

Comparison of Some Indices of Species Diversity in the Estimation of the Actual Diversity in Three Forest Types at Namprom Basin, Chaiyaphum Province

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ABSTRACT

Species diversity presented in a community was estimated from data sampled from it. The species diversity was calculated from a complete census of trees in a temporary plot of 40 m × 40 m, and also from sampling through point-centered quarter method. Of the four indices of species diversity compared, viz., the Simpson's D, Shannon Wiener's H, McIntosh's MC₁ and MC₂, MC₂ was found by far the best.

INTRODUCTION

The variability of natural communities is well known. Some are known to exhibit only a few species while others may contain very many. The term diversity is applied to represent this variability in a community (Pielou 1975). The notion of diversity was first introduced by Williams (Fisher *et al.* 1943) to mean the number of species, also called species richness. The inadequacy of this concept is understood when one considers two communities with the same number of species but differing in the species abundances. More generally therefore species diversity is defined as a function of the number of species present in a given area and of the evenness with which the individuals are distributed among the species :

Species Diversity = f (Species richness, evenness)

This is generally expressed as the ratio of observed diversity to maximum diversity (cf. Lloyd and Ghelardi 1964). Diversity measures based on this dual-concept are also called heterogeneity indices.

Thus a community that contains a few individuals of many species would have a higher

diversity of species than a community containing the same species and the same number of individuals but with most of them confined to a few species.

Two approaches in the measurement of species diversity are known. In the first, the species-abundance frequencies are fitted to the various theoretical distributions and when one or the other of these are found well fitted, the parameters of the fitted distribution are taken as the measures of species diversity. For example, Williams' index of diversity is based on the logarithmic series distribution. The theoretical distributions commonly used are log normal, negative binomial, geometric and logarithmic series, (Pielou, 1975). This approach however is not suitable as they are not widely applicable on account of difficult and impractical assumptions.

When no theoretical series can be fitted to the data, we should have alternative descriptive statistics that can be used for any community, no matter what the form of its species abundance distribution is. In this light, a number of indices have been proposed. They can be broadly classified into : (a) Information theoretic measures;

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(b) Probability measures; (c) Euclidean distance measures (Cf. Bullock 1971; Hill 1973; Peet 1974, for a review).

A difficult problem arises in determining the species diversity of a community from a sample. If a community is finite and is censused, its diversity can be determined exactly. But it is infinite, one has to rely on a sample with possible bias in the estimation of species diversity. Sanders (1968) has described an alternative strategy called the rare-faction technique which allows one to scale down all samples to the size of the smallest in the set being considered. Fager (1972) has shown that the rare faction technique over-estimates the number of species that would be estimated by random sampling and has suggested using scaled values for diversity measurement, the scaling being done in terms of the possible range of values of the index for the given number of individuals and species.

In the present work, some of the existing measures of species diversity have been compared by calculating them both for censused stands and sampled data from them. The object has been to determine how far the indices reflect the actual diversity of a community when sampled from it.

STUDY AREA AND METHODS

The present studies were conducted in the relatively undisturbed dry evergreen forest (DEF) mixed deciduous forest (MDF), and dry dipterocarp forest (DDF) on the upstream of the Namprom River, Khon San district, Chaiyaphum province, NE Thailand. Detailed descriptions of the meteorological conditions, floristic composition, and forest structure were described in Sahunalu *et al.* (1979) and Tsutsumi *et al.* (1983).

A temporary sample plot of 40 m × 40 m in size was marked in each stand, all tree species DBH above 4.5 cm were enumerated. This formed the censused data. The marked area were then sampled by the point-centered quarter

method (Cottam and Curtis, 1956) by locating 30 random points covering the whole area. In addition, the marked area were also sampled by laying sixteen random quadrats of 10 m × 10 m area.

DATA ANALYSIS

The diversity indices used for the present studies are as follows :

The first of the measures of species diversity on the 'dual concept' was given by Simpson (1949). His index measures the probability that two individuals selected at random from a sample belong to the same species. Simpson's index of diversity for an infinite sample is :

$$\lambda = \frac{s}{\sum_{i=1}^s P_i^2}$$

whereas for the finite sample, it is calculated from

$$L = \sum \frac{n_i(n_i - 1)}{N(N - 1)}$$

where P_i is the proportion of individuals in species i , n_i , is the number of individuals in species i and N is the total sample size.

The index as proposed above varies inversely with heterogeneity. It is therefore more meaningful to measure the species diversity by the Simpson's method using the modified form (Gini 1972, Pielou 1969).

$$D = 1 - \sum \frac{n_i(n_i - 1)}{N(N - 1)}$$

The value of D varies from zero (low diversity) to a maximum of $(1 - 1/s)$, where s is the number of species. The index gives relatively little weight to the rare species and more weight to the common species.

