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Original Investigation

Rodent endemism, turnover and biogeographical transitions on elevation gradients in the northwestern Argentinian Andes

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ABSTRACT

The aim of this research is to relate patterns of endemism and turnover along a local elevation gradient in northwest Argentina with continental biogeographical transitions. Specimen based records constituted the principal source of information to infer rodent distribution along the elevation gradient. I assessed elevational variation of richness, endemism and turnover by means of non-linear regression analysis. Then I identified five distributional patterns based on the overlap of species geographic range. Their frequency along elevation was used to validate biogeographical boundaries inferred by turnover rates. Eleven species out of 37 (30%) are endemic to the study area. Species richness and endemism were hump-shaped. The rate of endemism reached its maximum value at the upper limit of the forest (2500 m). By contrast, species turnover was *U*-shaped, with a small peak at 1500 m and a maximum at 3500 m. The species' geographic range patterns were not randomly distributed along elevation but agglomerated at specific elevation. Species turnover and chorological analysis suggest two biogeographical boundaries, a weaker at 1500 m and a stronger at 3500 m. The 1500 m boundary marks the transition from assemblages dominated by Lowland-widespread fauna at lower elevation to Montane (Andean eastern slopes) species at middle elevation. This boundary is characterized by moderate species turnover and high species richness. The strong turnover rate at 3500 and the dominance of highland Andean and Andean-Patagonian species above this elevation suggest the occurrence of the transition between the Neotropical and Andean regions; which is characterised by an almost complete species replacement.

Introduction

The concept of endemism implies the geographic restriction of a taxon to a particular area and nowhere else (Anderson, 1994). This is a scale-dependent concept and should be framed in an explicitly geographic context. However, beyond the level of geographical restriction, endemism is a significant operational concept for biogeographic regionalization. Congruence in the geographic distribution of endemic taxa allows dividing the world into different biogeographical units such as regions or provinces within them (Lomolino et al., 2006; Escalante, 2009). Alternatively, when two different biogeographical regions contact, or are just partially separated, a transition occurs. Darlington (1957) defined transition as an overlapping of faunal elements with progressive subtraction in both directions. Thus, biogeographic transition zones that are located at the boundary between regions harbour a mixture of taxa from different biogeographic regions promoted by both historical and ecological changes (Morrone, 2010). Furthermore, rather than just static lines, transition zone are areas where intense biological interactions may occur at a local scale affecting the dynamics of species populations on a larger scale (Ruggiero and Ezcurra, 2003). Very frequently biogeographic transition zones coincide with changes in physiography and environmental conditions, such as mountain ranges or desert, which influence species occurrence and limit their distribution. In this sense, the study of abiotic and biotic variation along elevation gradients has enormous potential to improve our understanding of species distributional patterns (McCain and Grytnes, 2010). This paper aims to relate species composition along an elevational gradient at a local scale with a continental biogeographical transition on the eastern slope of the subtropical Andes.

Classical zoogeographic classifications of South America divide the continent into two subregions: the Northeastern tropical lowlands (Guayano-Brazilian subregion) and the Central Andean highlands and Southern lowlands (Andean-Patagonian subregion) (e.g.Wallace, 1876; Sclater and Sclater, 1899; Hershkovitz, 1969). Morrone (2001, 2002) also divided South America into two, the

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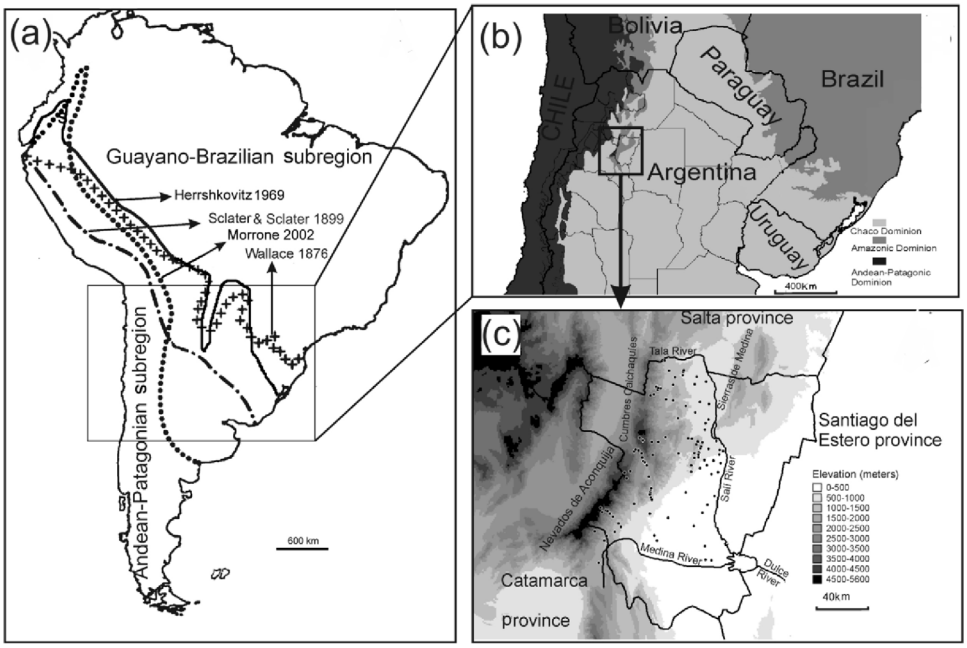

