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Using empirical field data of aquatic insects to infer a cut-off slope value in asymptotic models to assess inventories completeness

Uso empírico de datos de campo de insectos acuáticos para inferir el valor de corte de la pendiente de modelos asintóticos que evalúe la completitud de inventarios

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Abstract. The selection of the most appropriate model is essential to predict the potential species richness of a site or landscape. Species accumulation curves have been used as a basic tool for comparing richness when different sampling protocols have been applied. Among the parameters generated by these models the slope has been cited as an indicator of completeness without regard to a defined cut-off value. In this work, we fit 12 field data sets of aquatic Coleoptera (Hidalgo) and Odonata larvae (Michoacán) to 2 asymptotic models (Clench and Linear Dependence) in order to calculate the slopes at the maximum effort and relate them with efficiency. Then, the theoretical effort needed to achieve the 95% of the lists was calculated for each data set in order to get the theoretical slopes. The average slope value found was 0.01 with a variance of <0.001, so we propose this value as indicative of a list reaching 95% of completeness for data obtained from similar sampling protocols. Additionally, we propose the use of number of rare species as an additional criterion to evaluate the inventories completeness. The effect of different sampling intensity on fitted models and estimation of parameters and the importance of a cut-off slope value in asymptotic models as a criterion to evaluate completeness of biological inventories are discussed.

Key words: potential species richness, theoretical slope, Odonata, Coleoptera, Zimapán, Coalcomán.

Resumen. La selección del modelo más adecuado es esencial para predecir la riqueza potencial de especies de un sitio o paisaje. Las curvas de acumulación de especies se han utilizado como una herramienta básica para la comparación de la riqueza cuando se han aplicado diferentes protocolos de muestreo. Entre los parámetros generados por estos modelos, la pendiente se ha citado como un indicador de completitud sin tener en cuenta un valor de corte definido. En este trabajo, ajustamos 12 conjuntos de datos de campo de coleópteros acuáticos y larvas de odonatos de Zimapán (Hidalgo) y Coalcomán (Michoacán) a 2 modelos asintóticos (Clench y Dependencia Lineal), con la finalidad de calcular las pendientes al máximo esfuerzo realizado y relacionarlas luego con la eficiencia del muestreo. Después, calculamos el esfuerzo teórico necesario para conseguir el 95% de las listas y calculamos las pendientes teóricas. El valor promedio de la pendiente teórica fue de 0.01, con una varianza de <0.001, por lo que proponemos este valor como indicativo de una lista que ha alcanzado el 95% de completitud para datos obtenidos de protocolos de muestreo similares. Además, se propone el uso del número de especies raras como un criterio adicional para evaluar la completitud de los inventarios. Se discute el efecto de la intensidad de muestreo en los modelos ajustados y la estimación de los parámetros, así como la importancia de contar con un valor de corte de la pendiente en modelos asintóticos como criterio para evaluar la completitud de los inventarios biológicos.

Palabras clave: riqueza potencial de especies, pendiente teórica, Odonata, Coleoptera, Zimapán, Coalcomán.

Introduction

Biodiversity inventories are central to most conservation and planning efforts (Cutko, 2009). Inventories, however, are encumbering endeavors that often suffer from limited sampling efforts, either because resources are limited or the necessary sampling effort is unknown (Silveira et al., 2010). Assessment of biodiversity often relies on statistical techniques to estimate total diversity and inventory completeness (Colwell and Coddington, 1994; Hortal and Lobo, 2005). The rapid pace of global change and severe treats to global biodiversity increases the value of approximate methods to assess species richness and diversity. Therefore, it is urgent that we attempt our understanding of these methods and their limitations.

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The use of randomized sample accumulation curves, or species accumulation curves, has been a preferred technique when assessing biodiversity. This technique has been applied with variable degrees of success to field inventories using standardized sampling (e.g. Soberón and Llorente, 1993; Colwell and Coddington, 1994; Moreno and Halffter, 2000; Summerville et al., 2001; Noguera et al., 2002) and also to non-standardized samplings, like museum collections or faunal databases (Soberón et al., 2000; Hortal and Lobo, 2001; Martín-Piera and Lobo, 2003; Petersen et al., 2003; Rosenzweig et al., 2003; Hortal et al., 2004; Baselga and Novoa, 2008). Species accumulation curves are attractive because they allow for the estimation of the total number of species present in an area by extrapolating the function to its asymptote. Although the validity of this extrapolation is still source of controversy, it is a commonly used technique (Colwell and Coddington, 1994; Gotelli and Colwell, 2001; Willott, 2001; Hortal et al., 2004; Hortal et al., 2006).

