WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Species Diversity and Accumulation in Tropical Ecosystems: Preliminary Insights

Dr. P. Merlynna Esther Maxmellion*#

**Guest Faculty, Department of Biotechnology, Mother Teresa Women's University, Attuvampatti, Kodaikanal-624101, Tamil Nadu,India*

 # Email: dr.merlynnamtwu@gmail.com

A B S T R A C T

The fact that biodiversity exists within the confines of tropical ecosystems is well known, however their community structure remains relatively obscure. This particular study aimed to explore species diversity and community structure of tropical ecosystems through the use of species accumulation curves and various diversity indices. Based on the findings, the study highlights a significant amount of species richness owing to the Shannon diversity index of 3.947 and Simpson diversity index standing at 0.0265. Moreover, the Brillouin's index pointed out that the sample was highly diverse or overdispersed, suggesting the presence of numerous rare species within the community. With species accumulation curve rounding an asymptote between 10-13 sites, the total sampling effort has been achieved. For other species, further exploration will be needed regarding the remaining species. This research advances the understanding of tropical ecosystems and suggests that their management is vital in preserving heterogeneous habitats which highlights critical areas of environmental stewardship to strengthen species interactions and enhance biodiversity.

Keywords: Biodiversity, Tropical ecosystems, Attuvampatty, Kodaikanal, Species diversity

1. Introduction

Tropical ecosystems have the richest species diversity and are well-known for the high levels of endemism (Myers et al., 2000). They are interesting due to the numerous species interactions and the structure of these species communities because of mlution strategies that are optimal for conservation and management (Colwell & Coddington, 1994). Diffrehhcial metrics such as the diversity indices as well as species accumulation curves are useful to assess species diversity in combination with community composition such as in the case of (Gotelli & Colwell, 2001). In many previous studies these methods were employed to analyze dve community structure and the extent of sampling (Gotelli & Colwell, 2001; Ugland et al., 2003). Moreover, this type of research in teh Western Ghats also discovered communities with species eviding richendemsim along with considerable diversity (Rasingam & Rao, 2009). Any ecologcal research uses the diversity indices of Simpson, Shannon, and Brillouin (Hill, 1973; Pielou, 1966) since they offer meaningful interpretations on the structure of the community and diversity present. Moreover, species addition curves determine the appropriateness of sample size as well as the number of species (Colwell & Coddington, 1994). The shape of these curves together with their asymptotes indicate the fullness of sampling and the degree to which rare species are present. This study tried to evaluate the diversity of species in a tropical ecosystem with the provided methods. It was assumed that the population structure would show high species diversity, endemicity, and an abundance of uncommon species. These results provided so many new perspectives on the interactions taking place in tropical ecosystems which is very important from a conservation and management perspective.

1.1 Study Area

The study was conducted between January 2025 and April 2025 in a tropical ecosystem in Attuvampatty village and in the Mother Teresa Women's University campus, Kodaikanal, located in the Western Ghats region. This region is tropical area with montane forests, tropical grasslands and deep-rooted ecosystems, and are well-known for its rich biodiversity. The diverse geography of the region allows for the sustenance of numerous species of plants and animals. The study area located in the Western Ghats is a biodiversity hotspot and is well known for the diversity of flora and fauna which provides great opportunities for ecological studies (Rasingam & Rao, 2009). Combining these factors heightens the sensitivity to climate change and human activities, sustaining the region's critical need for effective conservation and management efforts.

1.2 Methodology

In this study, two methods were used to evaluate species richness. Species accumulation curves was used to estimate the number of species encountered in the community, as suggested by Colwell & Coddington (1994). The vegan package in R version 4.5.0, R Core Team, 2020; Oksanen et al., 2020) and RStudio was used to perform the Species accumulation curves analysis (RStudio Team, 2020). he vegan package's specaccum function was used to generate species accumulation curves using the 'exact' method (Gotelli & Colwell, 2001) based on presence-absence data. The obtained curve was visualized using ggplot2 (Wickham, 2016). Diversity indices were calculated using the Real Statistics data analysis program. The study encountered a total of 81 species and 764 individual birds within the community.

The Simpson, Brillouin, and Shannon diversity indices were performed. The Shannon diversity index (H') was estimated as:

$H' = -\sum (pi * \ln(pi))$ (1)

where pi is the proportion of each species in the population. The index provides an estimate of species diversity.

