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VEGETATION RECORDING IN FORESTS: COMPARISON OF THE CHINESE AND EUROPEAN APPROACHES

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Abstract - The field approach underlying a vegetation study influences the results of biodiversity assessments. In our paper we compared two main field survey approaches for forest vegetation recording, the Chinese and the European ("phytosociological") one, for their differences and efficiency when applied to the plant communities of temperate forests. The Chinese approach uses a design with different plot sizes for recording the tree, shrub and herb layer species, respectively, while the European one uses the same plot size for recording all layers and species. The two approaches result in significant differences in species richness (Simpson's diversity index and the Shannon-Wiener index), while there is no difference in the evenness index. The European approach has the ability to survey the number of different species more precisely than the Chinese one. For detecting the general patterns of diversity, however, the two approaches have the same ability, demonstrated here for the altitudinal gradient.

Keywords: Approaches for vegetation recording, Chinese approach, phytosociological relevee, species diversity

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INTRODUCTION

Any vegetation study dealing with species assemblages or plant communities is based on a precise record of vegetation stands in the field, usually according to selected plots. Vegetation studies are important to describe and determine plant communities (Mucina et al., 1993) and analyze their changes along site gradients (Kazakis et al., 2007) or in the course of time (Zhang et al., 2009; Fischer 1992, 1999; Fischer and Fischer, 2009). Such studies are also important for analyzing plant biodiversity.

Different sampling approaches are used for sampling vegetation types. Also, different approaches have been developed in different parts of the world. Different recording approaches may result in different numbers of recorded species. While species numbers are directly influenced by the size of the analyzed plots, the general characters of forest communities may be influenced.

A well-known approach for vegetation recording, which has been developed in Europe decades ago, is the so-called "phytosociological method" (Braun-Blanquet 1964, Mueller-Dombois and Ellenberg 1974). This approach aims at recording all the species (usually vascular species as well as bryophytes and lichens) living together on a selected plot of small size ("phytosociological relevees", in forests usually of 100-400 m^2). In China, for forestry purposes, another approach for recording vegetation was developed and has been used frequently. It considers large plots for recording the tree layer and embedded subplots for shrub and herb layers, respectively (Jin, 2009). This approach has been adopted by the Britain-America vegetation school, i.e. recording species pools for each layer (tree, shrub and herb layer) on plots of different sizes (Jin, 2009).

Both approaches are well established and intensively used in the two parts of the world. It is important clarify the differences that emerge as a result of using these different approaches, and which approach is best suited to which purpose. To the best of our knowledge, no such comparison of the two main approaches used in China and Europe, has been carried out up to now. This study aims to fill this gap.

Biodiversity (Wilson, 1988) includes the gene, the species, and the community/ecosystem levels. It has become a more and more important topic within the discussion of sustainability in the last decade, though the maintenance of the diversity of forest ecosystems has been needed for many years (Swindel et al., 1984; Schuler, 1998) as biodiversity is generally rapidly decreasing (Secretariat CBD, 2010).

Therefore biodiversity analyses are needed, including both the current levels and trends. We want to establish the methodological influence of two commonly used approaches for biodiversity analysis, the European "phytosociological" approach and the Chinese approach, for forest vegetation recording. To meet this objective, we carried out a set of parallel vegetation records, using the two different approaches on the same plot.

This study is part of a running project on biodiversity in the Qinling Mountains. Fieldwork was carried out in July and August 2009.

Study area

The study area is located on the south-facing slope of the Qinling Mountains in Shaanxi Province, central China, around Qinling Huoditang Forest Ecosystem Research Station (33°18'～33°28'N, 108°21'～108°39'W) (Fig. 1). The Qinling Mountains mark the borderline between the subtropical and the warm temperate climate zone in China. The study area is a major watershed of the Yangtze and the Yellow Rivers. The foothills in the study area are at 800 m a.s.l., and the mountains rise up to 2,500 m a.s.l.

The climate is temperate, with a mean annual precipitation of 900-1200 mm and mean annual temperature of 8-10^{0}C. At the lower elevation, it is warm and dry (mean annual temperature and precipitation 10.2^{0}C, 745 mm, respectively). At the higher elevation, it is cold and wet (mean annual temperature and precipitation 4.5^{0}C, 1200 mm). For the middle elevation the evaporation is 800-950 mm year^{-1}, the sunlight hours are 1,100 -1,300h year^{-1}, and the frostless season is 170 d year^{-1} (Peng et al., 2009).

