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Supplementary material

Appendix 1

Principle of the Canonical Outlying Mean Index (OMI) analysis

This factorial analysis is a slight modification of the classical OMI analysis (Doledec et al. 2000). The classical OMI analysis is a non-centered principal component analysis of the table containing the differences between the mean used and mean available values for each habitat variable (columns) and each observed group (rows). The classical OMI analysis returns a set of linear combinations of habitat variables which maximise the mean marginality, that is, the mean squared distance between the centroid of the space used by each group and the centroid of the cloud of available points in the ecological space (Fig. A1A and B). However, the shape of the cloud of available points is not taken into account with this analysis: when the cloud of available points presents a strong structure, this structure also affects the distribution of the niches in the ecological space and the first component of this OMI is likely to be affected by this structure (Chessel and Gimaret 1997, Fig. A1). Canonical OMI analysis circumvents this drawback, using the inverse of the matrix of the correlations between habitat variables as a metric. The correlations between the habitat variables are thereby eliminated, and the available space is 'sphericized' before the analysis is carried out (Fig. A1C and D).

For doing this, we assume that the studied area is made of a set of N discrete resource units (RU), on which P habitat variables are measured (Manly et al. 2002). These RU may be, for example, the pixels of a raster map (Fig. 1). We consider here that the N available RU have the same weight in the analysis, contained in the N × N (rows × columns) diagonal matrix $\mathbf{D} = \mathrm{Diag}(1/N)$. Let the matrix $\mathbf{Z}$ contain the value of the P habitat variables (columns) in each one of the N available RU (rows). We consider that the matrix $\mathbf{Z}$ is centered (the origin of the space defined by the columns of $\mathbf{Z}$ is located at the centroid of the cloud of available points). Moreover, for each statistical unit (i.e. the center of gravity of an AIU in our study case), we have a set of 'utilization weights' stored in a matrix $\mathbf{F}$, containing in columns the proportion of the relocations of each statistical unit, for each RU (row). Let $\mathbf{M} = \mathbf{F}^t \mathbf{Z}$, where $\mathbf{F}^t$ is the transpose of $\mathbf{F}$. The matrix $\mathbf{M}$ contains the coordinates of the marginality vector of each statistical unit (row) on each environmental variable (column), that is the difference between the average used conditions and the average available conditions for each statistical unit. Let $\mathbf{D}_t$ be the diagonal matrix containing the weights associated to each statistical unit in the analysis. It is the proportion of the relocations of each unit among all units. Finally, let $\mathbf{S} = \mathbf{Z}^t \mathbf{D} \mathbf{Z}$ represent the variance–covariance matrix of the matrix $\mathbf{Z}$.

The Canonical OMI analysis is the eigenanalysis of the triplet ($\mathbf{M}$, $\mathbf{S}^-$, $\mathbf{D}_t$), a non-centered principal component analysis of $\mathbf{M}$, using $\mathbf{S}^-$ and $\mathbf{D}_t$ as column and row weights respectively (Escoufier 1987). This analysis therefore searches the eigenstructure of the matrix $\mathbf{V}$:

$$\mathbf{V} = \mathbf{S}^{-1/2} \mathbf{M}^t \mathbf{D}_t \mathbf{M} \mathbf{S}^{-1/2}$$

Let $\mathbf{U}$ be the matrix containing the eigenvectors of $\mathbf{V}$ (concatenated by columns). The scores of the RUs on the components of the analysis are computed by $\mathbf{Z} \mathbf{S}^{-1/2} \mathbf{U}$. The components of the analysis can be interpreted, as in classical PCA, using the correlations between the environmental variables and the components of the analysis.

The classical OMI analysis is the eigenanalysis of the triplet ($\mathbf{M}$, $\mathbf{I}$, $\mathbf{D}_t$), where $\mathbf{I}$ is the identity matrix. In this case, the first component maximises the mean marginality explained (Doledec et al. 2000). The canonical OMI analysis does the same thing, except that the space is distorted so that the cloud of available points in the ecological space is 'sphericised' before the analysis (Fig. A1).

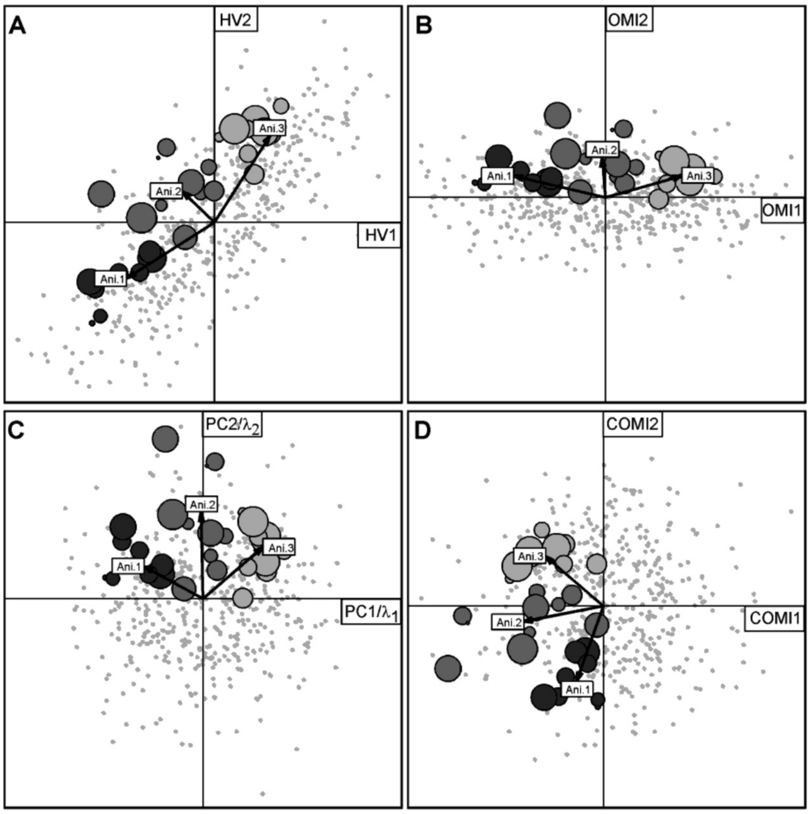

Figure A1. The principle of the Classical and Canonical OMI analyses. We describe the principle of the analysis using a virtual case. (A) The values of 2 habitat variables (HV1 and HV2) for a set of resource units available to the statistical individuals (i.e. an AIU for the mouflon in our study) define the coordinates of available points (grey points) in the ecological space. For each individual, a set of utilization weights (indicated by circles with diameter proportional to the weights) allows to define its niche, that is the available points which are actually used. They allow the computation of the marginality vectors of the individuals, i.e., the vectors connecting the origin of the ecological space (corresponding to the centroid of the cloud of available points), to the centroid of the niche (the arrows). (B) The canonical OMI analysis performs a rotation of ecological space so that the mean marginality is maximised on the first component. Note that, because of the correlation between HV1 and HV2, this direction is not the one on which the habitat selection is maximised. (C) To perform a Canonical OMI analysis, a PCA is first performed on the table containing the values of HV1 and HV2. The principal components PC1 and PC2 are then normalized (divided by the square root of the corresponding eigenvalue, so that the variance of the scores of the available points is equal to 1 on all the principal components). (D) The OMI analysis is then performed on this distorted space; the first components COMI1 and COMI2 of this analysis returns the direction on which the centroid of the niche of the animals are as far as possible from the centroid of the cloud of available points, while taking into account the relationships between the environmental variables.