The Brillouin index (HB) was calculated as:

$HB = ((\ln(N!) - \sum \ln(ni!)) / N)$ (2)

where N is the number of individuals and ni is the individuals of each species. The index can be used in communities with known sample sizes.

The Simpson index of dominance (D) was calculated as:

$D = (\sum (ni(ni-1)) / N(N-1))$ (3)

where estimating the probability that two individuals randomly selected belong to the same species.

Additionally, bootstrapping with 1000 iterations was used to estimate the standard error and 95% confidence intervals for each diversity index.

2. Results

The species diversity of the tropical ecosystem was assessed using species accumulation curves and diversity indices. The species accumulation curve (Figure 1) shows a steep initial slope, indicating a rapid accumulation of new species as the number of sites increases from 1 to around 4-5.The curve approaches an asymptote around 10-12 sites, suggesting that the sampling effort is nearing sufficiency (Ugland et al., 2003; Chao, 2005). The diversity indices calculated for the community are presented in Table 1. The Shannon diversity index (H') was 3.947, indicating high species diversity. The Brillouin index suggested an overdispersed or highly diverse sample, indicating that the community is composed of many rare species. The bird species abundance chart (Figure 2) shows a typical pattern of a few dominant species and many rare species. Overall, the results indicate that the community exhibits high species diversity, with a Shannon diversity index (H') of 3.947 and a Simpson diversity index (D) of 0.0265. The Brillouin index suggests an overdispersed or highly diverse sample, and the results are statistically significant ($p < 0.001$). The species accumulation curve suggests that the sampling effort is nearing sufficiency, but additional sampling may still be necessary to capture the remaining species.

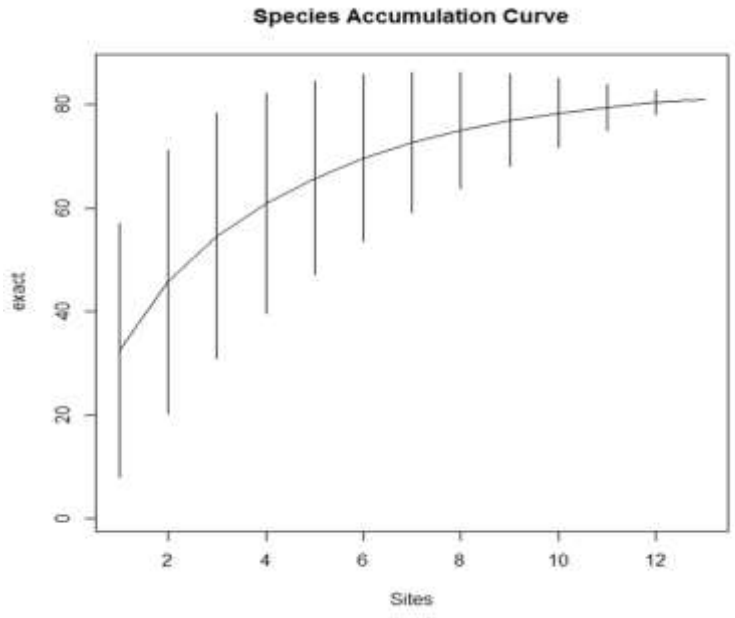

Fig. 1 - Species accumulation curve with 95% confidence intervals

Table 1 - Diversity indices with standard errors and 95% confidence intervals

S.No	Diversity Index	Value	Standard Error	95% CI
1.	Shannon diversity index (H')	3.947	0.023	(3.902, 3.992)
2.	Brillouin index	5.592	0.041	(5.512, 5.672)
3.	Simpson diversity index (D)	0.0265	0.0012	(0.0241, 0.0289)
4.	1-D	0.9735	0.0012	(0.9711, 0.9759)
5.	1/D	37.697	1.234	(35.278, 40.116)

