Journal of Basic Sciences, 2015, 1, 1-6.

Journal of Basic Sciences
www.skpubs.com
JOURNAL OF BASIC SCIENCES

Comparison of Statistical Methods for Measuring Biodiversity.

Sunanda T. Wagh
Department of Statistics, Arts, Science & Commerce College, Ozar (Mig), Nashik (M. S.) INDIA.
[*Affiliated to Savitribai Phule Pune University Pune*]
Email: sunanda_wagh@hotmail.com

Abstract: The degree of variation of flora & fauna on the earth is found due to genetic variation, species variation or ecosystem variation. Rapid environmental changes on earth cause extinction of various species in flora & fauna. It is estimated that approximately 1-3 % of the species are extinct on the earth. According to recent estimates there are about 89,451 known faunal species in India, which is about 7% of the total animal species in the world. However, only less than 50% of the geographic region of the country has been surveyed so far. In the reported species more than 50 % of them are from Western Ghats & Himalaya region only. However many areas in India have not been surveyed adequately and several invertebrate phyla and insect species are inadequately documented. Biodiversity cannot be captured in a single number therefore it cannot measure with 100 percent accuracy. There are several methods to estimate biodiversity. One has to choose that method which may best suit the project. For this one has to construct experiment which includes these steps: (1) sampling methods (2) collecting specimens (3) gather and organize data (4) run statistical tests to confirm precise & accurate results. Several methods are used to measure species biodiversity; the most popular are the Simpson Index and the Shannon Index.

Key words - Biodiversity, Evenness, Abundance, Simpson's Index, Shannon Index.

1 Introduction

On every fifth June all over the world Environment Day is celebrated. In our Savitribai Phule Pune University for second year students the Environmental Awareness Course is made compulsory on credit point basis. These steps are taken in the expectation that we must protect and conserve our environment in terms of the flora & fauna. Biodiversity is the degree of variation of life. It is a measure of the variety of organisms present in different ecosystems. The variation can refer to genetic variation, ecosystem variation or species variation (number of species) within an area, biome, or planet[1]. India is known for its great natural diversity. A total of 1, 26,656 species of living organisms has been described from our subcontinent and another 4, 00,000 are waiting to described[2-3]. According to recent estimates there are about 89,451 known faunal species in India, which is about 7% of the total animal species in the world[3-5]. However, only less than 50% of the geographic region of the country has been surveyed so far. More than 50 % of species are reported from Western Ghats & Himalaya region only[6]. Several invertebrate phyla are yet to be reported from India. The lower groups of organisms, especially insects are still to be documented in detail. A diversity index is a mathematical measure of species diversity in a community. Diversity indices provide more information about community composition than simply species richness that is number of species

 ISSN 2395-1265

present; the index also takes the relative abundances of different species into account.

The use of biodiversity is to determine the number of species in a biological community, and then use them in determining the sensitivity of an ecosystem. Further to conserve statuses of its species.

To fulfill tremendous demands of human population and for various reasons the mangrove forests have been ruthlessly exploited and cleared[4]. Coral reefs have been indiscriminately mined[7]. The fishery resources have been overexploited. Many other organisms have been exterminated for ornamental and medicinal purposes. There has been widespread degradation of the habitats. Due to industrial development and large scale use of pesticides and insecticides in agriculture, the pollution load has increased in the water resources, lands and seas[8]. Therefore there is a need for measuring biodiversity.

A diversity index is a mathematical measure of species diversity in a given community. Based on the species richness (the numbers of species present) and species abundance (the number of individuals per species) diversity indices are computed[9]. If the numbers of species are more, diversity is more in that area. Basically indices are of two types one is dominance indices and other is information statistic indices[10].

Biodiversity cannot be captured in a single number therefore it cannot measure with 100 percent accuracy. There are several methods to estimate biodiversity. One has to choose that method which may best suit the project. For this one has to construct experiment which includes these steps: (1) sampling methods (2) collecting specimens (3) gather and organize data (4) run statistical tests to confirm precise & accurate results[11-12]. Several methods are used to measure species biodiversity; the most popular are the Simpson Index and the Shannon Index.

