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Plant species diversity in different altitudinal ranges of a very moist forest of coastal Eastern ghat in Odisha

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Abstract
The present investigation to know the plant species diversity in different altitudinal ranges of a very moist forest of coastal Eastern ghat of Odisha was carried out in Balugaon Range under Khordha Forest Division of Odisha during April 2018- May 2019. Plant species richness and plant species diversity in 3 altitudes (valley, foot hill and mid hill) was investigated using nested sampling method in very moist forest of Rajini - Tamana Reserved forest which is a part of Eastern ghats of coastal Odisha. In the investigation 15 treatments comprised of 5 plant types in combination of 3 altitudes were taken into account. A total of 246 plant species were recorded from the studied site including 110 species of trees, 33 species of shrubs, 53 species of climbers, 38 species of herbs and 12 species of grasses. Elevation wise species composition, Importance Value Index (IVI) of trees, shrubs, climbers, herbs, grasses and Shannon-Wiener index of diversity (H') were found out to know the forest structure and floristic.

Keywords: Species diversity, altitudes, richness, eastern ghats, coastal Odisha

Introduction
A forest is distinguished by its floristic composition and it primarily depends upon the edaphic and climatic factors. The knowledge of forest structure and floristic is necessary to understand the forest biodiversity, forest dynamics and to formulate management plan accordingly. The tropical or subtropical dry forests account for 42% of the total global forest cover (Murphy and Lugo, 1986) [1]. The Eastern ghat forests are being heavily exploited for natural resources and for the sake of development, also these are least focused and least studied geographical areas in terms of biodiversity. The forests of coastal Odisha are part of Eastern g hats which are very important from ecology and economy point of view as population density in coastal regions is very high in comparison to interior areas. Keeping this in view the present study was carried out to know the plant species richness and diversity in this very moist forest which will be helpful to know the health of the forest ecosystem. Sal (*Shorea robusta*) has been found to be the dominant species according to study carried out by different researchers in Eastern ghat forests by Reddy *et al.* (2011) [2], Sahu *et al.* (2012) [3]. Interestingly the said studied site is a good Teak (*Tectona grandis*) growing forest which is introduced since the colonial period by clearing native species. Vegetation composition in the three altitudinal ranges i.e. (valley, foot hill and mid hill) will give a comparative idea about species establishment and occurrence of exotic species.

Materials and Methods
a) Location and Climatic condition
The experimental area is a very moist sal forest distributed over Rajini Reserved forest and Tamana Reserve forest of Balugaon Range under Khordha Forest Division, Odisha. It is aerially about 40 km away from Chilka lake (Balugaon) which is attached to Bay of Bengal in East coast of India. The altitude of study site varies from 120 m to 350 m above mean sea level. The study area is completely hilly and is a part of Eastern Ghat of India. The study area comes under East and South-Eastern Coastal Plain agro-climatic zone. It experiences coastal tropical climate. The mean annual rainfall is about 1340 mm. The mean maximum temperature is 39.0 ^{0}C and mean minimum temperature is 11.5 ^{0}C. The rainfall is received from south-west monsoon which sets on around mid June and recedes by mid October.

The soil of the study site is loam to loamy sand in texture. The micro-climate of study site is very moist because of continuous hill ranges with presence of perennial nalas and good vegetative cover. The forest of the locality comes under the sub group 3C (Norhern Indian Moist- Deciduous Forest) and the study area has the forest type of 3C/C1 (Very Moist Sal Forest). Originally the forest is very moist Sal forest type having sub type Peninsular Coastal Sal forest (3C/C1d) [4], but during British period many patches of this area were converted to Teak forest. Therefore, Sal and Teak both are present as dominant tree species in such forests.