The main soil types in the research area are yellow brown soil, burozem, and dark burozem soil. Vegetation types vary along the altitudinal gradient and include coniferous forests, mixed coniferous and broadleaved forests, deciduous broadleaved mixed forests and deciduous broadleaved mixed forest with evergreen tree species (Peng et al., 2009).

METHODS

Sampling design

The field survey was conducted along the altitudinal gradient from 1,000 to 2,400 m a.s.l. We selected forest stands each 150 meters in altitude: In each elevation we tried to find one N-facing and one S-facing stand, altogether resulting in a total number of 16 analyzed plots. Because there are only a very few possibilities to enter the area (very steep slopes, nearly no roads or trails), we used the main road from Ningshan county to Pingheliang as the basis for the altitudinal gradient.

Chinese approach (CA)

The horizontal plot size was 20 m×20 m. The whole plot was used for recording the tree species. Each plot comprised 5 subplots with the size of 2m×2m for shrub layer investigation, 4 of them in the corners and one in the centre of the main plot. Within each

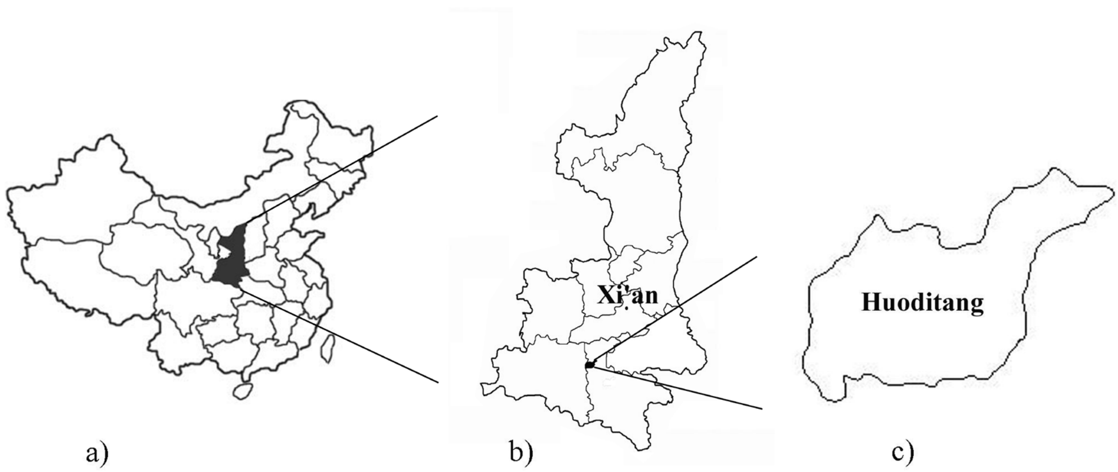

Fig. 1 Location of the study area
a) Shaanxi province in China; b) Huoditang in Shaanxi province; c) Huoditang Forest Ecosystem Research Station

