AgriCos e-Newsletter
ISSN: 2582-7049
AgriCos e-Newsletter
Open Access Multidisciplinary Monthly Online Magazine
Volume: 04 Issue: 12 December 2023 Article No: 23

Biodiversity Indices

M.Ponmani[1], S.Manickavasagam[2], P.Padmavathy[1] and D.Manimekalai[1]
[1]Department of Aquatic Environment Management, TNJFU - Fisheries College and Research Institute, Thoothukudi, Tamil Nadu
[2]Assistant Professor, TNJFU-DSA, Thanjavur Centre for Sustainable Aquaculture, Thanjavur, Tamil Nadu

SUMMARY

Diversity indices are mathematical tools commonly used in ecological and biological studies to quantify the diversity of species within ecological communities and ecosystems. These indices provide a systematic and quantitative approach to assess the variety of species and their relative abundances in a given area. They offer valuable insights into the structure and complexity of ecological systems, aiding in the comparison of different communities and tracking changes over time. Some of the widely employed diversity indices include species richness, Shannon-Wiener Diversity Index, Simpson's Diversity Index, Pielou's Evenness Index, Margalef's Diversity Index, Sørensen Similarity Index, Jaccard Index, Bray-Curtis Dissimilarity, and Simpson's Index of Diversity. These indices enable researchers and conservationists to better understand the health and dynamics of ecosystems, guiding decision-making processes related to conservation and management. The choice of a specific diversity index depends on the research objectives and the characteristics of the ecological data being analyzed.

INTRODUCTION

Biodiversity, the intricate web of life encompassing a wide array of species and ecosystems, is a cornerstone of the natural world. It underpins the health and stability of our planet, providing essential services, from clean air and water to food and medicine. The diversity of life on Earth, however, faces unprecedented challenges due to various anthropogenic factors, such as habitat destruction, climate change, pollution, and overexploitation. To effectively address these threats and assess the state of our environment, scientists and conservationists have turned to biodiversity indices as invaluable tools. Biodiversity indices come in various forms, each suited to specific research questions and ecological contexts. Some of the commonly used indices include species richness, Shannon-Wiener Diversity Index, Simpson's Diversity Index, Pielou's Evenness Index, and Jaccard Index, among others. Researchers select the most appropriate index based on their objectives, the type of data available, and the characteristics of the ecosystem under study. In summary, biodiversity indices are indispensable tools in the field of ecology and conservation. They offer a quantitative lens through which we can observe and understand the natural world. By quantifying biodiversity, we can better appreciate its value, monitor its health, and take proactive measures to safeguard the intricate tapestry of life that sustains our planet.

Diversity index

A diversity index serves as a quantitative tool that provides insights into the variety of different types, such as species, within a dataset, typically representing a biological community. These indices offer statistical representations of biodiversity, focusing on various aspects, including species richness, evenness, and dominance. In ecological contexts, the entities of interest are typically individual species, but they can also encompass broader categories like genera, families, functional types, or genetic haplotypes. The measure of abundance may take various forms, such as the count of individual organisms, biomass, or the extent of species coverage within the dataset.

Different Indices of Diversity

Simpson's Index

Simpson (1949) developed an index of diversity which is a measure of probability--the less diversity, the greater the probability that two randomly selected individuals will be the same species. In the absence of diversity (1 species), the probability that two individuals randomly selected will be the same is 1. Simpson's Index is calculated as follows:

$$D = \sum_{i=1}^{S} \left(\frac{n_i}{N}\right)^2$$

Where ni is the number of individuals in species i, N = total number of individuals of all species, and ni/N = pi (proportion of individuals of species i), and S = species richness. The value of Simpson's D ranges from 0 to 1, with 0 representing infinite diversity and 1 representing no diversity, so the larger the value of D, the lower the diversity. For this reason, Simpson's index is often as its complement (1-D). Simpson's Dominance Index is the inverse of the Simpson's Index (1/D).

Shannon-Weiner Index

The index of diversity that also considers both species richness and evenness is the Shannon-Weiner Diversity Index, originally proposed by Claude Shannon in 1948. It is also known as Shannon's diversity index. The index is related to the concept of uncertainty.