b) Experimental details

The experiment was carried out following nested sampling in very moist forest of Rajini Reserved forest and Tamana Reserved forest which are located adjacent to each other. For this 30 number of main sampling units (quadrates) of size $20\,m \times 20$ were laid out systematically at a distance of about 300 m from one another. Out of 30 main sampling units, 10 sampling units were distributed in the valley area (120 m-150 m altitude above mean sea level), 10 units in foot hill area (150 m-250 m altitude above msl) and 10 units in mid hill area (250 m-350 m above msl) of the forest. Within these main sampling units, nested sampling units of $5\,m \times 5\,m$ were laid out for studying shrubs, climbers and seedlings and $1m \times 1m$ size units (5 within each unit) for studying herbs. The $20\,m \times 20\,m$ sampling units were used for studying tree species. In the investigation 15 treatments comprised of 5 plant types in combination of 3 altitudes were taken into account. The plant types include tree, shrub, climber, herb and grass while the altitudes are valley, foot hill and mid hill. Diversity indices are calculated from the data observed from the sampling plots. Importance value index (IVI) was calculated which is important for comparing findings of other researchers. For calculation of IVI Frequency, Relative frequency, Density, Relative density, Dominance, Relative dominance, Abundance and Relative abundance was calculated. The height of trees was recorded for plants having ≥10 cm gbh following standard procedure with the help of altimeter and measuring staff. In case of trees GBH ≥ 10 cm the Basal $area\backslash ha$ was calculated where as for other plant type dominance and relative dominance was calculated. Shannon- Wiener index of diversity (H') was calculated using the formula $H' = \sum pi\ ln\ pi$ for the overall forest, valley area, foot hill area and mid hill area respectively for the 5 plant types. Species richness was summarized and compared for the 3 elevation level which gives the idea about the establishment of species wise preference in the said altitudinal ranges.

Result and Discussion

a) Species composition

The data on plant species richness shows that the forest under study is very rich with regard to plant species composition and found that there were 110 species of trees, 33 species of shrubs, 53 species of climbers, 38 species of herbs and 12 species of grasses were present in the study area. As this forest is reserve forest and as a part of Eastern ghat with close proximity of Chilika lake and presence of perennial nallas and restricted movement of people, it is supporting a good number of plant species. Reddy *et al.* (2011) [2] have observed a rich composition of plant species in Eastens ghats of Northern Andhra Pradesh. The species richness of the study area of 246 species indicates that the forest is as per with some forests of Western Ghats. Swamy *et al.* (2000) [5] have reported a total of 244 plant species in humid tropical forest of Veerapuli and Kalamalai reserve forest.

b) Elevation wise species composition

Significant variation in composition of species in different elevations in the study area was found and compared in Figure 1. In the lower elevation (valley) 90 tree species, 30 shrub species, 51 climber species, 38 herb species and 9 grass species were found growing. In mid elevation (foot-hill) the number of species of trees, shrubs, climbers, herbs, and grasses were 50, 16, 24, 16 & 8, respectively.

In the higher elevation (mid-hill), the values were 16, 3, 9, 7 & 4 for trees, shrubs, climbers, herbs and grasses. The significant variation in composition of plant species in different altitudes may be due to variation in site quality i.e. in terms of moisture reign, soil depth, nutrient availability, drainage, geological formation, etc. The lower elevation has supported more number of species followed by middle elevation and higher elevation. In a study made by Swamy *et al.* (2000) [5] found 82 number of species in low elevation, 142 species in mid elevation and 96 species in higher elevation of a humid tropical forest in Tamil Nadu of Western Ghats.