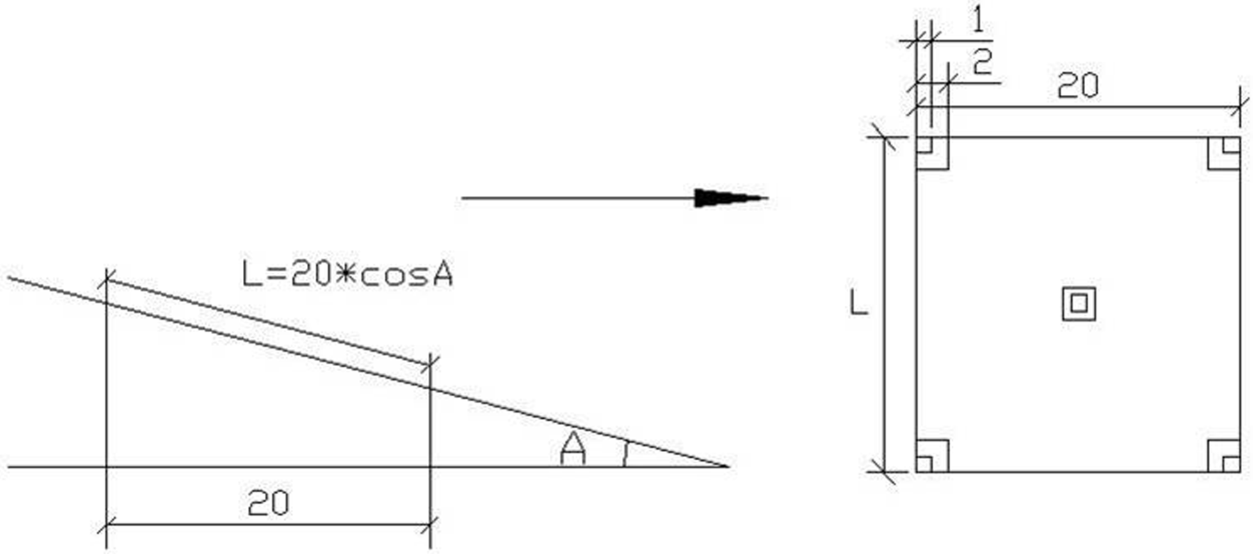

Fig. 2 Plot design according to the Chinese approach

of these subplots, there was another subplot, 1m×1m in size, for recording the herb layer species (Fig. 2).

In CA the horizontal area is used as plot size (Fang et al., 2004), therefore the plot size on the slope surface increases with increasing slope inclination (Fig. 2). The slopes on the Qinling Mountains are very steep, therefore the surface plot area is significantly larger than 1 m×1 m, 2 m×2 m and 20 m×20 m, respectively, depending on the slope degree of each plot.

On the whole plot for each tree species (individuals ≥1.3 m high) name, diameter at breast height (DBH), height, crown width, and number of individuals were recorded; on each shrub-subplot for each shrub species name, height, number of stems, the cover degree of each species, and tree samplings less than 1.3 m were recorded, and on each herb-subplot for each vascular plant species name and cover degree (%-value) were recorded. Bryophytes and lichens are not recorded.

European approach (EA)

According to the phytosociological approach, the plot size in principle is not standardized. As long as the plot is larger than the so-called "minimum-area", the plot size may vary from plot to plot (Braun-Blanquet, 1964; Müller-Dombois and Ellenberg, 1974). In forests in central Europe a plot size of a minimum 100 m^2 is often used, as well as a size of 200 m^2, and sometimes up to 400 m^2, depending on the structure of the forests (Fischer, 2003). A critical study of Chytry et al. (2003) demonstrates that the "minimum area-hypothesis" does not allow a critical plot size for recording all species. Plot size has to be defined (Chytry et al., 2003). For temperate forests the authors propose to use a plot size of around 200 m^2, not because of a certain "brake" in the species number/area-curve but from a practical point of view. This plot size is now becoming more widespread in Central Europe for new studies. The size is recorded on the soil surface, not depending on the slope inclination. In our study we used a plot size of 20 m×20 m.

According the European Braun-Blanquet approach (i.e. the phytosociological method), all the vascular plants, bryophytes and lichens that grow (root) on the ground of the whole plot are recorded. Because it is not common in the Chinese approach to record bryophytes and lichens, we also did not record these groups while using the European approach. We only recorded the vascular plants.

Cover-degree usually is not recorded in percent-point steps but in classes (Braun-Blanquet, 1964; Fischer, 2003); only for special purposes and on small plots a more detailed cover-degree scale is used (Londo, 1984). To be able to compare the results here as in the Chinese approach we recorded percent values.

Data treatment

For each plot we calculated species richness, Simpson's diversity index (Simpson, 1949), Shannon-Wiener index (Shannon, 1948) and Evenness index (Lloyd and Ghelardi, 1964; Magurran, 1988) in MS-Access using the cover degree of each species (Table 1). The Paired Samples T Test was used to check the significant difference of the two approaches.

RESULTS

The species richness (only vascular plants) per plot was generally higher when using the EA compared to the CA (Table 2) method: mean species number around 38 (CA) versus around 60 (EA). The SI index, SH index and Evenness index were calculated based on the cover degrees of the present species.

Table 3 shows that using the CA and EA for calculating species richness, Simpson and Shannon index the analyses yield quite different results (t-test: $p<0.01$), while the evenness index was not significantly different between the two approaches.