The Shannon-Wiener index (Shannon and Weaver 1949) :

$$H = -\sum P_i \log P_i$$

measures the information content of a code of s kinds of symbols, of which a proportion P_i are of the i th kind. The index was first introduced by Margalef (1957) to measure species diversity.

In ecological application, H' (Pielou, 1969) is estimated by :

$$h' = (n_i/N) \log (n_i/N)$$

where n_i is the number of individuals of the i th species and N the total no. of individuals of all species.

h' is a biased estimate of H' . The bias is however negligible for most ecological applications (Peet, 1974). An additional error in H' crops up if all species in the community not included in the A large sample however helps in overcoming the above errors. Depending upon the choice of the logarithmic base used, various names have been applied to, the units of H and H' such as Bit for the logarithmic base 2, natural bel if the base is e , and bel dicinal digit or decit (Pielou, 1969) if base 10 is used. In this investigation, we used based 10 throughout.

McIntosh (1967) proposed the measurement of species diversity using the 'distance' between an S -species community and the origin represented in an n -dimensional hyperspace where each dimension refers to the abundance of a particular species. The distance measured using the Pythagorean theorem is

$$(\sum n_i^2)^{1/2}$$

where n_i is the number of individuals of species i . The measure varies directly with the evenness of species represented in the community.

McIntosh suggested using the following standardized form

$$MC_1 = \frac{N - \sqrt{\sum n_i^2}}{N - \sqrt{N}}$$

where N is the total number of individuals and n_i is

the number in species i . Shaukat *et al.* (1981) have compared the numerous variation in the measures of diversity proposed by McIntosh and suggested using MC_1 and the following form as more appropriate measures :

$$MC_2 = 1 - \frac{\sqrt{\sum n_i^2}}{N}$$

MC_2 is used in comparisons when the sample size is held constant. For various sample sizes, MC_1 is preferred to other measures.

RESULTS AND DISCUSSION

The species composition as obtaining in the 40 m × 40 m marked area in DEF, MDF and DDF at Namprom basin, Chaiyaphum province is presented in Table 1, 2 and 3 respectively. The species diversity by the four indices calculated from the censused data and the sampled data obtained by the quadrat and the point-centred quarter methods is presented in Table 4.

In the case of Shannon-Wiener's H' and Simpson's D , the actual diversity as obtained from the censused data is closely represented by the quadrat sampled estimates. The point-centered sample estimates of the two diversities were slightly more than the true diversity. In the case of MC_1 , both the quadrat and the point-centered sampling methods estimate a higher diversity than the true diversity. Only MC_2 has been found to yield almost comparable values of the true diversity by both the quadrat and the point-centered quarter methods of sampling. McIntosh's MC_2 has been found the best of the four measures in estimating almost coincident population values. The results corresponded with Sai and Mishra (1986). The follows MC_1 , H' and D . The latter measures, by and large, tend to over estimate the population diversity. The amount of overestimation is a function of

Table 1 Distribution of species censused in the 40 × 40 m marked area in the dry evergreen forest at Namprom basin, Chaiyaphum Province

Species	No. of individuals	Density
1 <i>Acrocarpus fraxinifolius</i> Wight & Arn.	2	0.011
2 <i>Adenantha pavonina</i> Linn.	1	0.006
3 <i>Adina parvula</i> Geddes	10	0.057
4 <i>Amoora polystachya</i> Hook. F. & Jack	2	0.011
5 <i>Anthocephalus cadamba</i> Miq.	1	0.006
6 <i>Antidesma diandrum</i> Roth	7	0.040
7 <i>Aquilaria crassna</i> Pierre ex H. Lec.	1	0.006
8 <i>Ardisia anceps</i> Kurz	8	0.046
9 <i>Baccaurea sapida</i> Muell. Arg.	1	0.006
10 <i>Casearia grewiaefolia</i> Vent.	8	0.046
11 <i>Cinnamomum iners</i> Bl.	11	0.063
12 <i>Cleidion javanicum</i> Bl.	5	0.029
13 <i>Croton oblongifolius</i> Roxb.	17	0.098
14 <i>Dialium cochinchinensis</i> Pierre	7	0.040
15 <i>Dillenia pentagyna</i> Roxb.	1	0.006
16 <i>Diospyros montana</i> Roxb.	3	0.017
17 <i>Diospyros castanea</i> Fletch.	11	0.063
18 <i>Eugenia cumini</i> Druce	3	0.017
19 <i>Eugenia siamensis</i> Craib	2	0.011
20 <i>Eugenia zeylanica</i> Wight	8	0.046
21 <i>Ficus altissima</i> Bl.	1	0.006
22 <i>Flacourtia indica</i> Merr.	1	0.006
23 <i>Garcinia cowa</i> Roxb.	1	0.006
24 <i>Gmelina asiatica</i> Linn.	5	0.029
25 <i>Helicia robusta</i> R. Br. ex Wall.	4	0.023
26 <i>Heterophragma adenophyllum</i> Seem. ex Benth.	1	0.006
27 <i>Hibiscus tiliaceus</i> Linn.	1	0.006
28 <i>Hopea ferrea</i> Pierre	2	0.011
29 <i>Hopea odorata</i> Roxb.	1	0.006
30 <i>Ixora cibdela</i> Craib	1	0.006
31 <i>Ixora finlaysoniana</i> Wall.	1	0.006
32 <i>Knema conferta</i> Warb.	1	0.006
33 <i>Mangifera caloneura</i> Kurz	2	0.011
34 <i>Memecylon edule</i> Roxb.	1	0.006
35 <i>Micromelum hirsutum</i> Oliv.	2	0.011
36 <i>Paranephelium longifoliolatum</i> Lec.	3	0.017
37 <i>Polyalthia viridis</i> Craib	2	0.011
38 <i>Protium serratum</i> Engler	1	0.006
39 <i>Pterospermum semisagittatum</i> Ham.	8	0.046
40 <i>Quercus</i> sp.	12	0.069
41 Unidentified A	7	0.040
42 Unidentified B	1	0.006
43 Unidentified C	4	0.023
44 Unidentified D	1	0.006
45 Unidentified E	1	0.006