2 Measures of diversity

Measures of diversity are the indicators of the wellbeing of ecological systems. The term species richness means number of species in a community. Community is list of species included and their abundance, evenness. Diversity measures more abundance in various communities. There is a huge range of indices and models for measuring diversity. So for the various environments, habitats and situations the species abundance models and diversity indices should be used and the suitability evaluated. A diversity index is a mathematical measure of species diversity in a community. Diversity index measures species richness and relative abundances of different species.A mathematical expression that combines species richness and evenness is called as Diversity Index[13].

Species Richness Index is Simpson's Index. Simpson gave the probability of any two individuals drawn at random from an infinitely large community belonging to same species[9]. Suppose n denotes total number of individuals in the S species counted in the sample. n_i denote number of individuals of i^{th} species in the sample, for i = 1,2,3,....S.

Then of Simpsons Diversity Index is denoted by λ and is defined as

$$\lambda = n\sum_{1}^{s}(pi)2$$

Estimate of Simpson's Index is

$$\lambda = n\sum_{1}^{s}(ni\,(ni-1))/n(n-1)$$

λ lies between 0 to 1 , it is the probability of two individuals drawn at random from a population belong to the same species.High value of λ indicates high chances that two individuals belong to the same species implies less diverse community.Small value of λ indicates large biodiversity. Simpson's index is heavily weighted towards the most abundant species in the sample and being less sensitive to species richness[14].

The Shannon Index originally developed for use in information science, to measure abundance of a species within a sample plot. This is often used for identifying areas of high natural or human interference in ecosystems. The Shannon diversity index (H) is another index that is commonly used to characterize

species diversity in a community. Shannon's index accounts for both abundance and evenness of the species present[15]. The Shannon index is an information statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled. The proportion of species i relative to the total number of species (pi) is calculated, and then multiplied by the natural logarithm of this proportion (ln pi). The resulting product is summed across species, and multiplied by -1:

$$H = -\sum_{i=1}^{S} p_i \ln p_i = -\sum (ni/n) \log(ni/n)$$

Shannon index of diversity **H'** is widely used in community ecology. It measures the uncertainty in predicting to what species an individual chosen at random from a collection of S species and N individuals will belong. The average uncertainty increases and as the distribution of individuals among the species becomes even. **H' = 0** means there is only one species in the sample. H' ismaximum only when all species are in a same number of occurrences.

The observed Shannon's index of diversity (**H'**) is always compared with maximum Shannon diversity (Hmax) which could possibly occur in a situation where all species were equally abundant. Shannon diversity is widely used index for comparing diversity between various areas[16-20].

3 Conclusions

In order to measure the biodiversity of all habitats, variety of diversity measures, species abundance models and graphical tools are available. We need a measure which measures species richness and evenness into a single value. Several methods are used to measure species biodiversity; the most popular are the Simpson Index and the Shannon Index. These indices focus on the relative species richness and abundance and/or the pattern of species distribution. The Simpson index is a dominance index because it gives more weight to common or dominant species. In this case, a few rare species with only a few representatives will not affect the diversity. On the other hand if the community is dominated by a few very abundant species and one want to be able to track changes among the less abundant species, it may be worth to use Shannon's index. Shannon includes a "log" to the relative abundance of species and the "weight" of abundant species will thus be reduced slightly relative to more rare species. Simpsons index squares the relative abundance and the weight of rare species will thus be reduced relatively more than that of more abundant species. Which to use depends on the situation. If we have a wealth of "rare" species whose changes may "disturb" the overall pattern of change, it may be worth to choose Simpsons index.

The advancement in applied statistics and computer technology has made biodiversity studies more easy and interesting. However this development should be made good use in protecting the very rich biodiversity our country is blessed with.

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