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# Effect of Altitudinal Gradation on Population Structure, Composition and Diversity of Non Timber Forest Product Species of Central Western Ghats of Karnataka

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***Abstract***: Uttar Kannada and Shivamogga districts are situated in the Central Western Ghats of Karnataka and unique in nature by having rich diversity of Non Timber Forest Products (NTFPs) plant species. This paper deals with the population structure, composition and diversity status of NTFP species and these were studied in three altitudinal zones *viz.,* coastal zone (0-250 MSL), midghat zone (251-500 MSL) and plane zone (501-750). Population structure was worked out based on density of seedlings, saplings and adults. Sixty quadrats were laid for the floristic assessment. The vegetation of NTFP composition considered 205 species belonging to 49 families. Importance value index (IVI) recorded highest for *Knema attenuata* (35.49) followed by *Aporosa lindliyana* and *Hopea ponga* at coastal zone. At midghat zone the IVI recorded highest for *Hope aponga* (90.16) followed by *Knema attenuata* and *Garcinia gummigutta* and at plane zone the IVI of *Caryo taurens* was be most dominant (23.70) followed by *Aporosa lindliyana* and *Syzygium cumini.* The coastal zone was very rich in species richness as compared to rest of the altitudinal zones. The richness ranged between 64 (plane zone) to 74 (coastal zone). The diversity of NTFP species highest (3.62) in the Coastal zone followed by midghat zone (2.98) and the lowest was in the plane zone (2.95). The total tree density was highest in the coastal zone (616.25ha$^{-1}$) while, plane zone recorded the least (608.75 ha$^{-1}$). But basal cover was maximum at midghat zone (1485.77 m$^2$ ha$^{-1}$) and minimum for plane zone (502.19 m$^2$ ha$^{-1}$). The study suggested that structure, diversity and species richness are regulated by physiographic and climatic factors along the gradient.

***Keywords***: Population structure, Altitudinal gradation, Plant diversity, NTFPs

The forests are characterized by high species richness, biomass and productivity. The nature of forest communities depends on the ecological characteristics in sites, species diversity and regeneration of species (Rahman et al 2011). The Southern peninsular region of India along its Western coastline has a long ridge of mountain ranges called Western Ghats. These mountain ranges in the state of Karnataka stretch from Dandeli in the north to Mangalore in the south, and from the edge of the western coastline they go as far as Coorg and Madikeri. Western Ghats of India is one of the biodiversity hotspots of the world. They are well known for their rich and unique assemblage of flora and fauna. It has dense and valuable forests and based on various field based analysis of vegetation communities, there are basic forest types found in Western Ghats: evergreen, semi-evergreen, dry deciduous and moist deciduous (Bhat et al 2000). It has records of over 7,402 species of flowering plants, 1,814 species of non-flowering plants are known from the Western Ghats (Nayar et al 2014). Altitude is one of the most important determinants of structure of the vegetation due to its direct influence on the microclimate of the habitat (Adhikari et al 2012). The duration of dry months and altitudinal variations controlled the structure of the vegetation in the Western Ghats. Altitude in terms of elevation above sea level plays a vital role in the health and growth development of vegetation. As it affects the quality and quantity of sunlight that plants receive, the amount of water that plants can absorb and the nutrients that are available in the soil. As a result, certain plants grow very well in high elevations, whereas others can only grow in middle or lower elevations. Even the slightest change in altitude causes great differences in the growth and development of vegetation in the area.

Population structure of tree species reflects its ecological and biological characteristics (Da et al 2004) and is expressed as a direct impact on the community structure which in turn indicated the development trend of the community (Xia et al 2004). The most commonly used size variable in the analysis of population structure, height class distribution for seedlings and saplings is diameter/girth at breast height (DBH/GBH) which is also used for the study of population structure of tree species (Bharali et al 2012). The inclusion of seedlings and saplings would provide better information about the status of the species at early stage of regeneration. Non-Timber Forest Products (NTFPs) are source of subsistence, employment and income for of people living in and around the forests and also provide food and livelihood security particularly during droughts and famines. In recent years, human developmental activities have posed increasing threats to biological diversity of forest zones all over the world. Forests are subjected to a variety of disturbances during extraction of NTFP and this exploitation impact on forest community varies with the intensity and mode of extraction (Ticktin 2004). The collection of larger quantities, for commercial or any other purpose, can lead to over-exploitation, decreased local abundance, and extinction of some species that provide highly desired products (Dao and Holscher 2018). Collection of few fruits and harvesting of leaves may have negligible impact on plant population being exploited but intensive exploitation of seeds, flowers and fruits may lead to reduced species richness of community.

