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# Comparative Study of Biodiversity, Habitat Heterogeneity and their Relationships, with Reference to Large Mammalian Fauna of Kanha National Park : A Regional Perspective

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**Abstract** In our study, we estimated the biodiversity with respect to multiple regional sites or zones and types of heterogeneity with in it. We studied on large sized mammalian fauna. The biodiversities of different zones of the national park have been estimated with respect to species evenness and species richness. Topologies, drainage/streams and vegetation of different forest zones were estimated. The surveys and consecutive analysis indicates different zones in Kanha NP show variation in biodiversity in terms of species richness and species evenness. Different large mammalian fauna do not enjoy the uniform distribution in different zones of the national parks due to differences in topographic elevation, spatial extension and respective vegetational heterogeneity. Thus, evaluation of biodiversity and the conservation management, needs to be estimated and designed at regional scale. The heterogeneous, complex structures and its variations, in different segments of the Kanha National Park, are of great importance. The designing and demarcation of different forest zones is important when the forest is such large and heterogeneous. The present research work contributes towards SDM and SADs large mammals in Kanha NP.

**Keywords** Species richness, Species evenness, Habitat heterogeneity, Conservation, Biodiversity.

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## Introduction

Kanha National Park is located in Madhya Pradesh, central India. It is surrounded by Maikal Hills and extends from $80^0$-26´-10´´ to $81^0$-4'-40' in longitude and $20^0$-1'-5" to $22^0$-27'-48" in latitude [1]. It is composed of grasslands and plenty of water bodies and dense forest vegetation. Rugged landscape, flat- top hills and ridges encloses the valley that drains towards North into Narmada River (altitude 450-950 m above m.s.l.). It comprises of many trees of which Sal, Segun, Bamboos are prevalent. Kanha NP shows moist deciduous forest on lands below 650 meters, dominated by Sal *(Shroea robusta).* Above 650 meter it represents dry deciduous forest .

The maximum temperature reaches at around $46^0$C during the month of May-June. The minimum temperature can be as below as zero degrees Celsius during the month of January and December. In monsoons it gets around 60% of annual rain fall. Whereas, the average annual rain fall is about 1400 mm [1]. Kanha shelters 10 species of ungulates and large predators like Royal Bengal Tigers and leopards within 940 squares kilometers of core zones and 1134sq km of buffer zones.

The present study of biodiversity in terms of both species richness and species evenness [2] would determine the relationships between species and environment [3], [4]. It will be helpful for the SDM and SADs of large mammals of this National park [3, 4]. It could be used to predict climate change impacts, study biogeography, assist in reserve selection, improve species management and to develop conservation biology needs [5].

Our study proposes for implementation of conservation and management program at regional scale, to maintain biodiversity in Kanha National Park. It is important to restore the regional heterogeneous and complex habitat structures change of which would lead to a breakdown in species diversity [6, 7]. We also suggest necessary studies and researches for developing knowledge that are helpful to demarcate the forest in different categorical regional sections for more effective conservation.

## Materials and Methods

The survey was done by four different teams, at four different location/zones at Kanha NP, simultaneously. The visiting time was from 6 am to 12 noon in the morning and 3 pm to 5 pm in the afternoon during the month of February to March in 2014. The data on species was collected by Vote Counting method [8]. The assistance of binoculars (Pentax 10 × 50; XCF) and cameras were taken during the survey work. The satellite images are also taken into account for vegetational study while comparing and confirming heterogeneity.The TNT MIPS Version 2016 software was used to collect satellite images and geographical data and for subsequent analysis. Landsat 8 image from USGS Earth Explorer and IRS Liss III image from Bhuvan open achieve has been take into account for vegetational and NDVI images. While the contour and stream/drainage maps has been adopted through STRM DEM from USGS Earth Explorer.

## Results and Discussion

Data collected from all the 4 different zones namely Sarhi, Kisli, Mukki and Kanha are being analyzed to get the values of $H^1$ (Shannon Index), $H^1_{MAX}$, Species richness (S) and Species evenness (J') for the estimation of biodiversity at the regional seales [9].