Species diversity was calculated for the three vegetation layers separately (Fig. 3). The structure of Fig. 3 follows Fischer (1982) comparing species number and evenness of single relevees as well as of groups of relevees. For the tree layer, the mean value of species richness and evenness using the CA is very close to the mean value using EA; for shrub layer and herb layer the mean values of species richness using the CA are significantly lower than when using the EA. The evenness values, however, are the same for all layers.

In Table 4 the result of a Paired Sample test for different layers is shown. In the tree layer, the four indices do not revealed significant differences (t-test: $p>0.01$). However, the S, SI and SH indices in the shrub and herb layers were found to be significantly

Table 1. Applied diversity measures and formulas

Species richness: S = N	N: the number of species per plot
Simpson Index: $SI = \sum_{i}^{N}(1-\pi i)\pi i$	πi : the relative abundance of the *i*th species, this can be calculated by proportion of number, coverage or basal area
Shannon Index: SH = $\sum_{i}^{N}(-\log_2 \pi i)\pi i$	πi :is the relative abundance of the *i*th species, calculated by proportion of number, coverage or basal area; instead of $\log_2$ also In or $\log_{10}$ is used
Evenness: E = SH / $\log_2$ N	N: the number of species

Table 2. Species richness using the two approaches

	minimum	**maximum**	**median**	**mean**
S using CA	12	50	38	37.94±9.81
S using EA	38	83	60	60.31±12.74

CA = Chinese approach; EA = European approach

Table 3. Results of Paired Samples Text for different indices

Pair CA-EA	**N**	**t**	**df**	**Sig. (2-tailed, 95%)**
Species richness	16	-9.463	15	0.000
Simpson index	16	-4.345	15	0.001
Shannon index	16	-6.814	15	0.000
Evenness index	16	0.706	15	0.491

CA = Chinese approach; EA = European approach

Table 4. The result of Paired Samples Text for different layers

Pair CA-EA		tree layer				shrub layer				herb layer			
		S	SI	SH	E	S	SI	SH	E	S	SI	SH	E
N		16	16	16	16	16	16	16	16	16	16	16	16
mean	CA	7.63	0.578	1.856	0.679	18.06	0.806	3.074	0.765	15.13	0.737	2.764	0.727
	EA	7.44	0.576	1.843	0.682	29.13	0.864	3.700	0.779	27.25	0.819	3.586	0.757
T		1.861	0.630	1.115	-0.777	-6.356	-3.927	-6.032	-1.046	-9.639	-3.407	-5.355	-2.484
Df		15	15	15	15	15	15	15	15	15	15	15	15
Sig. (2-tailed, 95%)		0.083	0.538	0.282	0.450	0.000	0.001	0.000	0.312	0.000	0.004	0.000	0.025

N, sample number; mean, average; T, t value; Df, decode and forward; CA, Chinese approach; EA, European approach