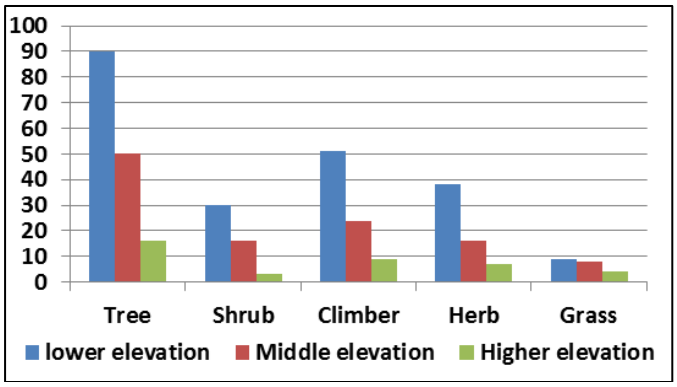

Fig 1: Elevation wise plant species composition

c) Diversity indices of tree species (≥ 10 cm GBH) of the forest

The plant diversity indices of tree species (≥ 10 cm GBH) reflect remarkable variation in terms of frequency, relative frequency, density, relative density, basal area. Relative dominance and importance value index of different tree species in the forest under study. The frequency of different tree species varied from 3.33 to 79.92% and *Mallotous philippensis* exhibited the highest frequency in the forest. The density of trees ranged from 2.5 to 97.5 $numbers/ha$ and *Shorea robusta* positioned top.

The basal area of tree species varied from 0.06 to 10.54 $m2/ha$ and *Tectona grandis* registered highest value. Important value index (IVI) of trees ranged from 0.85 to 51.69. *Tectona grandis* excelled in IVI value follows by *Shorea robusta* and *Mallotous philippensis*. The IVI of different tree species has been shown in Fig. 2. The Shannon-Wiener index of diversity (H′) was found to be 3.476. The variation in diversity indices of different forests have been reported by many authors scuch as Kadavul and Parthasarathy (1998) [6], Anitha *et al.* (2008) [7], Rasingam and Parthasarathy (2009) [8] Kushwaha and Nandy (2012) [9], Dutta and Devi (2013) [10]. Sahoo *et al.* (2012) [3] have reported the IVI value of 44.67 for *Shorea robusta* in a tropical deciduous forest Malyagiri hill ranges, Eastern Ghats in Anugul district of Odisha dominated by Sal.

d) Elevation wise diversity indices of tree species (≥ 10 cm GBH)

In lower elevation IVI was maximum under *Tectona grandis* (50.33) followed by *Mallotous philippensis* (21.64). In middle elevation IVI was highest also in *Tectona grandis* (46.94) followed by *Shorea robusta* (32.32) and *Mallotous philippensis* (25.59). In higher elevation maximum value was registered for *Shorea robusta* (42.30) followed by *Tectona grandis* and *Mallotous philipensis* with close value of *Pterospermum xylocarpum* (20.94) and *Garuga pinnata* (18.75). Shannon- Wiener index of diversity (H′) was 3.464 for lower elevation, 3.416 for middle elevation and 3.392 for higher elevation. Diversity indices of trees in different elevations have been summarized in table 1. In valley and foot-hill *Tectona grandis* dominated with maximum IVI where as in higher elevation *Shorea robusta* was found dominating. The gentle slope with good drainage in lower elevation and middle elevation are favouring silviculturally to *Tectona grandis.* The relative fast growth of Teak in expertises to Sal is another reason of dominace over Sal and others. In higher elevation *Shorea robusta* is dominating over teak and others because of its gregarious nature and to adopt better upper slope than *Tectona grandis*. Similar findings were obtained regarding dominance of teak in the study done in Kerala forests. (Chandrasekara *et al*. 1994) [11].

Table 1: Diversity indices of trees in different elevations

Indices	Overall forest	Lower elevation (Valley)	Middle elevation (Foot hill)	Higher elevation (Mid hill)
Density (No/ha)	789	845	770	685
Basal area ($m2/ha$)	27.172	31.432	24.849	22.803
Shannon-Wiener index of diversity (H′)	3.476	3.464	3.416	3.392

e) Diversity indices of shrub species of the forest and elevation wise comparative study

