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Comparative value of habitat biodiversity: an experimental system based on spider community analysis

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Summary

In order to identify for environmental managers a comparative value of the diversity of a biotope, we propose a patrimonial index based on the combined rarity of spider species. This index is still experimental, and can be modified, but its principle seems fixed and already provides a response to the evaluation of biotope diversity.

Introduction

Awareness of global environmental change gives some priority to the study of biodiversity and its maintenance (Blandin, 1986; Bridgewater & Walton, 1997). In the evaluation of biodiversity, invertebrates take an important place (New, 1995; Herrenschmidt, 1996; Cranston & Trueman, 1997), and spiders provide an interesting model to represent invertebrates. Numerous authors are aware of the qualities of spiders: they are predators and thus integrate some of the characteristics of food webs; they colonize all parts of the biotope; the species are not too numerous; and often the immatures can also be identified (Maelfait & Seghers, 1986; Maelfait & Baert, 1987, 1988; Mullhauser, 1990; Pinault, 1992; Furst *et al.*, 1993; Neet, 1995; Churchill, 1997).

The requirements of habitat managers are often precise: they need to test the relative quality of communities; they want to know the general actions required to maintain or restore biodiversity; and they need help to estimate the effects of their biotope management. The answers should not be understandable by specialists alone, they must be simple, comparable, and relevant to the initial question. Spiders have already given answers for biotope management (Marc *et al.*, in press), but only a few authors (e.g. Růžička, 1986, 1987; Růžička & Boháč, 1994; Gajdoš & Sloboda, 1995) have attempted to test spider communities with a general index.

Material and methods

The principle of this method is to compare our knowledge of the distribution of species with the composition of the community we want to test. Several indices are under consideration, but here we present only one of them: the “patrimonial index” (P_i).

Biogeographical data on spiders species serve as a reference base. With the help of computers, they can be selected according to one geographical region (country, region, town, station) or one ecological biotope. French data collected for the distribution study of French species is used here. As it is only an experimental system, we do not need a great amount of data so we only used verified data (18,500 records, each representing one species at one station; 12,000 more records from Brittany, in the collection from Rennes, are being verified and will be added later). The first results concerned biota from the Armorican Massif (west of France), so this was the geographic region selected. Sampling should combine several methods in order to minimize the selective action of each method. For collecting spiders, we use hand collecting, pitfall trapping, sweeping and beating, during all the year for the stations concerned.

Calculation of the index will indicate the global range of rarity of species that compose the community. Use of the computer allows the comparison of numerous datasets. The calculation consists of ordination of the number of

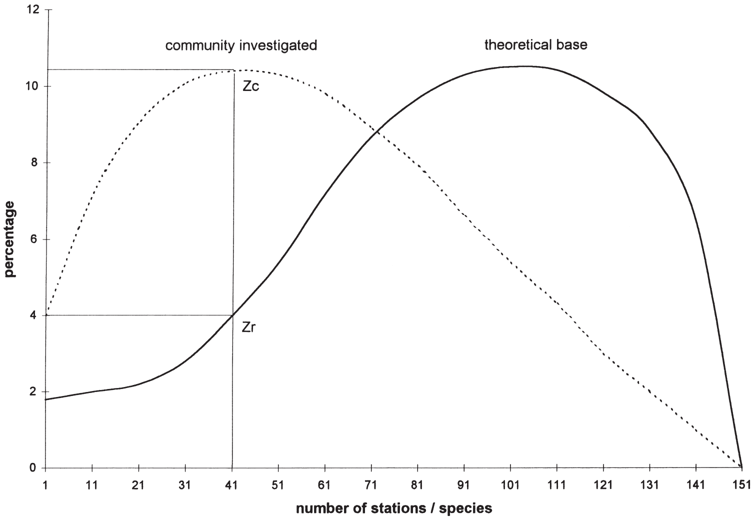

Fig. 1: Theoretical comparison of the investigated biotope curve and the reference base curve for a biotope containing few common species (P_i of high value). At point Zr there are 4% of the total species of the region known from 41–50 stations; at point Zc there are 10.4% of species in the community investigated known from 41–50 stations.

species collected or observed for all the spiders of the region chosen (NS) and in the community tested (NS') according to the different numbers of stations known for each species (s). These numbers are calculated as percentages relative to the general number (100NS/ΣNS) and (100NS'/ΣNS'). The patrimonial index that we propose (P_i) combines these values:

$$P_i = \Sigma\ [(100NS/\Sigma NS) - (100NS'/\Sigma NS')/s]$$

This index is calculated in a general program (D-BASE). Whatever the geographical scale of reference selected is, the reference base is obviously composed with some rare spiders but mainly with species present at numerous stations (see the theoretical shape of the reference base curve in Fig. 1). Thus, when the majority of the species of the community investigated are rare, we can predict that the shape of the tested biotope will be displaced to low values of s (Fig. 1) and the patrimonial index will be high. At the opposite, when the majority of the species of the community are common, the shape of the tested biotope will be displaced to high values of s (Fig. 2) and the patrimonial index will be low.

