Evolution of climate niches in European mammals?

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Our ability to predict consequences of climate change is severely impaired by the lack of knowledge on the ability of species to adapt to changing environmental conditions. We used distribution data for 140 mammal species in Europe, together with data on climate, land cover and topography, to derive a statistical description of their realized climate niche. We then compared climate niche overlap of pairs of species, selected on the basis of phylogenetic information. In contrast to expectations, related species were not similar in their climate niche. Rather, even species pairs that had a common ancestor less than 1 Ma already display very high climate niche distances. We interpret our finding as a strong interspecific competitive constraint on the realized niche, rather than a rapid evolution of the fundamental niche. If correct, our results imply a very limited usefulness of climate niche models for the prediction of future mammal distributions.

Keywords: niche evolution; niche model; species distribution model; mammal; phylogeny; phylogenetic signal

1. INTRODUCTION

Adaptive radiation and allopatric speciation are the key mechanisms in the creation of species diversity (Schluter 2001; Gavrilets & Losos 2009). Rapid adaptation to new or altered environmental conditions has been shown experimentally (e.g. Losos et al. 1998), by analysis of palaeontological data (Thompson 1998) and by comparisons of species across phylogenies (Benton 2009; Evans et al. 2009). Up to now, speciation has been commonly viewed as arising from adaptation to different habitats (Gavrilets & Losos 2009) and isolation (Schluter 2009), but rarely to climate (but see Evans et al. 2009). It could also thus be argued that the current changing climate may not have too severe consequences for species' continued existence, because they are able to adapt and evolve at a similar pace. A key question is whether phylogenetic constraints such as potential genetic and epigenetic mechanisms that restrict the evolution of new varieties within taxa (cf. Losos 2008; Wiens 2008) may be too strong to allow adaptive shifts in climate niches. Indeed, Kozak et al. (2006) show how...
3. RESULTS
We found that closely related species differed widely with respect to their climate niche (figure 1). For the vast majority of comparisons, climate niche overlap was much smaller than would be expected from their phylogenetic relatedness (assuming constant mutation rates), hence we detected no phylogenetic signal with respect to climate niche distances of sister species. Across all species, a very weak phylogenetic trend was discernible, relating to 23 of the 140 species (21 positive, two negative trends; see the electronic supplementary material). This faint signal indicates that phylogenetic constraints were largely unimportant for the currently realized climate niche of European mammals.

Within the lagomorpha, rodentia and insectivora, niche distances between sister taxa were significantly greater than in the chiroptera (figure 2). However, scatter was also large within groups and precluded a more in-depth analysis.

4. DISCUSSION
Our analysis indicates high flexibility of realized climatic niches independent of phylogenetic distances. One might conclude that owing to the rapid evolution of climate niches in European mammals, climate change poses a minor threat to these species. The alternative explanation, and the more conservative one, is that the fundamental niche of the mammals investigated here is much wider than the realized niche (Kearney 2006). Competition between closely related species may have shifted the realized climate niche without requiring major evolutionary adaptations.

Apparent climate niche space is similarly subject to character displacement as other dimensions of the niche hypervolume (size (Hutchinson 1959); (Diamond 1975); size of prey (Hespenheide 1975); forage quality (Olff et al. 2002); mutualistic gut microbe community (Ley et al. 2008); soil nutrient requirements (Tilman 1982)). Because our analysis does not comprise extinct mammal species (because both genetic and distributional data are known to a far lesser extent), we are hesitant to invoke the ‘ghost of competition past’ (Connell 1980) for the observed climate niche displacement. At the same time, we found no obvious convincing alternative explanation (e.g. shared pathogens, hybridization vigour, genetic drift; see Schluter 2001 for review).

From species ranges analysis it is known that mammals, as endothermic organisms, can occupy broader fundamental climate niches than insects or plants because they are able to buffer variation in climate (see also Gaston 2003). It is thus well conceivable that their fundamental climate niche is rather wide and less subject to physiological constraints than that of poikilothermic animals. Competition would thus simply act on the realized, not on the fundamental, climate niche. We speculate that a comparison with other species groups such as reptiles or insects should show a stronger phylogenetic signal.
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