## MATERIAL AND METHODS

The study was carried out along altitudinal gradation from the coast (Kumta taluk Uttar Kannada District) through mid ghat of Siddapur in Uttar Kannada to plains (Soraba taluk, Shivamogga District). The study site falls (14°23' N to 14°23'38"N and 74°48'E to 74'38"E) under the administrative jurisdiction of Canara Forest Circle, represented by Siddapur Forest Range in the Sirsi territorial Forest Division, Kumta and Gersoppa forest ranges in the Honnavara territorial Forest Division and Shivamogga Forest Circle, represented by Soraba Forest Range in the Sagar territorial Forest Division. The altitude varies from 0 to 750 m above sea level. In the present study, the data was collected by following systematic survey in the entire study area. Thus before commencing the field assessment work, the grid cells of 5 $km^2$ were laid on the map of reserve area using GIS tools. In each of these grids, phytosociological studies, different demographic parameters (tree density, regeneration etc.) and mainly the abundance data of the NTFP species were collected by laying quadrats. The study area was divided into three vegetation strata that occurred between 0-250 m, 251-500 m, and 501-750 m. Survey was undertaken and vegetation in relation to altitudinal gradient was demarcated. Quadrate sample plot method was adopted for analyzing vegetation composition of all types. Total of 60 sample plots were laid out to gather information on the density, population structure and regeneration of species. Vegetation was studied through sampling within three Ecological Zones (Coastal, Mid ghat, Plane). In each altitudinal zones a total of twenty quadrates of size 20 × 20 m were laid systematically at different localities. For assessing the tree diversity layer, quadrates of size 20 × 20 m were laid and at each sample point, all the trees ≥ 30 cm (gbh) within the quadrates were identified and measured. Importance value index (IVI) of each species was calculated by summing relative frequency, relative density and basal area as per Curtis (1959). Diversity indices were calculated as per Ludwig and Reynolds (1988).

## RESULTS AND DISCUSSION

**Composition and structure:** Vegetation was studied through sampling within three ecological zones. Selected top ten species and last five species in the entire three zones. The coastal zone exhibited a luxuriant growth. This zone is very rich in species diversity with as many as 74 woody species. Among all the species, *Knema attenuata* was most frequent species exhibiting higher frequency of 65 per cent followed by *Aporosa lindliyana*, *Hopea ponga* and *Myristica malabarica*. *Knema attenuata* superior (67.50 trees/ha) followed by *Aporosal indliyana* and *Hopea ponga*. The highest basal area was for *Knema attenuata* (93.25 $m^2$ $ha^{-1}$) followed by *Hopea ponga* and *Aporosa lindliyana*. Importance value index highest for *Knema attenuata* (35.49) followed by *Aporosa lindliyana* (27.37) *Hopea ponga* at Coastal zone (Table 1). The species frequency among various species ranged between 5 to 75 per cent. *Knema attenuata* was most frequent species (75%) followed by *Hopea ponga* , *Garcinia gummigutta* and *Aglaiae laegnoida*. The basal area was , highest for *Hopea ponga*(890.17 $m^2$ $ha^{-1}$) followed by *Garcinia gummigutta* and *Knema attenuata* . The importance value index highest for *Hopea ponga* (90.16) followed by *K. attenuata* and *Garcinia gummigutta* (Table 2).