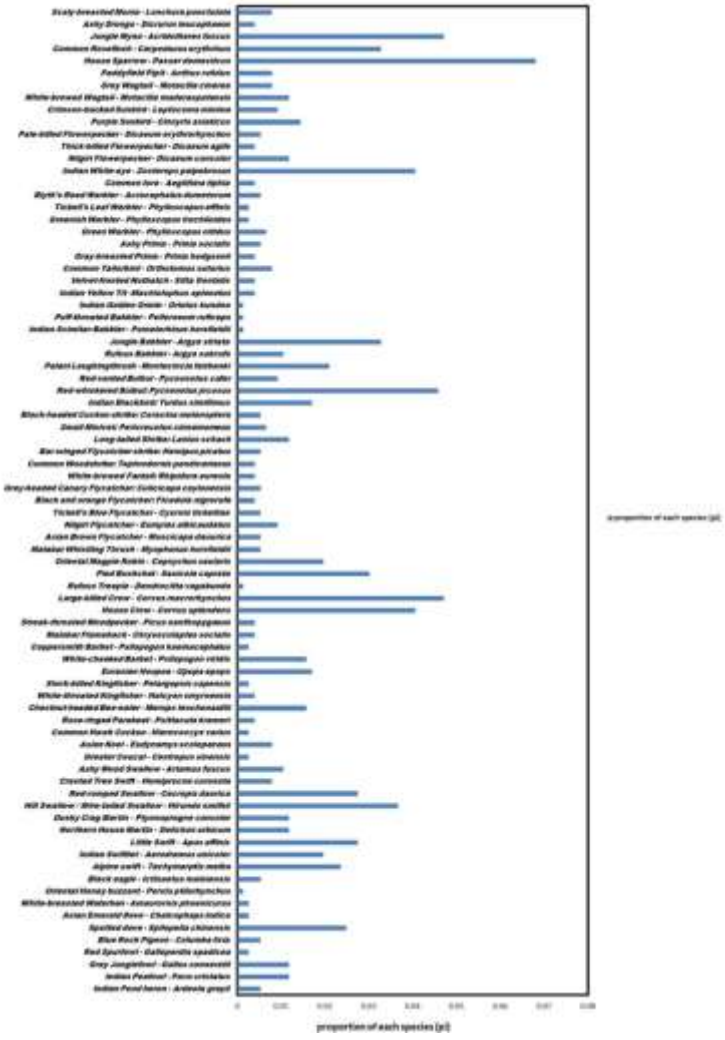

Fig. 2 - Bird species abundance chart

4. Discussion

Based on the results, the present study demonstrates that the communities in the study area are quite diversified, with a wide variety of species and a significant number of individuals. The Shannon diversity index (H') and the Simpson diversity index (D) both signifies a high degree of species diversity, with the Brillouin index showing an overdispersed or highly diverse sample. It is clear from the study that there are many reasons leading to occurrence of high level of diversity of bird species found in study area such as foraging sites, food availability, nesting sites, availability of nesting material, species interactions, habitat heterogeneity and environmental conditions. Figure 2 shows the total number of 81 observed bird species during the study with a few bird species really thrive in this area with a high proportion of pi values including House Sparrows (*Passer domesticus*, 0.07), Pied Bushchats (*Saxicola caprata* 0.055), Indian White-eyes (*Zosterops palpebrosus*) at 0.045, Red-whiskered Bulbuls (*Pycnonotus jocosus*) ranging from 0.035 to 0.04, and Spotted Doves (*Spilopelia chinensis*) at 0.025-0.03. The presence of invasive species like *Lantana camara* can alter bird community composition and provide food sources for certain species (Sharma et al., 2017). Notably, *Lantana camara* is widely dispersed in the study area, providing a suitable environment for birds like Red-whiskered Bulbuls and Indian White-eyes, which feed on its fleshy fruits, thereby contributing to their success and

adaptation in the area (Kannan & James, 2011). Likewise, the less common species (such as the oriental honey-buzzard (*Pernis ptilorhynchus*) and the black-headed cuckooshrike (*Coracina melanoptera*) had lower percentages under pi value (0. 005). Thus, it can be suggested that they are very rare in this region (Grimmett et al., 2016). During the study, it was observed that the nest material collecting in several bird species including House Sparrows, Pied Bushchats, Eurasian Hoopoes, Common Rose Finches. Nesting sites varied between species, House Sparrows and Dusky Crag Martins in buildings, White-cheeked Barbets and Jungle Mynas in tree holes, Red-whiskered Bulbuls in bushes, Palani Laughingthrushes and Streak-throated Woodpeckers in trees. Additionally, it was also observed that the parental care behaviors like feeding of young Dusky Crag Martins and House Sparrows, and presence of Red-whiskered Bulbul eggs. The study also observed the intesting behavious like first flights of young House Sparrows and Red-whiskered Bulbuls. As is noted by Sutherland et al. (2013), a lot of bird species generally mean healthy environment for a diverse avifauna. In addition, bird species abundance chart (Figure 2) indicates the diversity and composition of these bird communities. Such graph clearly shows the importance of conservation efforts for preserving both common and rare bird species (Donald et al., 2010). Thereby, this study emphasizes richness of bird species and their vital role in the conservation of the ecosystem.