Table 2 Distribution of species censused in the 40 × 40 m. marked area in the mixed deciduous forest at Namprom basin, Chaiyaphum province

Species	No. of individuals	Density
1 <i>Bauhinia variegata</i> Linn.	4	0.105
2 <i>Berrya mollis</i> Wall. ex Kurz	1	0.026
3 <i>Canarium kerrii</i> Craib	1	0.026
4 <i>Cassia garrettiana</i> Craib	2	0.052
5 <i>Colona flagrocarpa</i> Craib	1	0.026
6 <i>Dalbergia cochinchinensis</i> Pierre	1	0.026
7 <i>Dalbergia nigrescens</i> Kurz	5	0.131
8 <i>Grewia elatostemoides</i> Coll. et Hemsl.	1	0.026
9 <i>Heterophragma adenophyllum</i> Seem. ex Benth.	2	0.052
10 <i>Lagerstroemia calyculata</i> Kurz	6	0.158
11 <i>Lagerstroemia duperreana</i> Pierre	7	0.184
12 <i>Pterocarpus macrocarpus</i> Kurz	3	0.079
13 <i>Terminalia tripteroides</i> Craib	2	0.052
14 Unidentified	2	0.052

both the distribution of number of individuals per species and the amount of spatial aggregation within species (Fager, 1972) and Pielou (1975) suggest using scaled indices to reduce variation of the heterogeneity indices with changing sample size. But this could only be applied when the number of species in the underlying population is known (Peet, 1974) which in reality is close to impossible to determine for most ecological

Table 3 Distribution of species censused in the 40 × 40 m. marked area in the dry dipterocarp forest at Namprom basin, Chaiyaphum province

Species	No. of individuals	Density
1 <i>Anthocephalus cadamba</i> Miq.	2	0.013
2 <i>Buchanania reticulata</i> Hance	3	0.020
3 <i>Dalbergia dongnaiensis</i> Pierre	2	0.013
4 <i>Dipterocarpus intricatus</i> Dyer	2	0.013
5 <i>Eugenia cumini</i> Druce	1	0.007
6 <i>Gardenia coronaria</i> Ham.	1	0.007
7 <i>Heterophragma adenophyllum</i> Seem. ex Benth.	1	0.007
8 <i>Shorea siamensis</i> Miq.	90	0.600
9 <i>Quercus Kerrii</i> Craib	3	0.020
10 <i>Shorea obtusa</i> Wall.	28	0.187
11 <i>Terminalia alata</i> Heyne ex Roth	15	0.100
12 Unidentified	2	0.013

applications. The scaled values are however affected by sample size N even with constant S the no. of species (Fager, 1972 and Peet, 1974). The smaller the sample, the more skewed the distribution. McIntosh's indices MC₁ and MC₂ were found highly correlated with other indices of general diversity and equitability (Shaukat *et al.*, 1981). The Shannon-Wiener's H' & Simpson's D suffer from the significant negative kurtosis whereas McIntosh's MC₁ and MC₂ exhibit significant positive kurtosis (Shaukat *et al.*, 1981).

Table 4 Species diversity by four indices for censused and sampled data

Diversity Index	DEF			MDF			DDF		
	Censused data	Quadrat sampling	Point-centered sampling	Censused data	Quadrat sampling	Point-centered sampling	Censused data	Quadrat sampling	Point-centered sampling
	Simpson's D	0.962	0.943	0.976	0.919	0.921	0.925	0.598	0.529
Shannon-Wiener's H'	4.833	4.774	5.017	3.466	3.396	3.242	1.926	1.724	2.106
McIntosh's MC ₁	0.855	0.899	0.921	0.801	0.934	0.921	0.395	0.429	0.441
McIntosh's MC ₂	0.790	0.782	0.796	0.671	0.672	0.673	0.362	0.364	0.360

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