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Objective selection of indicator species for nature management

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Summary

A method for selection of indicator species objectively is presented. Species are selected using canonical correspondence analysis, to present the largest differences between the invertebrate communities studied, followed by the fit of species numbers per plot score on a Gausse curve. Species selected in this way are both indicative for known environmental factors, responsible for the largest differences among invertebrate communities, and representative for these communities. Examples of application are presented. Usefulness and application by laymen of a monitor system based on the selected species is discussed.
Key-words: Invertebrates, nature management, indicator species, monitoring system.

Samenvatting

Een methode wordt gepresenteerd voor de objectieve selectie van indicatorsoorten. De soorten worden geselecteerd middels een canonische correspondentie-analyse, die de grootste verschillen tussen gemeenschappen van ongewervelden laat zien, gevolgd door het passen van soortsaantallen per plotscore aan een Gausse kromme. Soorten, die op deze manier geselecteerd worden, zijn zowel indicatief voor bekende milieufactoren, verantwoordelijk voor de grootste verschillen tussen gemeenschappen van ongewervelden, als representatief voor deze gemeenschappen. Voorbeelden van toepassing worden gegeven en de bruikbaarheid en toepassing door leken van een monitorsysteem, gebaseerd op deze soorten, wordt bediscussieerd.
Trefwoorden: Invertebraten, natuurbeheer, indicatorsoorten, monitor systeem.

Introduction

Registration of changes in the natural situation, caused by changes in management or by external factors, in a short period of time are required by nature management. In the case of changes of management the system must have an evaluating character; in the case of changes by external factors it must have a signalizing one. Flora and avifauna, the main goals in nature management at this time, are not suitable enough for the mentioned evaluation or signalization system. In most cases changes in the flora take too much time and fluctuations in numbers of birds are not always related to the local situation. Invertebrate animals, however, do meet these requirements and have a relatively fast reaction to changes in the local environment. In this paper I focus on the objective selection of monitor-species from the large number of species of invertebrates and on the monitoring system built up using the selected species.

Outline of the method

Determination of environmental factors showing the largest differences in invertebrate species composition in the series of plots subjected to our study will be the first step. Next to this the species, responding best to these determined factors, are selected and are called indicator species. So, these species are both indicative for changes in environmental factors and representative for a large part of the fauna because the determined environmental factors show the largest differences in invertebrate species composition. A monitor system can be created based on these selected species. This system however will be an expert system, because not all of the selected indicator species are recognizable by laymen in entomology. Attention has to be paid to distinction and robustness of the system when unrecognizable species are dropped.

The procedure

In the selected experimental plots to study a gradient or gradients should be present concerning the environmental factors supposed to have a noticeable influence on the invertebrate fauna (if such an influence is not important for the fauna it will appear in the analysis) or concerning the environmental factors which effect on the invertebrate fauna one wants to monitor. Sampling of the sites is of vital importance in the procedure. Reliability of the monitorsystem and the selected indicator species are directly related to the reliability of the captures. Many research projects have already been carried out on the efficiency and reliability of sampling methods, for instance by Greenslade (1964) and Luff (1975) on pitfall traps, Duffey (1980) on the Dietrick Vacuum Sampler (D-Vac) and Schäfer & Haas (1979) on photo-eclectors for sampling mainly the vegetation dwelling invertebrates.