$$H = -\sum_{i=1}^{S} p_i * \ln p_i$$

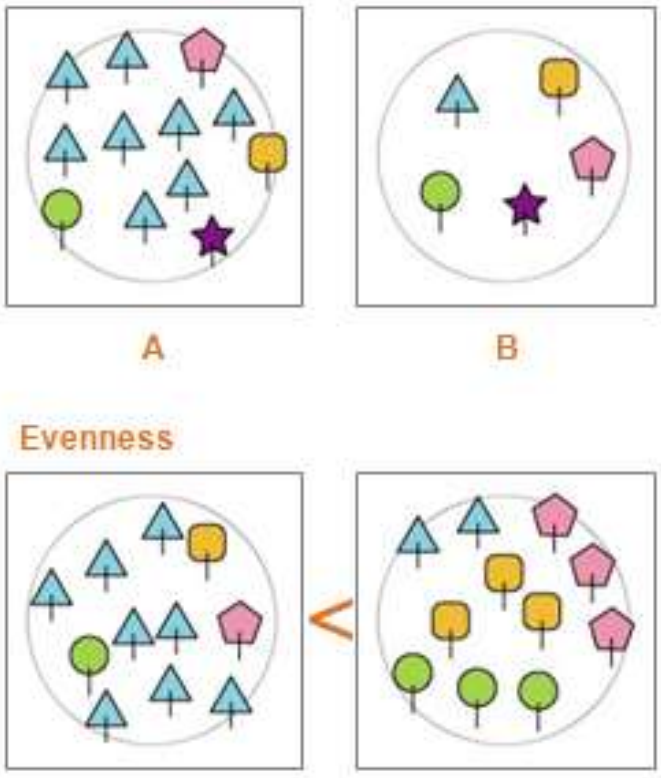
Where pi = proportion of individuals of species i, and ln is the natural logarithm, and S = species richness.The value of H ranges from 0 to Hmax. Hmax is different for each community and depends on species richness. It is denoted as Shannon-Weiner is often denoted H'.

Evenness Index

Species evenness refers to how close in numbers each species in an environment is. The evenness of a community can be represented by Pielou's evenness index (Pielou 1966): The value of J, which represents Pielou's Evenness Index, falls within the range of 0 to 1. Higher J values indicate a higher degree of evenness in the distribution of species abundances within a community. When evenness is at its maximum, J equals 1, signifying that all species in the community are equally abundant.

$$J = \frac{H}{H_{\max}}$$

Both J and D (Simpson's Diversity Index) can also serve as measures of species dominance, which is the inverse of diversity within a community. When J is low, it suggests that one or only a few dominant species exert significant control over the community's composition, with the majority of individuals belonging to these dominant species.



Margalef's Diversity Indexes (D):

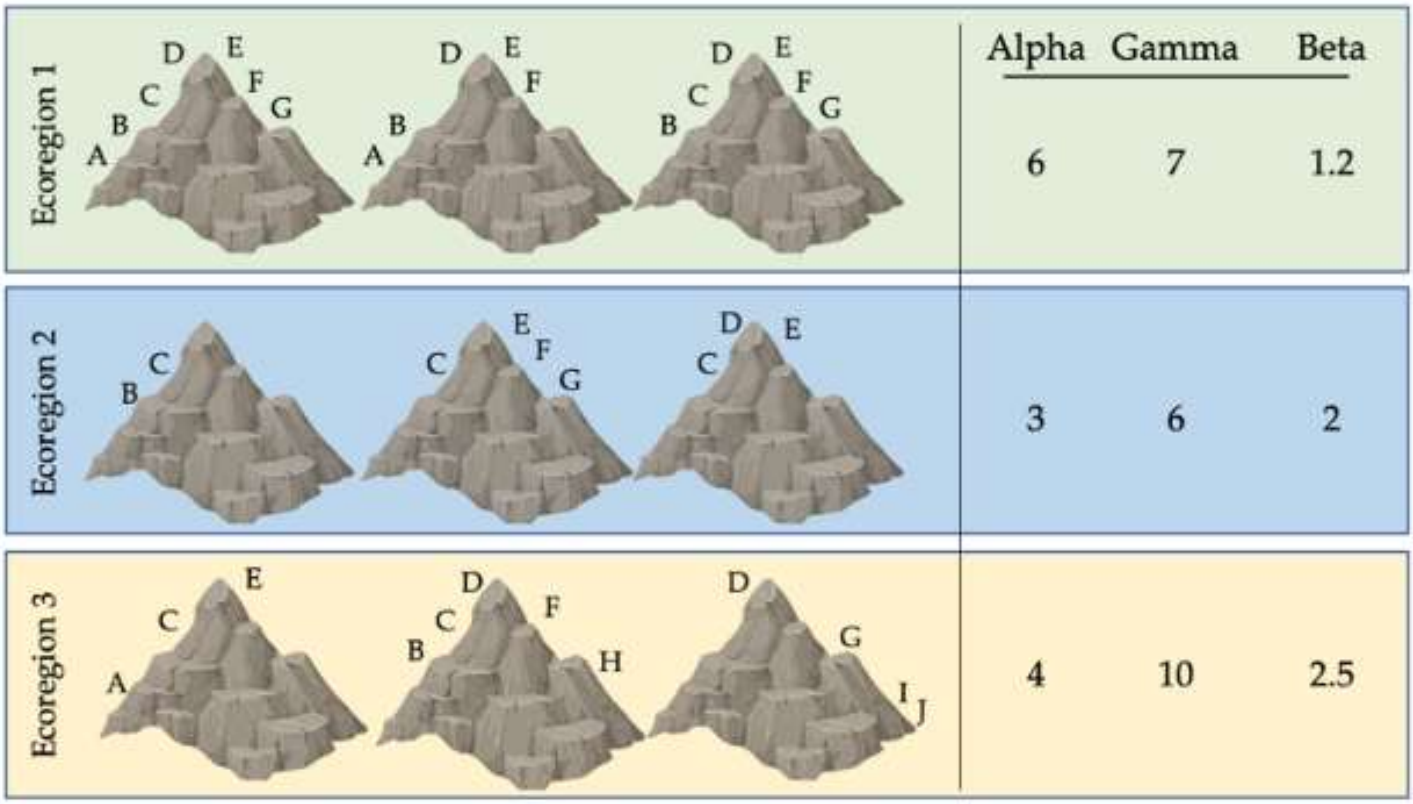
This index takes into account species richness and the total number of individuals. It is calculated by dividing the difference between the number of species and 1 by the logarithm of the total number of individuals.