The ranges of frequency, relative frequency, density, relative density, abundance and relative abundance of shrub species were 6.66-56.66, 1.4-12.14, 40-1200, 0.6-18.75, 1.50-6.00 and 2.59-10.39, respectively. Accordingly, IVI of shrub species varied from 4.65-39.95. *Desmodium triangulare* exhibited dominance over others followed by *Clerodendrum viscosum* (39.99), *Glycosmis pentaphyla* (30.47) and others. The Shannon-Wiener index of diversity was found to be 2.528. The very moist condition and the prevailing locality factors and species stratification may be more suitable for species like *Desmodium triangulare*, *Clerodendron viscosum*, *Glycosmis pentaphylla* etc. to dominate as shrub species. In lower elevation and middle elevation *Desmodium triangulare* dominated among shrub species securing highest IVI value followed by *Glycosmis pentaphyla* and *Clerodendrum viscosum*. The highest IVI value in lower and middle elevation was 44.72 and 45.92, respectively. In higher elevation *Chromolaena odorata* dominated with IVI of 46.79 followed by *Desmodium triangulare* (42.39) and *Glycosmis pentaphylla* (39.18). Shannon- Wiener index was 2.435 in lower elevation, 2.238 in middle elevation and 1.886 in higher elevation.

Table 2: Diversity indices of shrub species in different elevations

INDICES	Total forest	Lower elevation	Middle elevation	Higher elevation
Density (No/ha)	6367	9200	7040	5480
Shannon- Wiener index of diversity (H′)	2.585	2.435	2.238	1.868

f) Diversity indices of climber species of the forest and elevation wise comparative study

The data presented for climber species in the forest in and shows that there is a significant variation in frequency, relative frequency, density, relative density, abundance, relative abundance and IVI for climber species presented in the study site. The frequency and relative frequency ranged from 3.33- 46.66 and 0.40–5.69. Likewise density, relative density, abundance and relative abundance varied as 26.66-613.33, 0.32-7.44, 1.66-3.80, 1.28-3.25, respectively. IVI value for different climbers varied in the range 3.17-15.94. *Combretum roxburghii*, *Acacia pennata* and *Cocculus indicus* with IVI value 15.94, 10.74 and 10.70, respectively were the top three dominating species of climber in the forest. Shannon- Weiner index was calculated 3.669 for climber species. *Combretum roxburghii* has found dominating because of it's aggressiveness to grow in very moist condition with partial shade. In forests of Odisha this is found very commonly in moist situations. Wide variation in diversity indices were found in different elevations was found for climber species. In the lower elevation and middle elevation *Combretum roxburghii* was found dominating with IVI values 16.84 and 21.06, respectively. But in the higher elevation *Acacia pennata* and *Bauhinia vahlii* found dominating with a close range of IVI value of 42.48 and 42.33, respectively. The density of climber species is decreasing with increasing elevation. The value for density (Numbers/hectare) has been obtained 12720, 6960 and 3320 for lower, middle and higher elevation, respectively. Shannon- Weiner index was calculated 3.466, 3.294 and 2.569 for lower, middle, higher elevation which also shows a decreasing trend.

Table 3: Diversity indices of climber species in different elevations

Indices	Total forest	Lower elevation	Middle elevation	Higher elevation
Density (No/ha)	8240	12720	6960	3320
Shannon-Wiener index of diversity (H′)	3.669	3.466	3.294	2.569

g) Diversity indices of herb species of the forest and elevation wise comparative study

Data for herb species of the forest revealed that the forest floor handles a good diversity of herb species. The frequency and relative frequency ranged from 3.33-66.66 and 0.63–12.74. Likewise density, relative density, abundance and relative abundance varied as 333.33-17000, 0.35-18.02, 1.00-2.55, 1.15-4.60, respectively. IVI value of herb species ranged