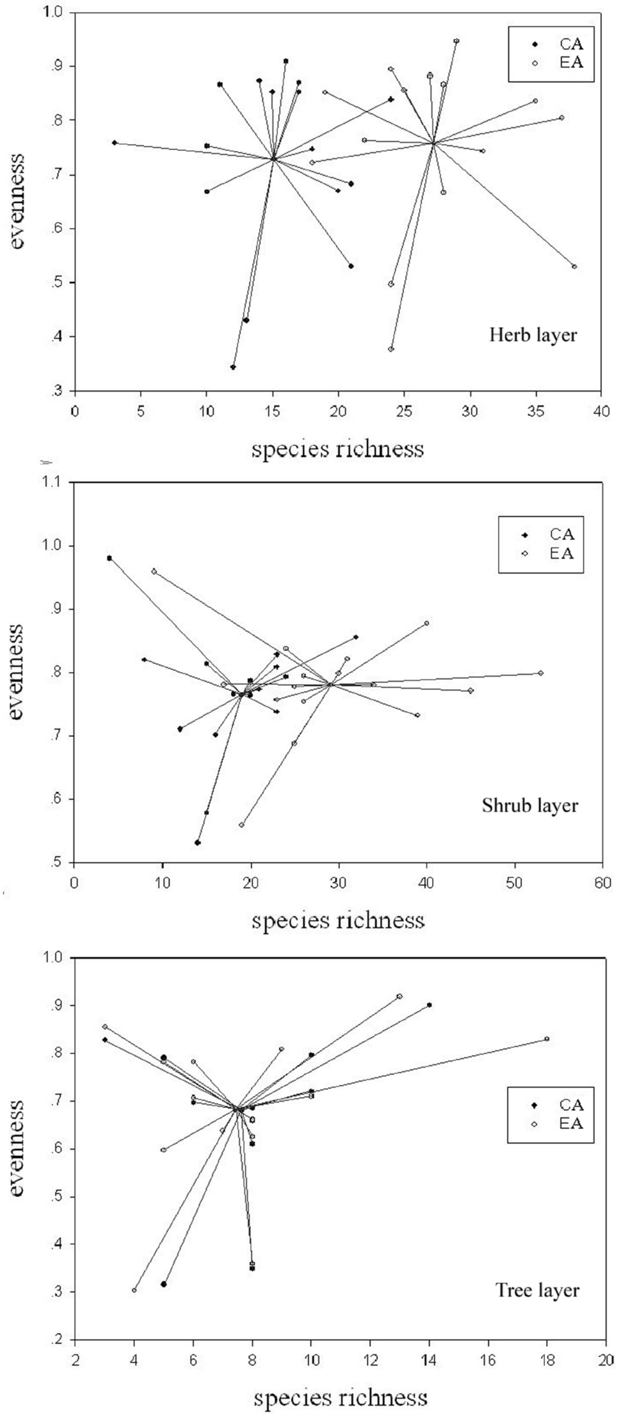

Fig. 3 The relationship between species richness and evenness in different layers: tree layer above, shrub layer middle, herb layer below. For each relevee the position is given as well as the mean for all plots (separated according to the two approaches) (CA = Chinese approach; EA = European approach).

different (*t*-test: $p<0.01$) whilst the evenness indices were not.

Fig. 4 shows the tendency for Species Richness, Simpson index, Shannon index and Evenness along altitude comparing the two approaches. Although there is a significant difference between the two approaches used in respect of absolute numbers of species (Tables 3, 4), it is remarkable that the general trend of change of species numbers in the altitudinal gradient is the same.

DISCUSSION AND CONCLUSIONS

The European and Chinese approaches are both used widely for forest vegetation recording in China and Europe, respectively. To explore plant species diversity in China's mountains, Peking University has been drafting the Survey Plan for Plant Species Diversity of China's mountains (PKU-PSD Plan) since the mid-1990s. The CA as the methodological standard for field surveys is included into the protocol of Peking University.

Compared with the European approach, the size of the CA for tree layer analysis is bigger than the usually used size of the EA, while for the shrub and herb layers, the size of the CA is drastically smaller. Furthermore, in the EA, tree and shrub height, crown diameter, DBH of each tree are usually not recorded, but they are recorded in the CA. Therefore, the CA is more time consuming, but records more data.

In the CA, all measurements are done on a horizontal-projection basis so that the real surface size is a variable depending on slope inclination. The slope angle affects the plot size (main plot as well as size of sub-plots) directly. There is a certain difference in species richness per plot depending on the slope inclination.

For the temperate-zone forests, the empirical value for plot size is 200 m^2 – 500 m^2 (Mueller-Dombois and Ellenberg, 1974; Chytry et al. 2003). Lan (Lan Gou-Yu, 2003, dissertation Yangling) studied the community characteristics and classification of

