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Diversity and abundance of small mammals in Iberia: peninsular effect or habitat suitability?

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Abstract

The influence of geographical and climatic factors (latitude, longitude, altitude, mean annual precipitation and mean annual temperature) were investigated on the diversity and abundance of Iberian small mammal fauna. We analysed 92 983 small mammal preys from barn owl pellets. Data were taken both from the literature and by ourselves in 183 localities throughout the Iberian Peninsula. No relationships were found between altitude and mean annual temperature. In contrast, a positive relationship between diversity, abundance, latitude and mean annual precipitation was found. Such a trend is discussed in relation to the "peninsular effect" hypothesis. Our results do not support this hypothesis, since we did not find differences in small mammal abundance between southern Spain and northern Morocco. We conclude that the latitudinal pattern observed in the diversity and abundance is most likely the result of the poor conditions of the Mediterranean environment for small mammals.

Introduction

The diversity of small mammals is affected by both geographical and climatic factors (Pianka 1966; Bond et al. 1980; Delibes 1985; Alcantara 1989; Brünner and Neet 1991; Moreno and Barbosa 1992).

The Iberian Peninsula shows a great variation from wet and temperate conditions of the Eurosiberian region in the north, to xeric and warm conditions of the Mediterranean region in the south. Altitude also shows great variability along such geographical gradients. In spite of this stated variability, there are few studies available dealing with the variation of species in respect to abundance and diversity among small mammals, which consider both main geographical variables (latitude, longitude and altitude) and main climatic variables (precipitation and temperature) together.

On the other hand, many authors have debated the presence or absence of the "peninsular effect" (species abundance decreases from base to tip of the peninsula) (Simpson 1964) in several animal groups and several peninsulas (McArthur and Wilson 1967; Kiester 1971; Taylor and Regal 1978; Seib 1980; Busack and Hedge 1984; Means and Simberloff 1987). In western Europe, abundance of small mammal species decreases from north th south (Herrera 1974). The aim of the present study was: 1) to test whether the pattern found by Herrera (1974) at the continental scale is consistent at the regional scale, and 2) to test the "Peninsular effect" on small mammals in Iberia.

Material and methods

We used data drawn from barn owl diet as the sample method. In spite of the limitations of this sampling procedure (Saint-Girons and Spitz 1966), it has been shown to be valid for biogeographical studies of small mammals (Herrera 1974; Brunet-Lecomte and Delibes 1984; Clarck and Bunck 1991;

Moreno and Barbosa 1992). Data were collected from literature and by ourselves (Benzal 1982; Barbosa et al. 1992).

We analysed about 92 983 small mammal preys from 183 localities (Fig. 1). Localities with less than 100 prey items were not considered.

Fig. 1. Area of samples on the Iberian Peninsula (stripped area). Eurosiberian region (above the dotted line). Mediterranean region (below the dotted line).

Small mammal diversity was calculated using the Shannon-Weaver Index and abundance was taken as the number of species at each locality.

Climatic data were obtained from Elias and Ruiz (1977) and from the Instituto Nacional de Meterologia Data Bank for the points nearest to sampling sites. We selected mean annual precipitation and mean annual temperature as the two most independent and comprehensive indicators of climate.

Partial correlation analyses were used to test for the effect of latitude, longitude, altitude, temperature and precipitation on the small mammal diversity and abundance (Neter and Wasserman 1974; Zar 1984). Stepwise multiple regression analyses (Sokal and Rohlf 1981) were performed when more than one variable was significant in partial correlation analyses (see Moreno and Barbosa 1992 for a similar approach).

To test for the peninsular effect hypothesis, abundance was compared among northern and southern Spain and northern Morocco (data from Corbet and Ovenden 1980; Aulagnier and Thevenot 1986). If a peninsular effect exists, the number of species should increase on the African side of the Strait of Gibraltar.

Results

Simple correlation analyses show a significant positive relationship for diversity and abundance with altitude, latitude, mean annual precipitation and a negative relationship with mean annual temperature (Tab. 1). These results also show a high correlation between abundance and diversity ($r = 0.51$ $p < 0.0001$). No relationships were found between diver-

Table 1. Simple and partial correlations between abundance, diversity and climatic and geographical variables. MAT = Mean annual temperature, MAP = Mean annual precipitation. ** $P < 0.01$, *** $P < 0.001$, n. s. = not significant

	Altitude	Latitude	Longitude	MAT	MAP
		Simple correlations			
Abundance	0.18**	0.42***	n. s.	−0.31***	0.35***
Diversity	0.35***	0.58***	n. s.	−0.49***	0.37***
		Partial correlations			
Abundance	n. s.	0.18**	n. s.	n. s.	0.17**
Diversity	n. s.	0.30***	n. s.	n. s.	n. s.

sity or abundance and longitude. The importance of altitude and mean annual temperature disappears when the relationship among variables is analysed using of partial correlation. Only latitude correlates with both diversity and abundance. Mean annual precipitation correlates only with abundance (Tab. 1). Latitude was the first variable selected by the stepwise multiple regression analysis performed on the relationship between abundance, latitude and mean annual precipitation ($r^2 = 0.19$ $p < 0.01$).