The Kisli zone shows maximum Shannon index values ($H^1$) of 1.604, followed by Sarhi zone (1.571). The Mukki zone shows the minimum value (1.381) and Kanha zone with a value 1.491, finishes third just above the Mukki zone. The Kisli zone shows maximum species evenness (.824) whereas, Kanha zone shows the least (0.662). But the Kanha zones show the maximum species richness (11) and Kisli and Sarhi shows the least (7).

Results of ANOVA test reveal that the different forest zones have significant impact on large mammalian species composition ($F$=5.39, df=11, $p$<.01). The primary consumer community shows diverse distribution pattern from one section to the next. The most abundant large herbivore species (primary consumers) that are taken in to consideration are Gaur *(Bos gaurus)*, Spotted Deer *(Axis axis)*, Samber *(Cervus unicolor)*, Swamp Deer *(Cervus duvaucelii)* and Langur *(Semnopithecus entellus)* in this study. ANOVA test on these 5 major primary consumers do not show statistically significant results with respect to their mean in different forest zones. But the species composition (5 dominant primary consumers) and the forest segments are found not to be independent functions as the result of $X^2$ test suggests ($X^2$= 54.697, df=12 ; $p$>.05).

The different zone of forest segments Sarhi, Kisli, Mukki and Kanha have also shown difference/variation with respect to the following geographical parameters. The ANOVA test indicates that the different forest zones show significant difference in topological heterogeneity. The contour and topology shows a significant variation ($F$=52.58 df=1, $p < 0.01$) among four different zones. The river stream/drainage system also varies significantly from one forest zone to the next ($F$=57.83, df=1, $p < 0.01$).

The NDVI images of Kanha National Park represented 10 different types of vegetations which, for statistical calculation are grouped in 5 major types, each of which comprise of two subtypes. The ANOVA test shows that the forest vegetation has significant role ($F$=16.63, df=4 ; $p$ <0.01) on determining the heterogeneity of different zones in Kanha National Park.

The satellite images on topology river/drainage and vegetation show visual evidences in supports of the heterogeneity. The topological map, with data points at 20 m interval, has represented the elevations and the degree of spatial variation in different zones of Kanha NP. With maximum heterogeneous topology and elevation ($R^2$=0.0103), Kanha zone appears to be most complex. In contrast, the Kisli zone appears to be the lesser complex zone ($R^2$=0.1734). Mukki zone with the highest value of $R^2$ ($R^2$=0.5294) proposes a unidirectional elevational variation with a slopping gradient.

The vegetational image also shows agreement with our findings that the Kanha zone has most abundance vegetation and also has highest heterogeneous plant communities. The vegetational analysis of NDVI image, has categorized the Kanha NP in 10 different vegetational types. Each of which indicates a definite type of vegetation. The water bodies were also indicated by this image. The NDVI values show variations with in the same zones and among different zones. The range of NDVI values with in a zone indicates toward the degree of heterogeneity with respect to the vegetation in a specific zone. The lowest (in negative) and highest NDVI values of Kanha also supersedes the respective values of Kisli zone. The overall range of NDVI values (difference between the max and minimum values) of Kanha zone is also much greater than that of Kisli zone. Therefore the vegetational heterogeneity in the Kanha zone is greater compare to that of Kisli zone. The lowest NDVI value (negative values) of kanha is greater than Kisli. This observation do aggregate with our later findings that the Kanha zone has better water resources for more efficient and extensive river/drainage system when compared with Kisli zone.

The Kanha NP is a vast and large NP that shelters a good species populations of which the large mammalian populations are of great importance. The Kanha habitat and its biodiversity with respect to the large mammalian species are found to vary significantly in different zones of forest. The species richness, the Shannon index and the species evenness values varies from forest section to section when all the mammals were considered. The emphasis has been given on both species richness and species evenness which is important while biodiversity is measured [2]. The large mammalian species varies both vertically and horizontally along the different forest zones under definite time. The species distributions are not uniform along the different sections of the forest.