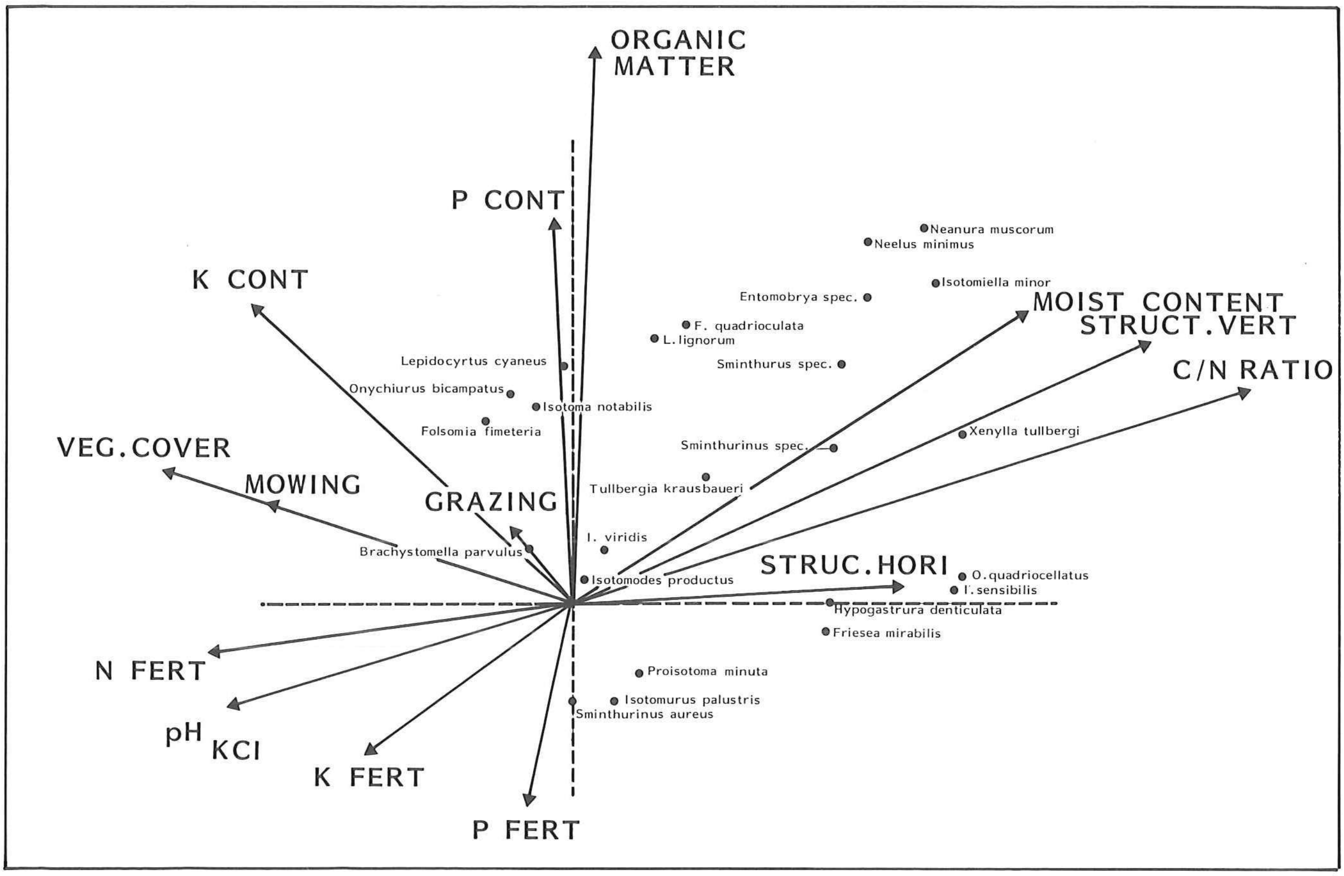

Figure 1. Ordination diagram of detrended canonical correspondence analysis for Collembola species. Species are dots, environmental factors are arrows. See text for explanation. (From Siepel & Van de Bund 1988).

A canonical correspondence analysis will be carried out using the numbers per species and quantified environmental variables (Ter Braak 1986). The analysis results in principal component axes (actually canonical correspondence axes), which can be related to the environmental variables, because these variables are involved in the calculation of species scores and plot scores. In the analysis, the environmental factors being responsible for the most important differences in invertebrate species composition among sites, immediately become clear. The analysis has been carried out for the soil mesofauna by Siepel & Van de Bund (1988). Collembola from this study are presented in fig. 1. Species are represented as a point in the plane formed by the first (X-axis) and second (Y-axis) canonical correspondence axis. The arrows represent the environmental factors. The more an environmental variable is correlated to an axis, the smaller the edge between arrow and axis is. The length of the arrow (in fact the size of its edge to the plane, because in n-dimensional space the arrows are of equal length and are projected perpendicular to the plane of two axes here) presents the correlation to the plane of the shown axes. The longest resultant of the perpendicular projection of the arrows to an axis is the most important environmental factor on the axis.

Sites can be put along an axis using the calculated scores on that axis (calculated in the canonical correspondence analysis from species scores and environmental variables). For every species apart the number of individuals per site is plotted as has been done artificially in fig. 2, and the collection of points is fitted to a Gaussian curve (Program DIATAB, C.W.N. Looman 1985). The position of the curve on the canonical correspondence axis shows the preference of the species, the broadness of the Gaussian curve its