Abundance shows a strong decrease from the north to the south of Spain (27 species and 15 species respectively; Corbet and Ovenden 1980); data from Aulagnier and Thevenot (1986) showed an abundance of 14 species in north Morocco.

Discussion

Geography (latitude) appears to be the main factor explaining the variation in abundance and diversity of small mammals on the Iberian Peninsula. Also, mean annual precipitation seems to be more important than temperature. We earlier calculated that abundance of most small mammalian species in Iberia depends on variations in precipitation more than on variation in temperature. The absence of a relationship between both abundance and diversity, and temperature are contradictory with results obtained for several other organisms. Turner et al. (1987) found temperature and sunshine to be closely related with species diversity of butterflies. Currie (1991) concluded that one of the three strongest correlates of species abundance among birds, mammals, amphibians and reptiles, was mean annual temperature. However, in a study of breeding birds on the Iberian Peninsula, Telleria et al. (1992) did not assure any relationship between abundance and mean annual temperature, similar to the results obtained here. Potential causal factors could be related to scale and geographic situation of the selected area in the theoretical gradient of small mammal abundance distribution in the Palearctic region (Telleria et al. 1992). Tilman (1982) pointed out that abundance is distributed along productivity gradients according to curves characterized by ascendant, peak and descendant phases along a range of low to high levels of resource availability. Telleria et al. (1992) stated according to Tilman's (1982) model that Iberian climatic gradient is too small to produce significant changes in abundance of forest birds, making it necessary to examine the abundance pattern on a broader, or more contrasting, geographical scale. This does not seem to be the case for small mammals, since results at broader scale (Herrera 1974) or more constraining geographical scale (Moreno and Barbosa 1992; Barbosa et al. 1992) show the same pattern as this peninsular study (but see Rosenzweig 1992 for north American rodents).

This reinforces the importance of latitudinal changes other than temperature for explaining changes in diversity and abundance (Rohde 1992).

Latitudinal gradients in abundance and diversity have been known for over a century (Wallace 1878), with species numbers decreasing as latitude increases (Stehli 1968; McCoy and Connor 1980; Clark and Bunck 1991). They have been shown to occur in many different organisms and habitats (Rohde 1992). Our results, however, show an increase in small mammal abundance, as well as in diversity, as latitude increases (Herrera 1974; Moreno and Barbosa 1992). Two reasons could explain this apparent contradiction to the general pattern found on a larger scale (from the Equator to the Poles); 1) a very scanty small mammal fauna is usually associated with Mediterranean environments (Herrera and Hiraldo 1976; Warburg et al. 1978; Cody et al. 1983); 2) the peninsular effect (Simpson 1964; McArthur and Wilson 1967; Seib 1980; Gilpim 1981) influences the species distribution.

Comparison of species abundance shows a strong decrease from north to south in Spain, but the abundance is almost the same in both south Spain and north Morocco. If a peninsular effect exists, then the number of species should decrease from north to south in Spain, however it should increase on the African side of the Strait of Gibraltar. The present results did not support this hypothesis. This suggests that the change in the small mammal fauna from northern to southern Spain is not related to the peninsular effect. Other authors (Taylor and Regal 1978; Wamer 1978; Seib 1980; Lawlor 1983; Busack and Hedges 1984; Means and Simberloff 1987) did not find a peninsular effect in other peninsulas (Florida and Baja California) which have a Mediterranean environment. They conclude that southern depauperation is most likely caused by habitat insufficiency in the south. On the other hand, several authors (Harris 1952; Batzli 1968; Delany 1981) have pointed out that differences in the diversity of a small mammal community are primarily due to habitat structure complexity. On the Iberian Peninsula there is an increase in habitat structure complexity from south to north (Peinado and Rivas-Martinez 1987). These statements reinforce the hypothesis that Mediterranean environments per se are less suitable to the small mammalian community considered as a whole.

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Zusammenfassung

Diversität und Abundanz bei Kleinsäugern in Spanien: Halbinsel-Effekt oder Lebensraumanpassung?

Untersucht wurde der Einfluß geographischer und klimatischer Faktoren (geographische Breite und Länge, Höhe, jährlicher Durchschnitt der Niederschläge und Jahresmitteltemperatur) auf die Diversität und Abundanz der iberischen Kleinsäugerfauna. Hierzu wurden 92 983 Kleinsäugerfunde aus Schleiereulen-Gewöllen analysiert. Die Daten wurden sowohl aus der Literatur, wie auch von den Untersuchern an 183 iberischen Orten gewonnen. Irgendeine Beziehung zwischen der Höhe über dem Meer und der Jahresdurchschnitts-Temperatur konnte nicht ermittelt werden. Eine positive Korrelation besteht zwischen der Diversität, der Abundanz, der geographischen Breite und dem mittleren jährlichen Niederschlag. Dieser Trend wird im Zusammenhang mit der Hypothese des „Halbinsel-Effektes" behandelt. Die Ergebnisse stützen diese Hypothese nicht. Unterschiede zwischen Südspanien und Nordmarokko in der Abundanz an Kleinsäugern konnten nicht gefunden werden. Vermutlich ist die Verteilung sowohl der Artenhäufigkeit, wie auch der Artenmannigfaltigkeit, parallel zu den Breitenkreisen das Resultat der ungünstigen Bedingungen für Kleinsäuger in mediterranen Lebensräumen.

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