The differences of topological elevations and spatial variations and their extensions are statistically significant in different forest zones. The drainage / stream systems and the direction of flow of water vary in diverse manners. The length of streams/drainage and mean stream/drainage lengths of a forest zones shows significant differences among different regional sections of forests. The streams/drainage system which flows through the forest sections and which nourishes both the habitat and species communities, show remarkable and significant diversities. Thus in Kanha national park, the different forest zones, namely Sarhi, Kisli, Mukki, Kanha vary with respect to several geographical attributes that are the primary cause of heterogeneity. The heterogeneous topology, spatial variations, and stream/drainage system have contributed substantial impact on the vegetation, animal distribution and their abundance and overall mammalian biodiversity. A negative correlation between species richness and elevation fits well with the general acceptance that the lowland tropical rain forest has the richest biota on Earth. Further research has shown that this may not always be true on a regional scale on mammals [10] and birds.

The Kanha zone having the highest peaks (905 m), shows a good differences between lowest plane to highest peak (347 m). It has highest no of streams /drainages (255), longest stream length (210.54 km). It shows a greater heterogeneous and most complex topological structure and stream/drainage variations than the other 3 zones. It also shows lowest values of mean stream length/sq km (1.47 km) and lowest value of mean stream length (0.83 km) with least standard deviation of (0.57) among all the zones. Therefore, in kanha zone, water is supplied more evenly, through streams/drainages. The longest mean length of Mukki zone with highest value of standard deviation indicates un-uniform streams/drainage length and disproportionate stream availability and water supply among the forest sub-zones. The Kanha zone and its subzones are penetrated mostly by the stream/drainage system. The chances of availability of water, in most of its sections, is highest compared to the rest of the forest zones. As the water resource contributes for both the floral and faunal content therefore the Kanha zone shows greater habital complexity and habitat heterogeneity.

The topological data reveals the Kanha zone, with 126 different data points, has the highest mean values 731.75 m ±8.83, highest median values (720) and highest mode values (620). That means the kanha zone is located on the highest section of the mountain range and it acquires the higher peaks and plateau. It has topmost areas of 900 m (approximate), lowest area of 580 m and a range of 320 m. The other few points (areas) that shows greater frequency are 860 m, 640 m, 700 m and 720 m. Therefore, the topology of Kanha zone, contributes to both vertical and horizontal variations with an effective blend so as to create the best out of it [10].

Thus topology and stream/drainage, have contributed towards complex heterogeneous plant communities (Map 3B) and habitat heterogeneity [8]. It is therefore more practical that the kanha zone habitats provide more physical niches and a greater diversity of resources that eventually support greater species richness, compared to the other zones of the national park (Map: 3 A and B). Here the habitat heterogeneity is co-related with the species diversity of large mammalian population, with reference to both species richness and species evenness [11].

The large mammalian populations of primary consumers level of Kanha zone shows maximum cumulative count in number compare to other section of the forests. That indicates this zone is most complex and productive in terms of the resources. Being structurally complex, the Kanha zone provides more niches and caters more species, by exploiting its environmental resources in diverse ways [12]. The availability of more and more physical niches appears to be more probable in this zone than the other sections of the forest. Here the potential niches are distributed both horizontally and vertically due to its heterogeneous structure [13] and therefore generates scopes for more species populations.

In contrary, the species even ness and the Shannon index of Kanha zone are on the down side. The complex habitat structure of Kanha zone with extensive topographic and spatial heterogeneity could act as physical as well as ecological barrier for the uniform distribution of the mammalian populations. The existence of diversified niche could open up the scope for more mammalian species populations but can restrict their distribution, simultaneously. The heterogeneous plant communities act as resources [12] for the primary consumers. But it also restricts the distribution of large mammals - evenly. The environmental heterogeneity in this part appears to promote opportunities for species diversification through geographic isolation [14, 15]. The species compositions, predominantly the ungulates [10] were affected both by dispersal limitation and local ecological conditions [16, 17]. This will open upopportunities for more genetic divergence between populations (β diversity)[11, 18] in the national park.