from 2.14 to 33.69. *Barleria strigosa* having IVI value 33.69 was found dominant over other herbs followed by *Oplismenus burmanii* (22.64) and *Desmodium gangeticum* (13.52). Shannon- Wiener index of diversity was calculated as 3.398 which indicate a very good diversity of the forest from herb species point of view. *Barleria strigosa* dominated the forest as this species is commonly found in moist forest. In other moist forest patches this species is found growing vigorously, which is similar to the findings of Sahoo *et al.* (2017) in the tropical moist deciduous forests of Nayagarh Forest Division, Odisha. The other species i.e. *Oplismenus burmanii* and *Desmodium gangeticum* were also found with good IVI value after *Barleria strigosa* because they also prefer moist habitat and found commonly in moist sal forest. The diversity indices such as relative frequency, relative density, relative abundance and IVI of herbs differed significantly in different elevations which may be due to the genetic ability of different herb species to be grown in different site qualities including composition of vegetation in upper storey. The dominancy of *Barleria strigosa* followed by *Oplismenus burmanii* and *Desmodium gangeticum* in lower as well as middle elevation may be attributed to their genetic character for dominancing in moist soil under partial shade of over wood. On the other hand in higher elevation *Thysanolaena maxima* was dominating which may be due to it's character to grow in moist areas with more availability of light as in the upper elevation where the over wood canopy cover is less.

Table 4: Diversity indices of herb species in different elevations

INDICES	Total forest	Lower elevation	Middle elevation	Higher elevation
Density	94333	111000	87000	36000
Shannon- Wiener index of diversity (H′)	3.398	3.195	3.132	2.359