$$\mathbf{D} = (S-1)/\ln(n)$$

Biodiversity at Different Scales

Biologists have developed three quantitative measures of species diversity as a means of measuring and comparing species diversity:

- Alpha diversity (or species richness), the most commonly referenced measure of species diversity, refers to the total number of species found in a particular biological community, such as a lake or a forest. Bwindi Forest in Uganda, with an estimated 350 bird species, has one of the highest alpha diversities of all African ecosystems.
- Gamma diversity describes the total number of species that occur across an entire region, such as a mountain range or continent, that includes many ecosystems. The Albertine Rift, which includes Bwindi Forest, has more than 1,074 species of birds, a very high gamma diversity for such a small region.



- Beta diversity connects alpha and gamma diversity. It describes the rate at which species composition changes across a region. Beta diversity is calculated as gamma diversity divided by alpha diversity. For example, if every wetland in a region was inhabited by a similar suite of plant species, then the region would have low beta diversity; in contrast, if several wetlands in a region had plants communities that were distinct and had little overlap with one another, the region would have high beta diversity.

CONCLUSION

Diversity indices are indispensable tools in the fields of ecology, biology, and conservation. They provide quantitative measures that allow us to assess and compare the diversity of species within ecological communities and ecosystems. These indices offer valuable insights into the complexity, evenness, and dominance of biological diversity, enabling us to better understand the health and structure of natural systems. While species richness (S) is a fundamental index that quantifies the number of unique species within a dataset, it often serves as a basic measure of biodiversity when detailed abundance data are lacking. However, for a more comprehensive understanding of biodiversity, ecologists and conservationists turn to indices that incorporate both species richness and measures of abundance. These more inclusive indices, such as the Shannon-Wiener Diversity Index and Simpson's Diversity Index, account for the evenness of species distribution within a community, providing a

more holistic perspective on diversity. By quantifying and communicating the value of biodiversity, these indices empower us to take informed and proactive measures to protect and preserve the intricate tapestry of life on our planet. As we face increasing environmental challenges and the loss of biodiversity, diversity indices will continue to be essential tools in our efforts to monitor, understand, and protect the diverse and interconnected ecosystems that sustain life on Earth.

REFERENCES

Chao, A.; Shen, T-J. (2003). "Nonparametric estimation of Shannon's index of diversity when there are unseen species in sample" (PDF). Environmental and Ecological Statistics. 10 (4): 429–443. doi:10.1023/A:1026096204727. S2CID 20389926.

Colinvaux, Paul A. (1973). Introduction to Ecology. Wiley. ISBN 0-471-16498-4.

Cover, Thomas M.; Thomas, Joy A. (1991). Elements of Information Theory. Wiley. ISBN 0-471-06259-6. See chapter 5 for an elaboration of coding procedures described informally above.

Hill, M. O. (1973). "Diversity and evenness: a unifying notation and its consequences". Ecology. 54 (2): 427–432.

Jost, L (2006). "Entropy and diversity". Oikos. 113 (2): 363–375. doi:10.1111/j.2006.0030-1299.14714.x.

Tucker, Caroline M.; Cadotte, Marc W.; Carvalho, Silvia B.; Davies, T. Jonathan; Ferrier, Simon; Fritz, Susanne A.; Grenyer, Rich; Helmus, Matthew R.; Jin, Lanna S. (May 2017). "A guide to phylogenetic metrics for conservation, community ecology and macroecology: A guide to phylogenetic metrics for ecology".

Tuomisto, H (2010). "A diversity of beta diversities: straightening up a concept gone awry. Part 1. Defining beta diversity as a function of alpha and gamma diversity". Ecography.