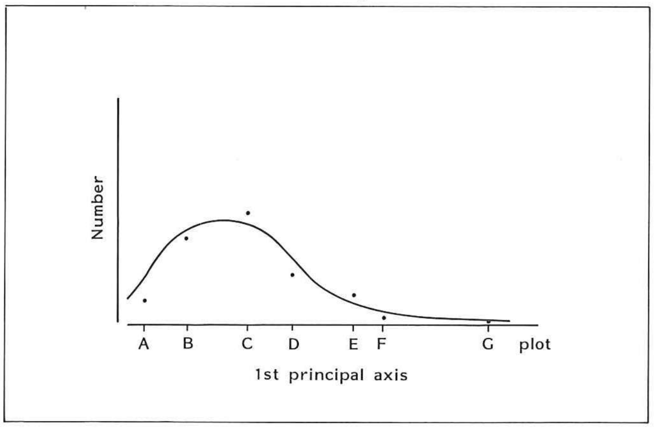

Figure 2. Artificial plot of species numbers per plot. The plots are placed on a principal axis by their scores calculated from species and environmental variables.

tolerance, and the percentage of explained variance its goodness of fit. Species having a percentage of explained variance higher than 30 (an arbitairy à priori fixed limit) are called indicator species. The usual limit in plant ecology is 10% (Looman, 1985), because of the higher mobility of insects compared with plants, the limit is set three times higher. The usefulness of an indicator species is of course also dependent on the broadness of the curve; its tolerance. A limit has not been fixed because of its interference with the length of the studied gradient. The reliability of the analysis depends on the number of plots. Percentages of explained variance are biased positively towards the ends of the canonical correspondence axis, because few points create here already a quite high percentage of explained variance in a fit to the half part (ascending or descending) of a Gaussian curve. It is recommended either to raise the limit of the percentage explained variance in these cases or to be cautious in the application. Table 1 presents the data on Collembola, a selection from the dataset presented in fig. 1. Analyses of this kind have been carried out in grasslands for the soil mesofauna (Siepel & Van de Bund 1988), the surface macrofauna (Siepel et al., 1989) and the vegetation fauna (Siepel et al., in prep.). In every analysis only data of one sampling method should be compared, unless the data can be transformed to densities.

Application

The obtained lists of indicator species can be used in a monitoring system. The system, using the surface macrofauna data only, has been applied to the experimental site "Donkse Laagte", untill 1984 an intensively used heavy fertilized grassland in agricultural practice. From 1985 on it is fertilized with 50 kg N $ha^{-1} yr^{-1}$ (low) and mown twice every year. Decrease of plant production is yet not clearly to observe because of a high year to year variation. Changes in vegetation structure probably occur, but are hard to quantify. Results of the application of the monitorsystem are presented in table 2. The presented percentage of indicator species is the fraction of the total number of indicatorspecies indicative for a fertilizer level. The increase of the percentage of indicator species for low fertilization is obvious and even some indicator species for unfertilized sites appear. Indicator species for heavy fertilization are without exception eurytopic species, which decrease indeed in numbers with decreasing fertilization, but will maintain a smaller population for a long time. The system is here quite insensitive for changes in population size, because of the use of a presence-absence criterium for the indicator species. In the above example it is a disadvantage concerning the indicator species for heavy fertilization. It is an advantage however, for the robustness of the monitor system entirely. Interpretations are not changed because this particular or that particular species is not present, but only because of a change in the percentage of a number of species, using some kind of margin in this case will be recommended.

Application by laymen

When the above presented monitorsystem has to be made applicable for non-entomologists, for instance in the nature conservancy, all not recognisable species have to be dropped. It depends entirely on the obtained list of indicator species, whether this reduction in the number of species can be accepted concerning the sensitivity and robustness of the system. Dropping complete families and orders of invertebrates has to be prevented as much as possible, to guarantee good representation of the invertebrate fauna. Carrying out the described analysis on the recognizable part of fauna only has to be dissuaded, because in that case the selected species are representative for the recognizable part of the fauna only, which essentially differs from the analysis described here where species (recognizable or not) are representative for the main differences in the entire invertebrate fauna.

Table 1. Percentage explained variance, position on the axis (100 = high C/N ratio) and range of the Collembola species selected from fig. 1.

	% explained variance	position (1-100)	range
Hypogastura denticulata	42.8	73.9	20.0
Xenylla tullbergi	88.9	99.8	28.4
Isotomiella minor	35.7	95.1	18.9
Isotoma sensibilis	73.3	98.2	27.6
Isotoma viridis	32.2	31.5	12.7

Table 2. Percentage indicator species for no, low and high fertilization in three successive years after a change of fertilization level.

Donkse laagte experimental plots	% monitorspecies for fertilization		
year	no	low	high
1985	0	45	50
1986	16	58	61
1987	16	70	50

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