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The overall score R, a tool for assessing Orthoptera community richness

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Abstract

The purpose of this paper is to propose a synthetic evaluation of the richness of the Orthoptera community at a given site. A global score (R) is obtained by combining four indices, some of which are already in use. This paper describes the appropriate use of these indices and provides an example.

Zusammenfassung

Es wird ein synthetischer Parameter "R" zur Kennzeichnung des Reichtums von Orthopteren-Zönosen vorgeschlagen. Er besteht aus vier teils schon bekannten Teilparametern. Die Ermittlung und Bedeutung der Parameter wird auch an einem Beispiel gezeigt.

Résumé

Cet article propose une approche synthétique de l'évaluation de la richesse du peuplement d'Orthoptères d'un site donné. La combinaison de quatre indices, dont certains sont déjà utilisés, permet d'attribuer une note globale au peuplement. L'indice R ainsi obtenu permet de caractériser la richesse de différentes populations, et de hiérarchiser celles-ci. La méthode est explicitée par un exemple pris sur le terrain.

Introduction

Adult Orthoptera often represent an excellent biological material for assessing the quality of environments. Compared to that of other taxonomic groups, sampling of Orthoptera is relatively simple and identification of most species easy. As they are at various levels of the food chains (carnivores, omnivores, herbivores and scavengers), these insects are highly dependent upon environmental conditions (altitude, microclimate, vegetation structure etc.) and are excellent markers of biotope conditions. The aim of this paper is to propose an overall rating of Orthoptera community, derived from a combination of various indices, some of which already widely in use, for a rapid evaluation and hierarchisation of entomological issues at given sites. It is a tool for pre-ecological analyses which allows evaluating community richness of at a first stance, without necessarily having to set up the cumbersome process of systematic surveys. As the overall score R is calculated for each site, different stations can be compared from this point of view. Its applications are varied, such as targeting sites of biological interest over a wide area (national parks, natural areas etc.), more detailed studies being carried out at a later date.

The proposed approach, by trying to calculate the score R, enables the observer to follow a process which will lead him/her to a very more accurate assessment of richness of a station for Orthoptera, rather than providing a simple global qualitative expert notation.

Of course, in addition to the global score, the communication of intermediate four values will be of high interest for expert exchange.

The Orthoptera are used here as a reference, but transposition to some other groups of insects could be performed with some adjustments. However, the overall score R can be used only for station comparisons (or same station during several years) within the same group (Orthoptera).

Moreover, the use of this notation presupposes a fairly good knowledge of local wildlife and environments present in the region studied.

Methods

Computing of our indices is based only on qualitative and quantitative observations of adult Orthoptera, first instars being encountered much too randomly and their identification too difficult to carry out in the field. Thus, field surveys should be undertaken at a moment when the Orthoptera populations studied comprise few larvae. The four indices, aimed to cover all aspects of a global assessment are the following:

- **Diversity**: Number of different species on the site: Nsc (Number of Species (Capped))
- **Richness of the community** (derived from a simple percentage of the low ecological valence species among the total species of the site): Rv (Richness Value)
- **Equitability of species** (predominance or not of some species): Es (Equitability of species)
- **Richness abundance** (relative abundance of low ecological species): Rn (Richness in Numerous)

Sampling

The process of sampling has already been described in detail by VOISIN (1980). It can be summarized as follows: The observer chooses a large area, homogeneous in regard to vegetation, exposition, soil, etc. He walks through it in every direction, randomly capturing the adult Orthoptera he encounters until he reaches a sample which can be considered as representative of the station. In Western Europe, the number of species per station is usually less than 10, and sampling 100 individuals is generally sufficient. This figure may be increased in richer regions, particularly in southern Europe, where the number of taxa is often much higher. The surface area of the station can be large, provided it remains homogenous, but experience shows that anywhere between a few hundreds to several thousand square meters is a good size. In case Orthoptera populations are poor, making the observation of 100 individuals impossible to carry out in a reasonable time, the observer may cease his investigations after one hour, whatever the number of captured individuals may be.

If the observer knows the local fauna well, making it possible for him to identify the species visually, he may tick each individual encountered on a list of species as he goes through the station. This way, only questionable specimens are collected for later verification. This method has the advantage of greatly limiting disturbance; nevertheless the observer must be quite experienced. It is also quicker than capturing a sample of adults. It has been widely used, for instance by DREUX (1962, 1972), MARTY (1968), DEFAUT (1978), VOISIN (1979, 1980, 1986) and LUQUET (1985). For completely assessing the richness of a station, these surveys have in most cases to be completed by further investigations, for instance amidst dense herbaceous vegetation, within bushes, on stone heaps etc., in order to take in account discreet and rare species, and thus minimize richness underestimation.

The assessment of indices

The results of these counts are used to calculate four indices, Nsc, Rv, En and Rn, which will in turn be used to reckon the overall score R characterising the richness of the Orthoptera community of the station. The assessment of those indices presupposes the knowledge of the ecological valence of each species recorded, and the estimation of its Species Specialization Index (SSI) as proposed by JULLIARD et al. (2006).

The ecological valence "h" of a given species is the number of habitats it uses in the region of study. It is peculiar to each species and, as it may vary geographically, it has to be defined independently by observations in the field over the whole region of study.

The SSI is defined as SSI = $\sqrt{\frac{H - h}{h}}$, with:

h = Σ habitats potentially occupied by the taxon
H = Total number of habitats defined in the region of study.