The frequency among various species ranged between 5 to 70 per cent. *Caryota urens* most frequent species (70%) followed by *Aporosa lindliyana*, *Mangifera indica* and *Ixora brachiata*. *Aporosa lindliyana* was superior with highest number of trees (41.25 trees $ha^{-1}$) followed by *Terminalia paniculata* and *Caryota urens*. *Syzygium cumini* possess highest basal cover followed by *Caryota urens* and *Aporosa lindliyana.* In terms of importance value index *Caryota urens* was most dominant (23.70) followed by *A. lindliyana* and *Syzygium cumini* (Table 3).The stand density exhibited wide range of variations among communities of various altitudinal zones of the study area. The total tree density was highest in the coastal zone (616.25 trees/ha) while, Plane altitudinal zone (501-500 m MSL) recorded the least (585 trees/ha). But basal cover was maximum at midghat zone (1485.77 $m^2$/ha) and minimum at plane altitudinal zone (502.19 $m^2$/ha) (Table 4). This may be the due to basal area contribution is very dependent on the presence of large individual trees within the sample areas. Similarly these results are in line with Inamati et al (2005) who recorded that basal cover and species richness was highest in fourth altitudinal zone (401-500 m MSL).

The composition of three altitudinal zones was carried out in the entire area and composed of 49 taxonomic families represented by 205 species across all three altitudinal zones located between 0 to 750 m MSL (Table 5). Among the altitudinal zones, the vegetation of the coastal zone (0-250 m MSL) was richest in floristic and family composition (144 and 42 species) followed by midghat zone (251-500 m MSL) representing 117 and 39 species, and the least (103 and 36 species) was recorded by the plane zone (501-750 m MSL). The variation in quantitative parameters of forest composition among all the studied altitudinal zones may be due to difference in climatic, physiographic and edaphic factors as supported by Sharma et al., (2017). Malik and Bhatt (2016) also reported a total of 44 tree species of 36 genera and 25 families were recorded from the Western Himalaya.

Species richness and diversity parameters gradient (0 - 150 m MSL) is depicted in Table 2. The species richness ranged between 64 (Plane zone). The various diversity indices calculated for NTFP tree species along the altitudinal ne) to 74 (Coastal zone). The plane zone is poor in species

**Table 1.** Tree layer structure of NTFP species at Coastal zone (0-250 m)

| Rank | Species | Density/ha | Frequency % | BA/ha ($m^2$) | IVI |
|---|---|---|---|---|---|
| 1 | *Knema attenuate* | 67.50 | 65 | 93.25 | 35.49 |
| 2 | *Aporosa lindliyana* | 60.00 | 50 | 65.41 | 27.37 |
| 3 | *Hopea ponga* | 43.75 | 50 | 78.34 | 27.28 |
| 4 | *Myristica malabarica* | 26.25 | 50 | 29.36 | 14.78 |
| 5 | *Syzygium caryophyllatum* | 35.00 | 10 | 28.91 | 12.33 |
| 6 | *Garcinia indica* | 30.00 | 35 | 17.90 | 11.71 |
| 7 | *Mammea suriga* | 25.00 | 10 | 28.32 | 10.59 |
| 8 | *Caryota urens* | 17.50 | 35 | 17.28 | 9.56 |
| 9 | *Cinnamomum verum* | 16.25 | 40 | 15.02 | 9.39 |
| 10 | *Terminalia paniculata* | 16.25 | 25 | 19.89 | 8.93 |
| 70 | *Symplocos racemosus* | 1.25 | 5 | 0.01 | 0.68 |
| 71 | *Ficus racemosa* | 1.25 | 5 | 0.01 | 0.68 |
| 72 | *Bridelia retusa* | 1.25 | 5 | 0.01 | 0.68 |
| 73 | *Embelia ribes* | 1.25 | 5 | 0.01 | 0.68 |
| 74 | *Albizia chinensis* | 1.25 | 5 | 0.01 | 0.68 |