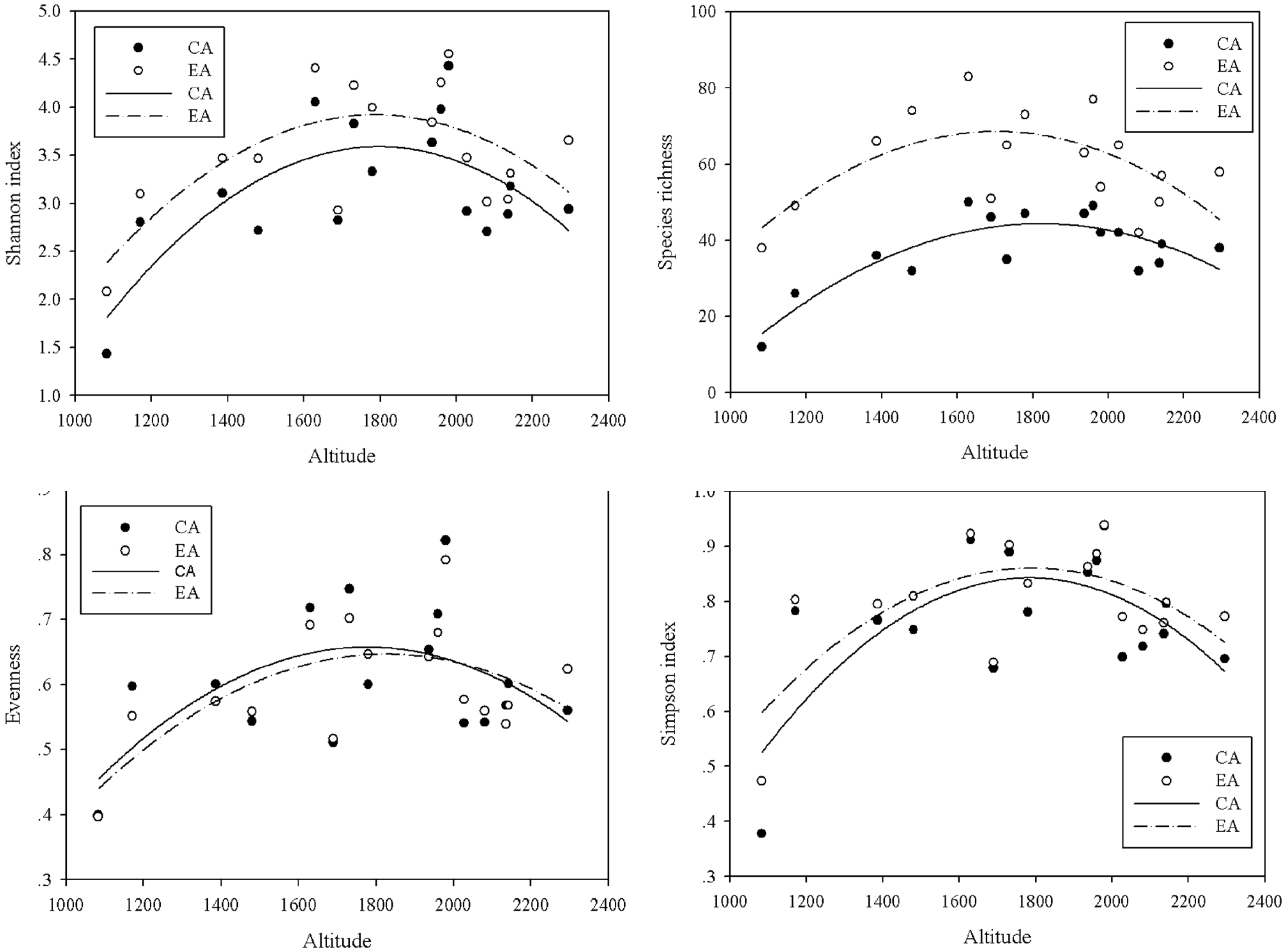

Fig. 4 The tendency of species diversity along the altitude (CA = Chinese approach; EA = European approach)

a Pinus *armandii* forest in the Qinling Mountains, and the plot size was 400 m^2 (horizontal projection). The same plot size was used by Wang (Wang Jian-Feng, 2004, dissertation Yangling) who worked on the ecotone characteristics of plant communities in Shaanxi's Natural Forest. Therefore, selecting 400 m^2 as the plot size for the running project is useful for comparison with previous studies in the Qinling Mountains.

Species richness, i.e. the number of different species in a given area, is in itself an important characteristic of a community type (McIntosh, 1967). The Simpson index measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). It is often used to quantify the biodiversity of a habitat. The Shannon index is used to measure diversity in categorical data. It is simply the information entropy of the distribution, treating species as symbols and their relative population sizes as the probability. Following the differences between two approaches, we conclude that the EA provides a better assessment of the species richness and the Simpson and Shannon indices, than the CA. The species richness patterns, however, are the same elaborated with both approaches, differing only on the different levels of the absolute number of species. Also, the evenness (the degree of equal distribution of individuals or cover of single species within the whole species pool) leads to identical results with both approaches.

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