On the other hand, the Kisli zone with highest species evenness and Shannon index shows a downfall of species richness (3B, 3C, 3A). The Kisli zone shows the least elevations and lesser topological and vegetationl heterogeneity. Thus it becomes least complex zone. It shows a mean value (elevation) of (578.78 m ± 4.94). The values of both median and the mode are 560. Amongst 115 data points, it shows a highest elevation value at 720 m and a lowest at 480 m with a range of 240 m and standard deviation of ± 53. The mode, median values and the mean values indicated that the Kisli zone is relatively flat with least elevational variations within the least range value. The higher frequency of values from 520 m to 640 m indicates towards more horizontal extensions. The potential to create, complex vegetation and subsequently vertical niches are greatly compromised due to the lesser elevation variations. Here the horizontal variation is the major contributor of habitat heterogeneity and available niches.

The stream/drainage system that replenishes the whole habitat has a different formation in this zone when compared with the other. The Kisli zone shows the least total area of 76.75 sq km, and a boundary length of 60.06 sq km. This zone has the least no of stream (137), least no of streams/km (1.78) and shortest total stream length (115.61 km). The mean stream length (0.84 km) and the mean stream length/sq km (1.50) are also on the lower side with a highest standard deviation of ±.68. These indicate the presence of limited number of streams in that section of forest. The distribution of the streams and water availability are therefore restricted to certain sections. The streams lengths vary greatly as the standard deviation is very high. Therefore it appears that the streams do not penetrate this section of forest evenly and effectively, as in Kanha zone. The water availability in Kisli zone thus appeared not to be as uniform as Kanha zone. The lack of evenly distributed water resource and elevational variation, have caused negative effect on habitat heterogeneity and complexity in Kisli zone. The species richness is compromised in this section of forest. Limited elevational/vertical complexities, heterogeneous habitat and physical (vertical) niches, have allowed the existing populations to distributes more evenly. The physical and ecological barriers are appeared to be least in this part of the forest zone [14–17].

The flat and less complex structure has niches which are more overlapped with each other than mountain species, have resulted even distribution of species population [13]. The observation of Arellano G et al. [13] shows strong agreements with our observations in Kunha and Kisli zones. They also suggest that lowland forest zones have greater interspecific competition. The lesser heterogeneous topology and least complex structure of Kisli zone have facilitated higher chances of niche overlapping. Therefore it appears to be practical that the competitions with in the species are more intense in this part of forest [13].

The species populations and interaction in between, also influence the species diversity and species distribution pattern [17, 19] apart from demography [16]. But this part of study is beyond the scope of current findings.

Thus we can conclude that Kanha National Park has different zones which are heterogeneous and complex in structure. The topology and stream/drainage system have contributed complexity and heterogeneity, both vertically and horizontally. Here different zones of Kanha National Park, namely Sarhi, Kisli, Mukki and Kanha have different degrees of potentials to create physical niches. The complex and heterogeneous vegetation of different section of the forest, create resource dependent large mammalian populations [20]. The biodiversity of different section of forest, in terms of species richness, Shannon index and species evenness, do not show uniformity. The large mammalian primary consumers of our interests especially, show significant variations in biodiversity along the different forest zones. Therefore species distribution models, biodiversity estimation, conservational managements, effect of climate change and species management are needed to be considered, at regional scale. The keystone structures also contribute towards habitat complexity and heterogeneity (at regional scales). As, it is our assumption therefore it need to be validated through new research works.

Therefore the considerations of all these factors are appeared to be important for a better understanding of species diversity, niche characterization [21], SDM [5], SADs [13] and species management at spatially separate zones and subzones of Kanha National park. The overall planning on forest zonation/fragmentation in to different zones/sub zones is a matter of great importance, for effective conservation and productive forest management [22].

The relationships between habitat heterogeneity, along the spatial scale (horizontal and vertical) [23] and the resource dependent large mammalian diversities play key role [22, 23] in developing knowledge which are useful to demarcate a large heterogeneous forest like Kanha NP, in to different zones, in a more natural and ecological way.

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