Biota (stations)	**nos. of spp. (x)**	P_i	$P_{i\ 100}$
peat bog (Erdre)	129	–15.03	–16.73
fallow field edge (Candé)	60	–18.42	–15.68
central heathland (Mt d'Arrée)	107	–18.99	–19.50
fallow field (Candé)	120	–20.11	–21.43
littoral heathland (Cap Fréhel)	81	–23.02	–21.78
pool rings (La Musse)	45	–26.70	–22.60
house (Tual)	28	–28.90	–23.26
forest (Forêt de Rennes)	117	–22.94	–24.94
wet heathland (La Musse)	79	–26.26	–24.97
dry heathland (Néant/Yvel)	154	–22.94	–26.09
dry heathland (Baulon)	168	–22.40	–26.29
dry heathland (Paimpont)	155	–23.16	–26.34
dry heathland (Trécesson)	129	–25.03	–26.74
dry heathland (Tiot)	139	–24.52	–26.78

Table 1: P_i and $P_{i\ 100}$ values for some different kinds of biota.

Results and discussion

Range of values of P_i and importance of the reference base

By referring to the database of the west of France, the theoretical range of the values of P_i is calculated for a theoretical community composed of rare spiders (known from one station only; e.g. *Pirata uliginosus* Thorell, 1856; *Panamonops mengei* Simon, 1926): $P_i = +65.2$ and for a theoretical community composed of common species (e.g. *Araneus diadematus* (Clerck, 1757), *Pisaura mirabilis* (Clerck, 1757)): $P_i = -33.7$. The first biota tested concerned mainly heathlands (Fig. 3). This shows immediately that the shape of the reference base does not conform to the theoretical shape, due to

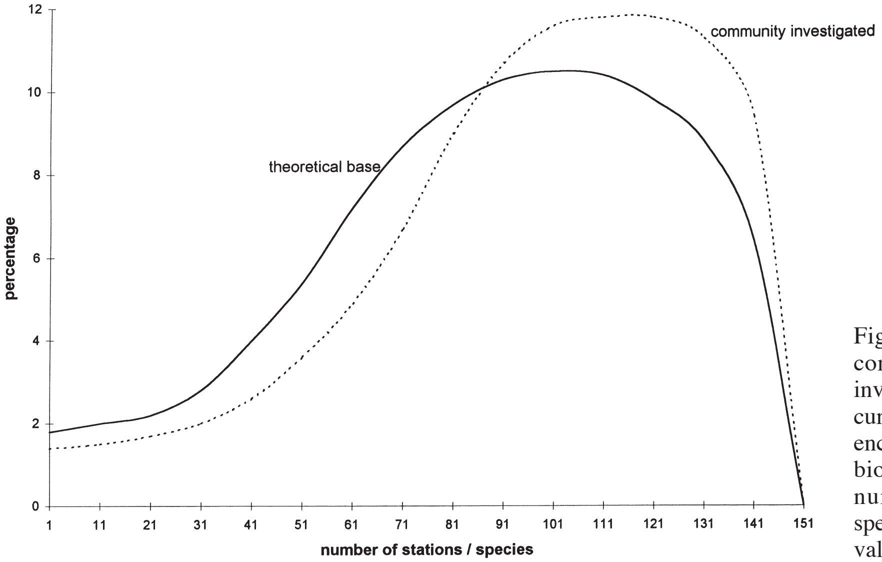

Fig. 2: Theoretical comparison of the investigated biotope curve and the reference base curve for a biotope containing numerous common species (P_i of high value).

the low number of data integrated. But this observation would not affect greatly the relative value of the indices of different biota. Although the reference base is still incomplete, comparative values of different biota investigated (heathlands, forests, peat bogs, etc.) can be given by way of example (Table 1), but the number of stations is still too few to allow general conclusions.

The value of P_i and richness

The calculation of P_i is inferred from the relative rarity of the species inhabiting the area investigated and must be independent of species richness. However, for the same biotope, for instance dry heathland (Table 1), it can be stressed that the value of the patrimonial index, as calculated, is likely to vary with the number