Species accumulation curves are also useful at describing the rate of new species additions to inventories (Soberón and Llorente, 1993; Hortal and Lobo, 2005; Soberón et al., 2007). In asymptotic models the slope of the species accumulation curve describes such rate, and can be used as a measure of survey completeness (Hortal et al., 2004; Hortal and Lobo, 2005; Delgado et al., 2012): the higher the slope value the greater the sampling effort needed for a complete inventory. Conversely, small slope values indicate more complete surveys, since additional samples add little to the number of species in the inventory. If the slope is small, but not zero, it can be assumed that the species missing from current inventory are locally rare or vagrants (see Moreno and Halffter 2000). Thus the inventory can be considered reliable, though incomplete. The slope can be easily calculated from the fitted function, for it is the first derivative of such function. Many functions have been proposed to describe the relationship between sampling effort and species diversity (Soberón and Llorente, 1993; Colwell and Coddington, 1994; Moreno and Halffter, 2000; Thompson, 2003). Among them, Clench´s equation is one of the best options, as it avoids problems of overfitting and critical richness underestimation, providing a good description of the inventory process (Hortal et al., 2004; Hortal and Lobo, 2005). Once the function has been fitted, its slope becomes a simple, yet powerful, measure of inventory completeness at current sampling-effort levels. Although no studies have explored which is the most adequate slope cut-off to identify a reliable inventory, the use of intuitive thresholds of 0.05 or lower has been proposed (Hortal and Lobo, 2005).

The use of species accumulation curves generated by asymptotic models has been widely used with different faunal groups (Moreno and Halffter, 2000; Alcázar-Ruiz et al., 2003; Thompson et al., 2003; González and Baselga, 2007; González-Oreja et al., 2010; Pedraza et al., 2010). However, in very few papers the slope value has been calculated and reported, and it has been much less used as criteria to assess the completeness of inventories (León-Cortés et al., 1998; Novelo-Gutiérrez and Gómez-Anaya, 2009; Pedraza et al., 2010; Gómez-Anaya et al., 2011;). Likewise, very few authors have considered intuitively the slope value in relation to obtain a nominated percentage (e.g. 95%) of completeness of their inventory (Delgado et al., 2012) without considering a cut-off value as indicative of completeness.

In this work, we compare the relative fit of 2 asymptotic models (Clench and Linear Dependence) when applied to aquatic Coleptera and Odonata larval assemblages (habitat scale), and their combined assemblages for each group (landscape scale). The main purpose of this work is to recommend an appropriate cut-off slope value as indicative of inventories at 95% of completeness. We hypothesize that: (1) slopes of cumulative species curves will decrease with increasing sampling effort, (2) species richness will increase with sampling effort, 3) few rare species (singletons, doubletons, unique and duplicates) will be found where slopes are small and higher effort was applied, because oversampling reduces their presence in inventories.

Materials and methods

Study area. Analyzed data come from the hydroelectric dam Zimapán, Hidalgo (20°39'-20°52' N, 99°27'-99°32' W) and from Coalcomán Mountain Range, Michoacán (18°35'-19°00' N, 102°28'-103°40' W). Details on sampled sites have been published by Arce-Pérez et al. (2010, Hidalgo) and Novelo-Gutiérrez and Gómez- Anaya (2009, Michoacán). Herein nomenclature used for the water bodies is as follows: Hidalgo State: San Francisco River (SF), El Saucillo stream (ES), San Juan River (RJ), Tula River (TL), the entire area of influence of the Zimapán dam (ZHP); Michoacán State: streams El Ticuiz (TZ), Estanzuela (EZ), Pinolapa (RP), Colorín (CL), Chichihua (CH), and the whole Coalcomán Mountain Range (CMR).

Sampling size and intensity. Sampling effort was monthly in all water bodies but with different intensity and size. In SF sampling was monthly throughout the year with an average of 36 D-net samples in each occasion while in ES was also monthly but with an average of 12 D-net samples each month; in SJ sampling was only during 6 months with an average of 10 D-net samples each month and in TL just 1 monthly big sample (about 10 D-net size) was