The SSI reflects the ability of a given species to occupy various habitats, the higher the SSI, the lower the ecological valence of the species. By setting a threshold to the SSI, we can rank the species in two classes: low ecological valence (high SSI number), and high ecological valence (low SSI number). We have set this SSI threshold at h = H / 4, therefore the SSI threshold is equal to $\sqrt{3}$ (1.732).

Ns represents the total number of species recorded on the site during sampling operations as described above, as well as additional species eventually found during non-quantitative surveys. The index Nsc used in the final formula is derived from this index by simply capping it at 30 as a maximum value.

The Rv index is the ratio of species with low ecological valence found on the site to the total number of species recorded (Ns). Its purpose is to take into account the overall richness of the station without excluding taxa that might have escaped quantitative sampling. It is defined as: Rv = 25 * vs / Ns, with "vs" being the number of species with low ecological valence (i.e. over the SSI threshold), vs = Σ (SSI > threshold SSI).

The Rv index highlights the local interest of species with low valences, which are by definition more vulnerable because they are less eclectic in their choices of elective habitats.

The En index measures the balance between the abundance of each species. It falls as one or a few species dominate more over the others. It defined as: En= 25 * Es**,** where Es is the Equitability index. This latter index is defined as: $Es = \frac{Is - 1}{S - 1}$, (in BARBAULT 1992), where Is is the index of diversity of Simpson-Weaver, itself computed from the formula:

$I_S = \frac{1}{\sum_{i=1}^{S} Pi^2}$, where Pi = ni/Nr is the relative abundance of species "I" in the sample, "ni" is the number of data for species "I", and "Nr" the number of records of the quantitative sampling. When only one species is recorded, Is equals 1 and Es equals 0, and when all species are equally abundant, Is equals S and Es equals 1.

The Rn index is the quantitative ratio between species with low and high ecological values. It is defined as: Rn = 20 * vn / (Vn + vn), with vn = Σ n_i for species over or equal to the SSI threshold, and Vn = Σ n_i for species under the SSI threshold, "ni" being the number of observations of species "I" in the quantitative sampling.

The overall score R, ranging from 1 to 100, of the richness of the Orthoptera community considered is calculated by summing the four parameters: R = Nsc + Rv + En + Rn.

Risk of error, impact on the score

Can we use use it to make comparisons such as different landscapes / in different years / by different observers? What is the global effect of every mistake or every missing fact or every change of conditions (e. g. list of potential biotopes, list of species, process of sampling, number of captured individuals, experience of observer, landscape, weather, time of day, season etc.)?

The number of different species of Orthoptera on a station is quite low and after one hour of investigation, the observer should obtain a good vision. Assuming that the sampling is performed at the correct season for the station, but taking into account the above parameters, we can assume an error of 30% (worst case) on the total number of species, mainly on the species with the lowest abundance, and we assume that one third has low ecological valence.

Impact is the following:

- Nsc: if capped (> 30), the impact is obviously null (in the case of stations with a high number of species). For a station populated with a medium number of species, the average error for R induced by Nsc error is 9%.
- Rv: average impact of 5% for R
- En: no sensible impact
- Rn: no sensible impact

The global impact for R is about 14%, which is still acceptable.

If we assume an initial error of 20%, the global impact for R is decreased to 10%. Therefore we suggest, after computation, to round R to the multiple of 5 just above.

Example

Given a station sampled in late August, in the region of Lake Ohrid, National Park Galičica, in the south-east of the Republic of Macedonia (FYROM). The environment is a subalpine grassland with *Juniperus communis nana*, between 1950 m and 2000 m altitude on a north slope. Table 1 shows all species observed on the station, including non-quantitative samplings, the habitats where Orthoptera species live in the region of Lake Ohrid being defined in Table 2.

Table 1: Results of sampling of Orthoptera in a subalpine meadow near Lake Ohrid (FYROM).

Full list of species	**Potential biotopes**	**SSI**	**Species with low ecological valence**	**Number recorded (n_i)**
Gampsocleis abbreviata	5, 7, 10, 11	1,5		9
Polysarcus denticaudus	5, 7, 10 11	1,5		Not counted
Stenobothrus rubicundulus	7, 10 ,3, 4	1,5		18
Stenobothrus nigromaculatus	4, 10	2,35	X	22
Gomphocerus sibiricus	10	3,46	X	15
Oropodisma macedonica	10	3,46	X	25
Anterastes serbicus	3, 10	2,35	X	11

Table 2: List of potential biotopes in the region of lake Ohrid (FYROM).

1	Hill zone: edges and clearings in xerophilous deciduous woods.
2	Hill zone: edges and clearings in mesophilic deciduous or mixed woods.
3	Montane zone: edges and clearings in mixed hardwood forests.
4	Montane and subalpine zones: dry calcareous grasslands with Mediterranean affinities.
5	Hill and mountane meadows, including hayfields.
6	Villages: gardens, paths, hedges and embankments.
7	Hill and montane zones: heathlands, shrubberies.
8	Wet meadows, reedbeds.
9	River beds and rocky river banks
10	Montane and subalpine meadows
11	Agricultural crops, fallow lands
12	Screes
13	Caves

We can now easily calculate :

Ns = Nsc = **7**

Rv = 25 * 4 / 7 = **14.3**

En = 25* 0.875 = **21.9** (I_s = 5.38, E_s = 0.875)

Rn = 20 * 73 / 100 = **14.6**

R = 7+14.3+21.9+14.6 = 57.8

R is rounded to 60

In this example, the result clearly shows the interest of the station through its varied communities of Orthoptera. The majority of the species have a low ecological valence, occupying their optimum range in high-altitude habitats of these mountains. In addition, although the number of species is limited to seven, high species diversity indices are recorded, reflecting the good balance of this community.

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