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Short Communication

A comparison on the impacts of short-term micro-environmental and long-term macro-climatic variability on structuring beta diversity of microarthropod communities

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ABSTRACT

It is unknown whether long-term climatic variability or short-term microhabitat environmental fluctuation would be the key mechanism in determining the microarthropod compositional variation. In the present brief report, by utilizing microarthropod communities as the study model, I aimed to test the relative importance of macro-climatic versus micro-environmental variability on structuring the beta diversity patterns of microarthropod communities. The random sampling effect in quantifying beta diversity has been controlled using a null model. Variation partitioning technique is employed to test the relative importance of both mechanisms. The results showed that microarthropod beta diversity pattern is exclusively influenced by micro-environmental condition, especially for oribatids and collembolans. The influence of macro-climatic variability on structuring microarthropod community structure is exactly zero as indicated by variation partitioning analyses. Correspondingly, the interaction between micro-environment and macro-climate plays no roles on structuring microarthropod beta diversity too. Conclusively, microhabitat condition, but not regional climate, is the driver of microarthropod diversity patterns in SW Canada.

Introduction

Species composition and distribution are determined by a variety of ecological processes, for example, contemporary ecological conditions, historical factors, biotic interaction, and food-web interaction. It has been well studied on the relative importance of historical and contemporary factors in shaping species communities (Buckley and Jetz, 2007; Zobel et al., 2011; Belmaker and Jetz, 2012; Chase, 2012; Jetz and Fine, 2012). However, all these studies only considered broad-scale macro-climatic variables. Due to the nature of macroecological studies, they are never able to utilize local environmental variable data gathered from the sampling fields.

Therefore, it is still unknown whether there is a difference between persistently cycling macro-ecological variables (for example, mean year-round climatic conditions measured by several decades) and snapshot-like temporary micro-ecological variables (for example, daily humidity and temperature fluctuation during the sampling season). No studies have been carried out so far to systematically quantify these two groups of variables on structuring local species communities.

In the present study, to fill such a knowledge gap, I used microarthropod communities as the study model to examine the influences of short-term and long-term disturbances on influencing species composition. I am interested in their roles on beta diversity of the species communities.

Materials and methods

Sampling locations

32 moss field plots were surveyed across SW Canada based on the following standards of site selection: (1) they should be contiguous with the mainland (islands excluded); (2) they should be flattened large rocky outcrops with >4 m^2 of moss carpets; (3) they should be accessed easily, being adjacent to highway roads. Identification of microarthropod species followed the online key (http://www.zoology.ubc.ca/~srivast/mites/) using microscopes.

Measurement of beta diversity

Following some previous studies (Kraft et al., 2011; De Caceres et al., 2012), I quantified and modeled beta-diversity as the way like this: the observed beta-diversity of a community defined as follows:

$$B_{obs} = Var(Y)/(n-1) \quad (1)$$

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where Y is the Hellinger transformation of the original abundance-site matrix X for a focused plot:

$$Y_{ij} = \sqrt{X_{ij} / \sum_j X_{ij}} \quad (2)$$

and $Var(Y) = Trace(YY^T)$. T denotes the transpose of a matrix, and $Trace()$ is the sum of the diagonal elements of a matrix.

The expected beta-diversity of the studied moss plot is generated by a null model (De Caceres et al., 2012). During the randomization, the total individual per site and the relative abundance of species in the species pool were kept unchanged. The beta-diversity was calculated for each simulated random matrix using Eq. (1) after Hellinger transformation as above. The mean of the simulated beta-diversity is taken as expected beta-diversity B_{exp}. Finally, the deviation of beta-diversity B_{dev} is quantified as the difference of observed and expected beta-diversity, divided by the standard deviation of expected beta-diversity (De Caceres et al., 2012). The deviation of beta-diversity is treated as the focused beta-diversity in which the random sampling effect has been removed. Fig. 1 showed the relationships between B_{obs}, B_{exp} and B_{dev}.