**Table 2.**Tree layer structure of NTFP species at Midghat zone (251-500 m)

| Rank | Species | Density/ha | Frequency % | BA/ha ($m^2$) | IVI |
|---|---|---|---|---|---|
| 1 | *Hopea ponga* | 151.25 | 70 | 890.17 | 92.33 |
| 2 | *Knema attenuata* | 85 | 75 | 180.41 | 34.21 |
| 3 | *Garcinia gummigutta* | 61.25 | 65 | 197.22 | 30.36 |
| 4 | *Garcinia morella* | 48.75 | 55 | 39.49 | 16.61 |
| 5 | *Aglaiaela egnoida* | 28.75 | 65 | 45.44 | 14.81 |
| 6 | *Dipterocapus indicus* | 13.75 | 15 | 59.60 | 7.89 |
| 7 | *Ixora brachiata* | 12.5 | 45 | 3.14 | 7.13 |
| 8 | *Reinwardtiodendron anamalaiencse* | 20 | 25 | 11.76 | 6.78 |
| 9 | *Myristica dactyloides* | 11.25 | 20 | 6.36 | 4.44 |
| 10 | *Persea macrantha* | 7.5 | 25 | 5.38 | 4.30 |
| 61 | *Arenga wightii* | 1.25 | 5 | 0.02 | 0.75 |
| 62 | *Calophyllum inophyllum* | 1.25 | 5 | 0.01 | 0.75 |
| 63 | *Mallotus philippinsis* | 1.25 | 5 | 0.01 | 0.75 |
| 64 | *Ventilago maderaspatana* | 1.25 | 5 | 0.01 | 0.75 |
| 65 | *Calycopteris floribunda* | 1.25 | 5 | 0.01 | 0.75 |

richness as compared to rest of the altitudinal zones. However, the tree species diversity is higher in coastal zone as compared to other zones. The value of tree species richness in the present study may be attributed to anthropogenic pressures such as extraction of minor forest produce (fruits, seeds, leaves etc.) and cattle grazing. The species diversity of NTFP species highest (3.62) in the coastal zone followed by midghat altitudinal zone and the lowest in the plane zone (2.95) (Table 6). The dominance of tree species was more in coastal altitudinal zone as compared to all other altitudinal ranges. The dominance was inversely proportional to species diversity in all the three altitudinal zones (Fig. 1). Conversely, Simpson's dominance index and the number of species exploited were highest for Plane zone, signifying the predominance of fewer NTFP species at this site. It is hypothesized that the NTFP spectrum reflects the floristic richness of a locality, which in turn, is dependent on the magnitude of disturbance that a site experiences. Although strong association between the local environment and plant community composition have been reported (Muraleedharan et al 2005) in areas subjected to considerable anthropogenic influence. Presumably, locations such as plane zone where a higher number of species were extracted may suffer far greater disturbances than other zones; particularly coastal zone Thus, floristic richness of a forest may be strongly impacted by the magnitude of NTFP extraction. Less disturbed zone showed higher species richness and density than more disturbed (Egbe and Tsamoh, 2018). The present study, therefore, suggests that NTFP extraction, as other forms of human induced disturbances, is related to decline in species richness and a greater magnitude of such disturbances, leads to a greater potential for species loss. This study was devoted primarily to NTFP diversity as measured by species

**Table 5.** Species composition of NTFP species

| Altitudinal gradation | Values of floristic composition | Values of family composition |
|---|---|---|
| Coastal zone (0-250) | 144 | 42 |
| Midghat zone (251-500) | 117 | 39 |
| Plane zone (501-750) | 103 | 36 |

