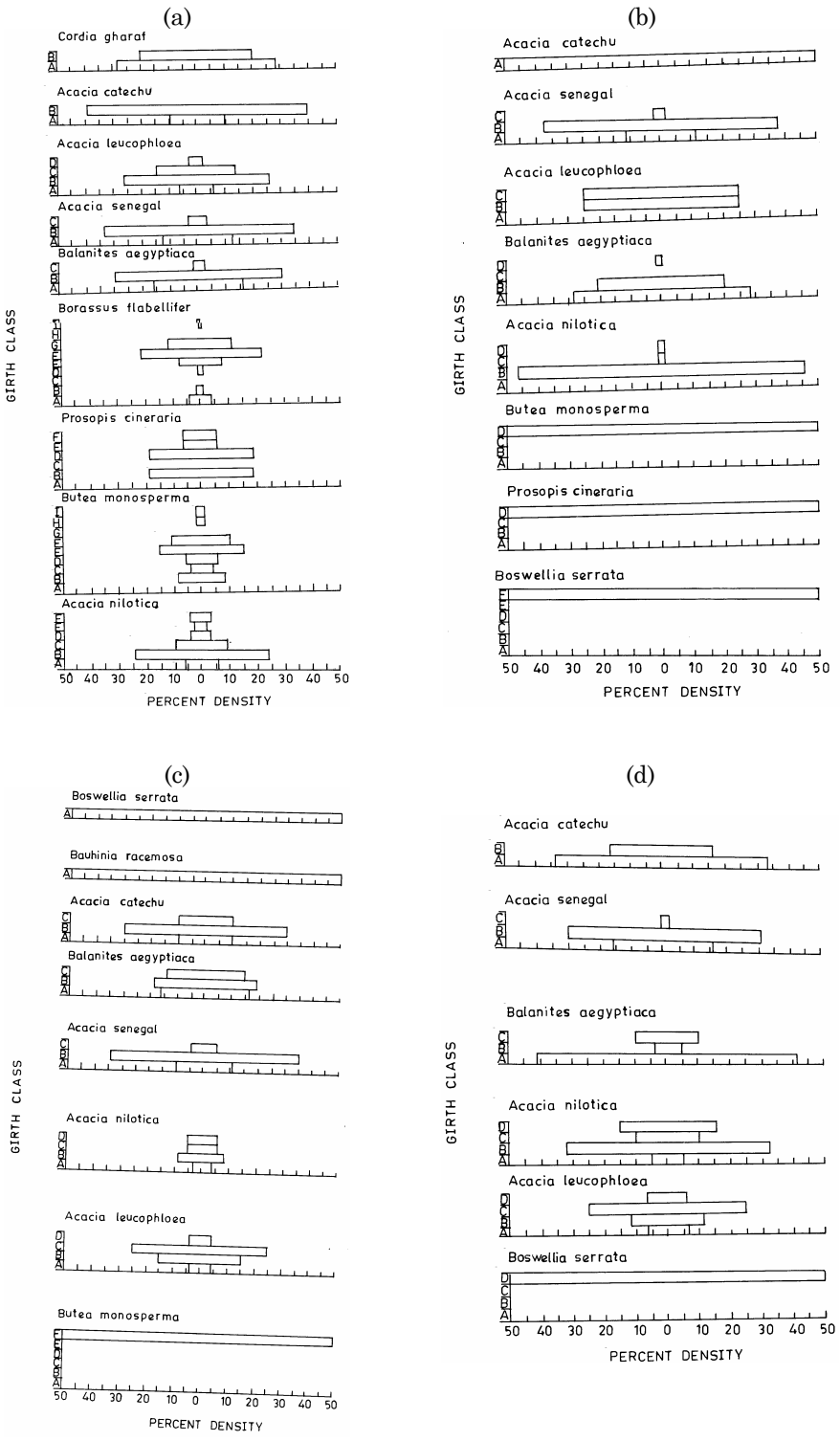

Fig. 5. (a) Population structure of species at site 1; (b) site 2; (c) site 3; (d) site 4.

The low species diversity suggests for conservation of biodiversity because the dry regions of Gujarat state of India is vulnerable to desertification (Pandey *et al.* 1999).

The concentration of dominance on density basis was highest at site 2 and lowest at sites 3 and 4, on cover basis highest at site 1 and lowest at site 2 and on IVI basis highest at site 1 and lowest at site 4. Risser & Rice (1971) have reported values for concentration of dominance for certain temperate vegetation; these range between 0.10 to 0.99. For a tropical forest Knight (1975) reported an average value of 0.06. The values of concentration of dominance was between 0.30 and 0.43 on density basis, 0.22 and 0.52 on cover basis and 0.28 and 0.33 on IVI basis in the scrub forest. These relatively high values for concentration of dominance are in accordance with low species diversity at the studied scrub forest because species diversity ($\overline{H}$) behaves inversely to the index of dominance (Odum 1971).

Dominance – diversity curves for the woody species (trees + shrubs) (Fig. 4) on the basis of basal cover (data for trees and shrubs were pooled), has been drawn for the present forest sites to interpret the community organization in terms of resource share and niche space. The curves for all the forest sites fit the geometric series which conforms to the niche pre-emption hypothesis (Whittaker 1975). The geometric series pattern of species abundance is found primarily in species-poor (and often harsh) environments or in the very early stages of a succession (Whittaker 1972).

Population structure

The population structures of various tree species occurring on different sites (Fig. 5a,b,c,d) indicate five characteristic patterns. One pattern of population structure is represented by *Cordia gharaf* and *A. catechu* at site 1, *A. catechu* at site 2, *Bauhinia reacemosa* and *B. serrata* at site 3 and *A. catechu,* at site 4, with individuals only in seedling and sapling stages. This structure indicates that species could be recent invader and may become canopy species later on. Second pattern is exemplified by *P. cineraria, B. monosperma* and *B. flabellifer* at site 1 having most of the individuals in intermediate girth classes and decreasing population both towards higher and lower girth classes with absence of seedlings. Benton & Werner (1976) stated that if such a trend continues, the population is on the way to extinction. However, *P. cineraria, B. monosperma* and *B. serrata* at site 2, *B. monosperma* at site 3 and *B. serrata* at site 4 illustrate third pattern indicating that these species reproduced in the past but have stopped doing so in recent years. Fourth pattern indicates expansion of *A. leucophloea, A. senegal, B. aegyptiaca* and *A. nilotica* at site 1, *A. senegal, B. aegyptiaca, A. leucophloea* and *A. nilotica* at site 2, *A. catechu, B. aegyptiaca, A. senegal* and *A. leucophloea* at site 3 and *A. senegal, B. aegyptiaca, A. nilotica* and *A. leucophloea* at site 4. Fifth pattern suggests stable population for *A. nilotica* at site 3.

In conclusion, different tree species were predominant at different forest sites. The dominant tree species were *B. flabellifer, A. nilotica* and *A. senegal.* Total tree species at the forest sites were merely 5 to 7. These tree species grow naturally on moisture and nutrient deficient soils in Saurashtra region and also in other parts of western India. *A. senegal* was dominant in sapling and seedling population at all the forest sites. The values of diversity index and concentration of dominance do not fall in the range of values reported for tropical forests. Population structures of different species indicate that *A. nilotica* had stabilized population while populations of other species were under the state of change.

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