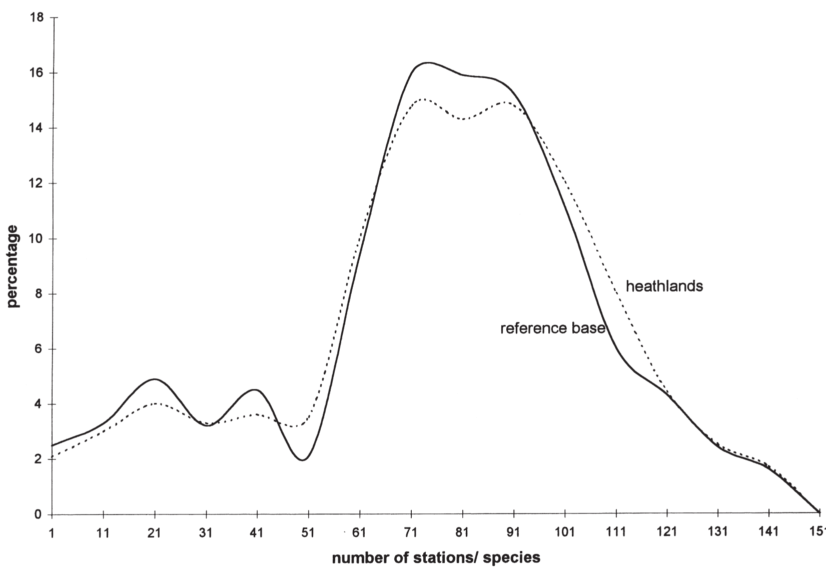

Fig. 3: Comparison between the heathland curve and the reference base curve for Brittany.

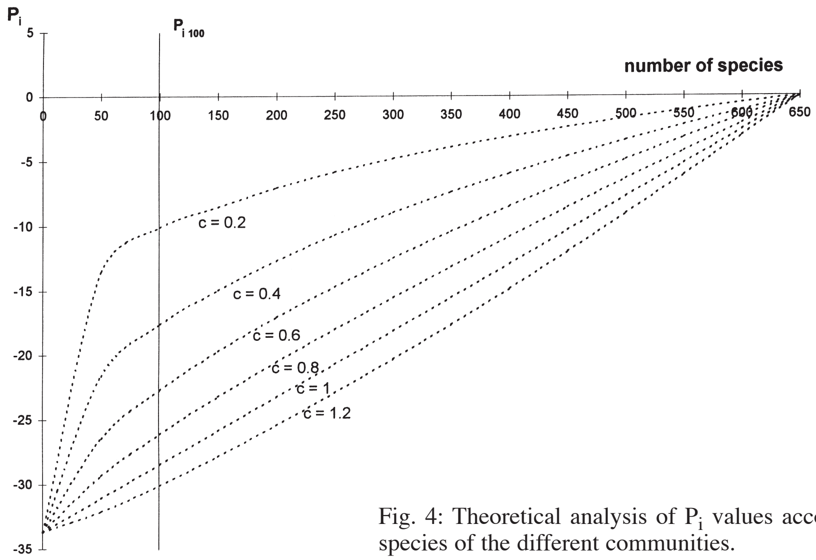

Fig. 4: Theoretical analysis of P_i values according to the numbers of species of the different communities.

of species collected (x) in the different stations. The value of P_i is decreases as the value of x is increases. The theoretical relationship between the number of species and the value of the patrimonial index (Fig. 4) may correspond to several curves (logarithmic, linear or exponential) belonging to a single equation of the type $y = b + ax^c$ (where $y = P_i$ and x = the number of species). The theoretical shapes of the different curves depend on the value of c; the graphic representation clearly shows that the main differences observed between the values of P_i correspond to $50 < x < 100$ (whatever the value of c is). Thus, we propose to compare the values of the patrimonial index ($P_{i\ 100}$) by referring to a fix number of species (x = 100) for all the biota (Table 1).

Conclusion

The patrimonial index give a unique value to describe the spider community which integrates the relative rarity of each spider species; therefore it fundamentally differs from the other classical indices used to compare spider communities (e.g. Shannon-Weaver index, Jaccard index, Sorensen coefficient, Wishart index, Mountford's index of similarity). This kind of calculation must lead to general assumptions about the ecological value of the habitat investigated. When only ubiquitous species are found in a biotope, then this biotope is unbalanced or has been destroyed or disturbed; on the other hand, when rare species are found, the biotope is unusual and has retained its characteristics without any disturbance. However, we know that some rare species are rare everywhere (Drury, 1974; Blandin, 1989; Duffey, 1993; Neet, 1995) and that their presence does not necessarily reflect the specialness of a particular biotope. These species will not obscure comparison of the patrimonial indices of different communities.

Modification of the calculation of the index is so easy that it is possible to adjust it to fit new theoretical considerations. Other indices, integrating the numbers of specimens of each species or the relative composition of the spiders' functional groups, will be added to the program. The program can also provide a list of rare spiders (known from few stations) in the geographic region or the ecological system chosen.

The rapidity of the process allows comparative studies on the different methods of sampling used. These analyses could be pursued further, and might answer some interesting questions, for example: is the index for a station different according to the sampling method, or to the period of the year? Further studies could be carried out to investigate the range of variability related to sampling methods.

The index presented here is still experimental, but the first trials seem very interesting because of the speed with which results are obtained, and the complementarity with other biotic indices such as richness.

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