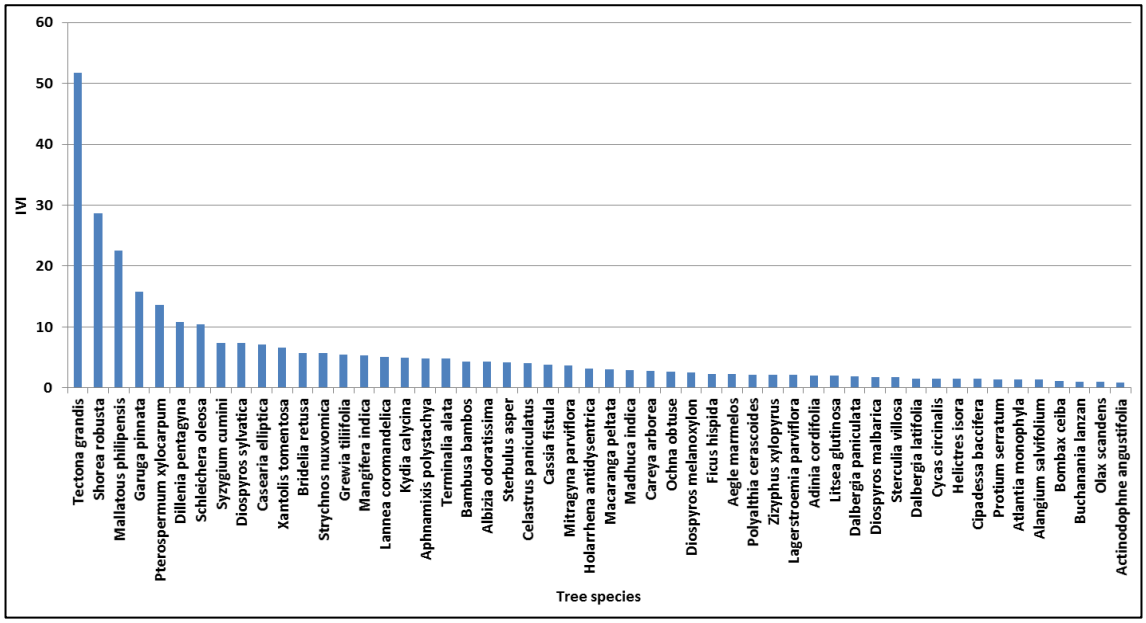

Fig 2: IVI of tree species

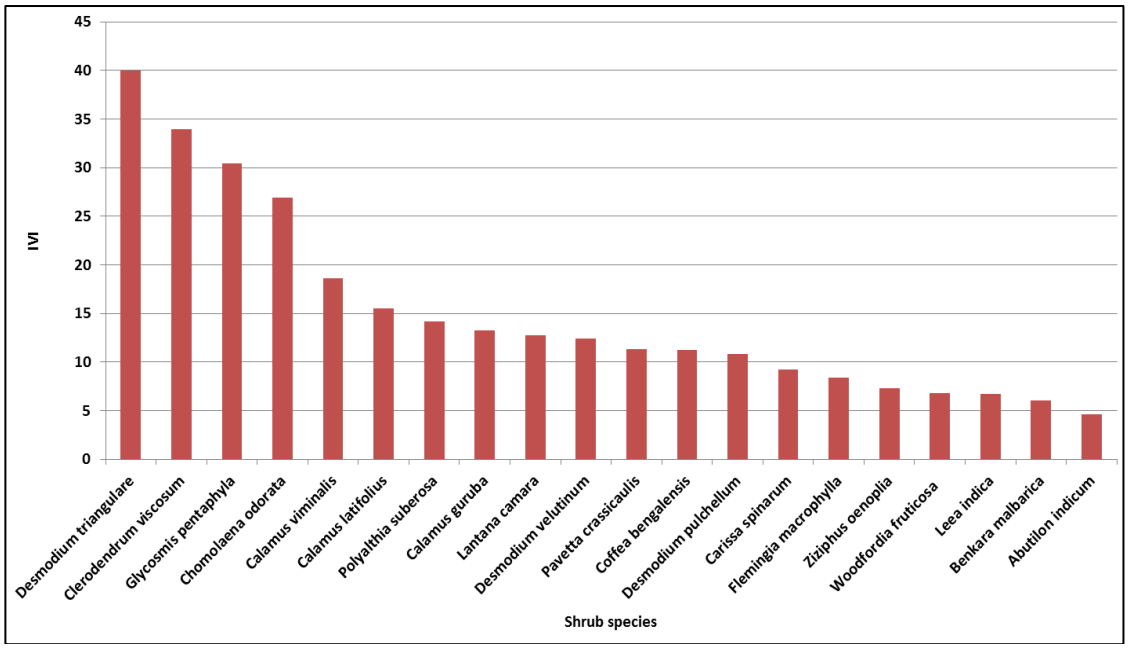

Fig 3: IVI of shrub species

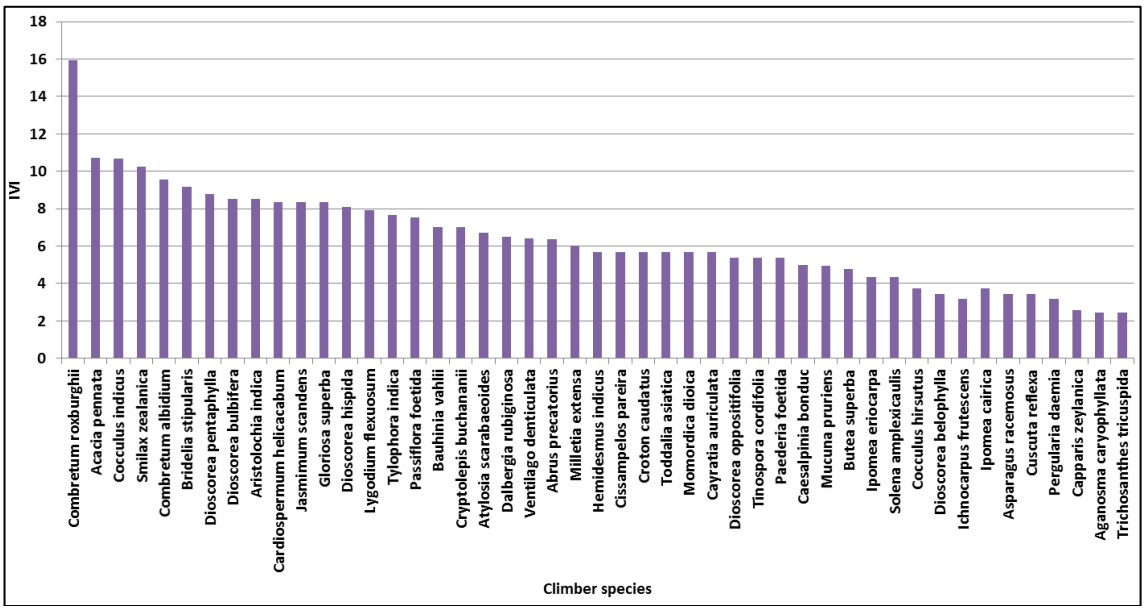

Fig 4: IVI of climber species

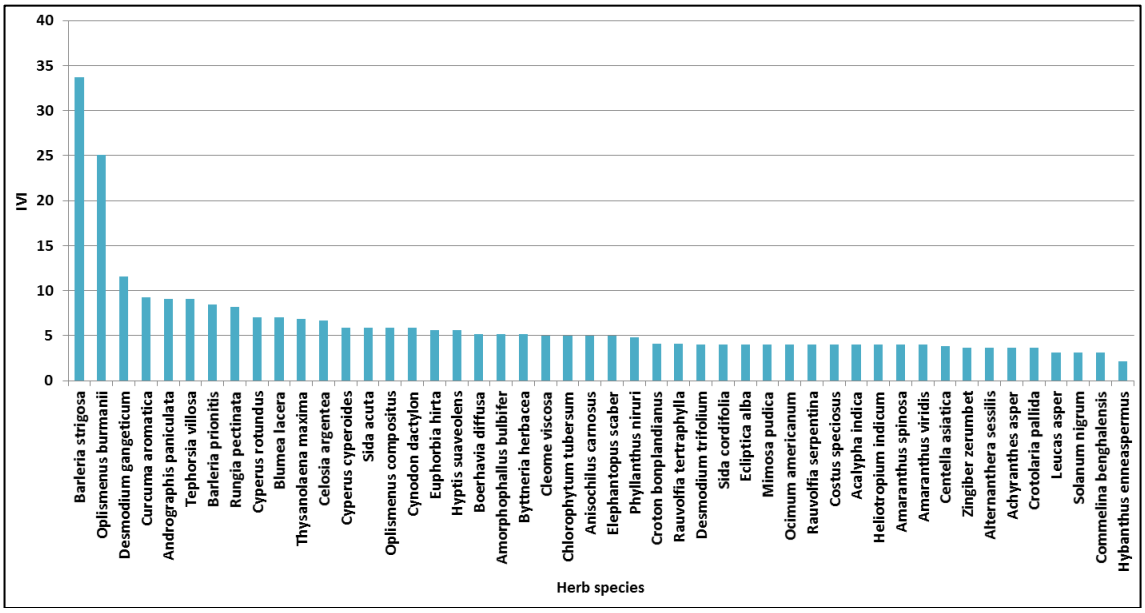

Fig 5: IVI of herb species

Conclusion

The present study site which is very moist forest in Rajini and Tamana reserved forest area of Balugaon forest range found a genetically rich forest in coastal coastal eastern ghat. This forest harbors the finest teak stand in this region so it is being in the eye of smugglers for illegal felling of timber. Due to heavy anthropogenic interventions the natural dynamics of the forest is deteriorating, so invasive species are taking the space rapidly. Among shrubs *Lantana camera*, *Chromolaena odorata* are suppressing ground flora in higher elevation and forest edges. Traditionally this forest serves as a major source of forest derived foods especially species of *Dioscorea* and cucurbits. Cane and bamboo were used to be major economical products in the past years but unsustainable harvesting process has made the dependent industries sick. Due to rich biodiversity NTFP products are collected by the forest dwellers and they are purely dependent on the forest ecosystem for their survival. Ecologically this forest is important as it is situated in a cyclone prone belt. This forest bears a good amount of wild animals and birds due to favourable environment. The findings of this investigation would be very useful to monitor the health of such forest and take course of action to maintain it's health. Further research may be carried out in such aspects in future for generating more useful information.

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