5. Conclusion

The study's findings revealed that the community had high species diversity with many species and many individuals. The results were statistically significant so the diversity patterns are not just coincidence. The species accumulation curve suggests the sampling is nearly adequate but additional sampling is needed to get the available species. These results highlight the importance of habitat diversity and species interactions which has implications for management and conservation. So more research should be done to understand species interactions and community structure in tropical ecosystems. To accomplish this, comprehensive studies and monitoring to observe changes in species diversity and community structure over time. To conserve biodiversity and sustainable management, it is essential to conserve habitat diversity and support species interactions.

Acknowledgements

I would like to extend my sincere gratitude to the following institution and individuals for their invaluable contributions to this study. I deeply grateful to Vidhya Anandhavel and Anand Shibu, renowned birding experts, for their expertise in identifying the bird species encountered during this research. I acknowledge the generous support provided by Mother Teresa Women's University and the Head of the Department of Biotechnology, who granted permission to conduct this study. My heartfelt appreciation also goes to my colleagues in the biotechnology department and the student volunteers and who enthusiastically participated in the birding events: Abinaya, Janani, Deepika, Devakhi, Rakshana Devi, Surya Prabha, Kirija, Lalitha, Packiya Lakshmi, and Sabeetha.

Appendix A.

A.1. Photographs off the birds observed in the study area

References

Brillouin, L. (1956). Science and information theory. Academic Press.

Chao, A. (2005). Species richness estimation. In Encyclopedia of Statistical Sciences (pp. 7907-7916).

Colwell, R. K., & Coddington, J. A. (1994). Estimating terrestrial biodiversity through extrapolation. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 345(1311), 101-118. https://doi.org/10.1098/rstb.1994.0091

Gotelli, N. J., & Colwell, R. K. (2001). Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. Ecology Letters, 4(4), 379-391. https://doi.org/10.1046/j.1461-0248.2001.00230.x

Hill, M. O. (1973). Diversity and evenness: A unifying notation and its consequences. Ecology, 54(2), 427-432. https://doi.org/10.2307/1934352

Legendre, P., & Legendre, L. (1998). Numerical ecology. Elsevier.

Kannan, R., & James, D. A. (2011). Fruit consumption by birds in relation to seed dispersal of Lantana camara. Journal of Tropical Ecology, 27(2), 147-155.

Magurran, A. E. (2004). Measuring biological diversity. Blackwell Science.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. Nature, 403(6772), 853-858. https://doi.org/10.1038/35002501

Oksanen, J., Blanchet, F. G., Friendly, M., Kindt, R., Legendre, P., McGlinn, D., ... & Wagner, H. (2020). vegan: Community Ecology Package. R package version 2.6-0.

Pielou, E. C. (1966). The measurement of diversity in different types of biological collections. Journal of Theoretical Biology, 13, 131-144. https://doi.org/10.1016/0022-5193(66)90013-0

R Core Team. (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing.

Rasingam, L., & Rao, P. N. (2009). Tree diversity and structure in the Western Ghats, India. Journal of Tropical Ecology, 25(3), 283-294. https://doi.org/10.1017/S0266467409006023

RStudio Team. (2020). RStudio: Integrated Development Environment for R. RStudio, PBC.

Shannon, C. E., & Weaver, W. (1949). The mathematical theory of communication. University of Illinois Press.

Sharma, G. P., Singh, J. S., & Raghubanshi, A. S. (2017). Lantana camara invasion alters bird community structure in tropical forests. Biological Invasions, 19(10), 3105-3118.

Simpson, E. H. (1949). Measurement of diversity. Nature, 163(4148), 688. https://doi.org/10.1038/163688a0

Ugland, K. I., Gray, J. S., & Ellingsen, K. E. (2003). The species-accumulation curve and estimation of species richness. Journal of Animal Ecology, 72(5), 888-897. https://doi.org/10.1046/j.1365-2656.2003.00748.x

Wickham, H. (2016). ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York.