Fig. 1. Study area indicating the regional biogeographic context. (a) Schematic representation of the principal biogeographic divisions of South America according to different authors. (b) Geographic distribution of the three phytogeographic dominions in the present in the study area. (c) Map of the study area (Tucumán province) showing the elevational gradient and the sampling localities.

Andean and the Neotropical regions; which in turn represent the transition between the Holotropical and Austral kindong. Later, he proposed the South American Transition Zone (Morrone, 2004, 2006), which corresponds with the previously proposed boundaries for the subregions (Fig. 1). Ruggiero et al. (1998) detected strong changes in the shape and size of geographic distributions of South American mammals that are coincident with the boundary between these regions, particularly on the eastern slopes of the central Andes. In fact, the Andes are the most important biogeographic feature in South America, influencing distribution of virtually all taxa from the Caribbean to 25–30°S latitude (Patterson et al., 2012). The mountain ranges studied herein are located at 26°S, where the Neotropical montane rain forests that occur on eastern Andean slopes reach their southern limit. The elevational gradient ranges from 500 to 5000 m, encompassing a succession of contrasting biomes such as savannas, rainforests, grasslands and deserts. Along this elevation gradient, I attempted to relate the variation in species composition to a continental scale biogeographic transition. The underlying hypothesis is that the taxonomic homogeneity within biogeographical regions is altered at transition zones, generating discontinuities in the taxonomic composition of assemblages that results in high rates of species replacement, or a combination of turnover and gradients of species richness (Williams et al., 1999; Ruggiero and Ezcurra, 2003). The altered species composition could be interpreted in terms of biogeographical transition by the analysis of the whole distributional range of the species inhabiting the elevation gradient. If the elevational gradient actually plays a role in the maintenance of the regional biogeographic structure, two features of communities along elevation should be observed. First, elevational range limits shared by a set of species and second, those species should share a common geographic distribution.

Rodents, as the most diverse group of mammals (42% of all known species), are frequently the most important part of mammal assemblages concerning the number of species. Additionally, constitute quite conspicuous assemblages (Patterson et al., 1998; Mena and Vázquez-Domíguez, 2005). Many studies have shown that a large proportion of rodents have restricted distributions, independently of taxonomic level (genera/species) or spatial scale (Arita et al., 1997; Danell, 1999; Danell and Aava-Olsson, 2002). Therefore, rodents seem to be particularly useful to analyse species composition and endemism patterns along elevational gradients. Mountain ranges are well known to be inhabited by many endemic species in a wide range of taxa (Fjeldså and Rahbek, 1997; Kessler 2002; Kluge and Kessler, 2006; Badgley, 2010). This phenomenon is usually attributed to the isolation of mountain habitats, which support fragmented populations with restricted gene flow, and thus more prone to speciate than species inhabiting continuous habitats (Vrba, 1992). Speciation rates might be high toward the mountain top, as a consequence of the greater isolation of higher-elevation habitats; however, the isolation of habitats might also lead to greater rates of extinction on highland isolated populations. Thus, concentrations of endemic species are predicted to occur at mid elevations as a result of the balance between habitat isolation and sufficient habitat extent to perpetuate isolated populations (Brown, 2001; Heaney, 2001; Lomolino, 2001).

In this paper I inspect a biogeographical transition by analysing the distributional pattern of rodent species along an elevational gradient. I attempt to identify peaks of endemism along the gradient as well as to recognise and characterise biogeographical boundaries by means of turnover rates and chorological analysis.

Material and methods

The Nevados del Aconquija and Cumbres Calchaquíes are contiguous mountain ranges of approximately 200 km long located along the western margins of Tucumán province, in north western Argentina (26°00′ to 27° 30′ S along 66° W). This mountain system constitutes the headwater of an endorheic drainage basin known as Salí-Dulce basin. Therefore, I defined the study area by the mountain tops to the west, the Salí River to the east, the Tala River to the north, and the Medina River to the south (Fig. 1). The spectacular slopes of the Nevados del Aconquija range raise directly from the flat eastern lowlands at 500 m, rising to 5550 m in only 30 linear kilometers. The Cumbres Calchaquíes reach 4650 m high, but unlike the Nevados del Aconquija, there are smaller mountain ranges (Sierras de Media, 2000 m and Sierras de San Javier, 1900 m)