Measurement of short-term micro-environmental variables (E)

The following variables are sampled in the field and lab settings during the time of the sampling survey: (1) Soil depth (Depth, centimeter); (2) maximum temperature during the sampling time (MaxTemp, Celsius); (3) minimum temperature during the sampling time (MinTemp, Celsius); (4) average temperature during the sampling time (MeanTemp, Celsius); (5) variance of the temperature during the sampling time (VarTemp, positive numeric value); (6) canopy cover of the plot (Cover, percentage); (7) distance to the closest road (Distance2R, meter); (8) slope for the field plot (Slope, degree); (9) elevation (Elevation, meter); (10) the nearest distance to the sea (Distance2sea, kilometer); (11) soil mass (SoilM, gram); (12) water mass (WaterM, gram); (13) soil water content (WaterC, percentage); (14) soil pH (pH, positive numeric value); (15) large particle mass (ParticleM, gram); and (16) large particle content (ParticleC, percentage).

I quantified these variables as short-term micro-environmental variables because they are directly related to the current living conditions of microarthropods when they were sampled. To some extent, short-term micro-environmental variables might be regarded as local ecological processes.

Measurement of long-term macro-climatic variables (C)

The following variables for each sampling plot are gathered from an online database (http://www.worldclim.org/): annual mean temperature (bio1), mean diurnal range (bio2), isothermality (bio3), temperature seasonality (bio4), maximum temperature of the warmest month (bio5), minimum temperature of the coldest month (bio6), temperature annual range (bio7), mean temperature of the wettest quarter (bio8), mean temperature of the driest quarter (bio9), mean temperature of the warmest quarter (bio10), mean temperature of the coldest quarter (bio11), annual precipitation (bio12), precipitation of the wettest month (bio13), precipitation of the driest month (bio14), precipitation seasonality (bio15), precipitation of the wettest quarter (bio16), precipitation of the driest quarter (bio17), precipitation of the warmest quarter (bio18), and precipitation of the coldest quarter (bio19). These variables were derived from the monthly temperature and rainfall values (Hijmans et al., 2005), which have been widely used in many previous studies (Chen, 2008, 2009; Qian, 2010; Qian and Shimono, 2012).

I quantified these variables as long-term macro-climatic variables because they are not directly related to the current living conditions of microarthropods when they were sampled, but instead, they are related to the adaptation of historical generations of microarthropod species since the time when they colonized the sites. Thus, long-term macro-climatic variables might be regarded as regional or historical ecological processes to an extent.

Variation partitioning on beta diversity

The partitioning of variation in the species composition data matrix X is implemented using partial canonical correspondence analysis (pCCA) (ter Braak, 1986). The two categories of explanatory variables, micro-environmental variable matrix E and macro-climatic variable matrix C, are used as covariance matrices for the purpose to determine the relative contribution of long-term and short-term ecological processes on structuring beta diversity patterns of microarthropod communities.

Proportions of beta diversity that are explained by micro-environmental variables and macro-climatic variables, after the controlling of random sampling effect, thus are quantified as follows (De Caceres et al., 2012),

$$B_E = B_{dev} \times R^2_{adj}(E) \quad (3)$$

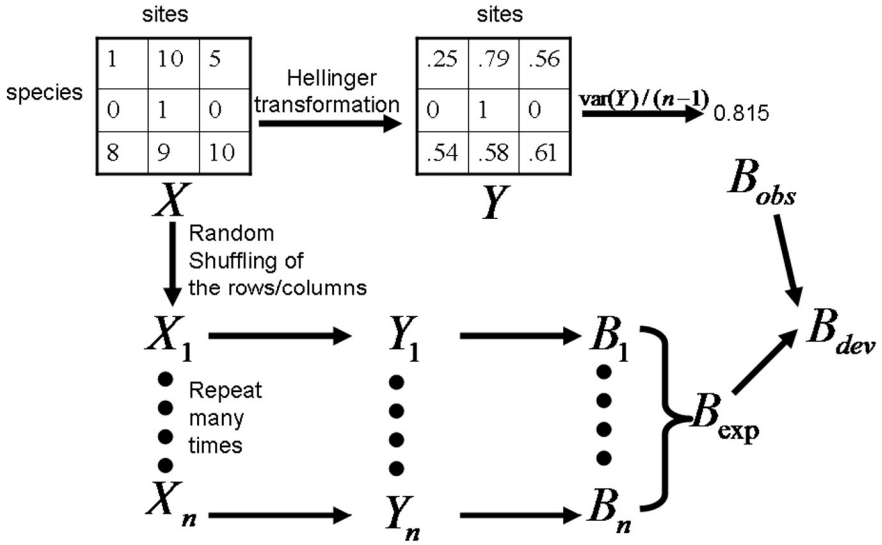

Fig. 1. The computation of different beta diversity metrics.