**Table 3.** Tree layer Structure of NTFP species at Plane zone (501-750 m)

| Rank | Species | Density/ha | Frequency % | BA/ha ($m^2$) | IVI |
|---|---|---|---|---|---|
| 1 | *Caryota urens* | 38.75 | 70.00 | 56.57 | 23.70 |
| 2 | *Aporosa lindliyana* | 41.25 | 60.00 | 50.24 | 22.03 |
| 3 | *Syzygium cumini* | 26.25 | 40.00 | 59.51 | 19.66 |
| 4 | *Terminalia paniculata* | 40.00 | 50.00 | 36.76 | 18.31 |
| 5 | *Mangifera indica* | 22.50 | 55.00 | 32.67 | 14.92 |
| 6 | *Aglaiaelaegnoida* | 26.25 | 35.00 | 37.28 | 14.81 |
| 7 | *Teminalia tomentosa* | 27.50 | 35.00 | 33.75 | 14.33 |
| 8 | *Artocarpus hirsutus* | 17.50 | 45.00 | 25.72 | 11.85 |
| 9 | *Stereospermum personatum* | 16.25 | 35.00 | 28.98 | 11.45 |
| 10 | *Ixora brachiata* | 20.00 | 55.00 | 7.65 | 9.51 |
| 66 | *Albizia odoratissima* | 1.25 | 5.00 | 0.01 | 0.63 |
| 61 | *Chukrasia tabularis* | 1.25 | 5.00 | 0.01 | 0.63 |
| 62 | *Dalbergia latifolia* | 1.25 | 5.00 | 0.01 | 0.63 |
| 63 | *Holarhena antidysentrica* | 1.25 | 5.00 | 0.01 | 0.63 |
| 64 | *Pandanus* species | 1.25 | 5.00 | 0.01 | 0.63 |

**Table 4.** Density and basal area of woody component of the vegetation in relation to different altitudinal zones

| Vegetation strata (m MSL) | Density/ha | | | Tree basal area/ha ($m^2$) |
|---|---|---|---|---|
| | Establishment | Tree | Total | |
| Coastal zone (0-250) | 32770 | 616.25 | 33386.25 | 507.37 |
| Midghat zone (251-500) | 26470 | 608.75 | 27078.75 | 1485.77 |
| Plane zone (501-750) | 29890 | 585 | 30475 | 502.19 |
| Mean | 29710 | 603.33 | 30313.33 | 831.78 |

**Table 6.** Key diversity values of NTFP species in different altitudinal zones

| Parameters | Diversity values | | |
|---|---|---|---|
| | Coastal zone (0-250 m MSL) | Midghat zone (251-500 m MSL) | Plane zone (501-750 m MSL) |
| Species richness | 74 | 65 | 64 |
| No of individuals | 493 | 487 | 468 |
| No of genus | 59 | 46 | 41 |
| Total basal area (sq.m) | 507.37 | 1485.77 | 502.19 |
| Shannon-Weiner index | 3.62 | 2.98 | 2.95 |
| Simpson index | 0.04 | 0.03 | 0.03 |
| Evenness index | 0.88 | 0.84 | 0.71 |
| Margalef's index | 3.33 | 2.95 | 2.94 |

**Table 7.** Species similarity indices among different altitudinal zones of the vegetation

| Altitudinal zone (M MSL) | Coastal zone (0-250) | Midghat zone (251-500) | Plane zone (501-750) |
|---|---|---|---|
| Coastal zone (0-250) | - | 61.87 | 56.52 |
| Midghat zone (251-500) | - | - | 44.96 |
| Plane zone (251-750) | - | - | - |

richness and Shannon diversity along the altitudinal gradient. The species similarity among different altitudinal ranges of study area was assessed and community species composition coefficients were determined based on species composition of three altitudinal zones (Table 7). The percentage of similarity among three altitudinal zones varied between 44.96 (plane and midghat zones) and 61.87 (coastal zone and midghat zone). The coastal and midghat zone recorded highest similar species (61.87) followed by plane and coastal zone (56.52) and least percentage of similar species recorded in plane and mid ghat zone (44.96).

## CONCLUSION

The study provides useful information on the present condition of the woody species diversity, structure and regeneration status of NTFP species along different altitudinal gradation. The present study highlights the lower elevation (Coastal zone) NTFP species had comparatively higher number of species, whereas lower number of species was recorded at higher elevation (Plane zone) NTFP species, which imply the climatic adaptation by plant species. It is found that altitude affect population structure. The fluctuation in population density of seedlings, saplings and adults along the altitudinal gradation may be linked with the environmental factors. The findings of this study will provide the baseline data to assess future migration of species. Vegetation response to recent climatic changes on NTFP species is dependent on initial species composition, vegetation structure and environmental conditions. Thus to reduce pressure on NTFP population, creating awareness among local peoples in harvesting techniques of NTFP species.

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