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Distribution, spatial interaction and niche analysis in three species of European moles (genus *Talpa*, Soricomorpha: Mammalia) in Italy

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We investigated the spatial relationships among three phylogenetically related and ecologically convergent moles in Italy: *Talpa europaea*, *Talpa romana* and *Talpa caeca*. The spatial niche of each species was described through environmental predictors of climate, soil moisture and topography. Niche overlap between each species pair was quantified, and niche similarity tests were performed through a randomization procedure. The potential distributions of mole species were modelled through an ensemble forecasting approach, while their actual distributions were derived by using a fixed-radius local convex-hull technique. *Talpa europaea* and *T. caeca* exhibited the narrowest and the broadest niche, respectively. The highest values of niche overlap were detected between *T. caeca* and each of the two large moles *T. romana* and *T. europaea*, while the lowest value emerged between the last two. The potential and actual distribution ranges of *T. europaea* were almost equivalent, whereas *T. romana* and *T. caeca* were each restricted to limited portions of their potential distribution. We discuss whether competitive interactions could be responsible for their actual distribution pattern, with *T. europaea* dominant over the other two and *T. caeca* occupying the most marginal portion of its niche due to competitive exclusion. This study provides an example of how eco-evolutionary factors may be involved in driving the geographical range of closely related and ecologically convergent taxa.

ADDITIONAL KEYWORDS: competitive exclusion – niche modelling – niche overlap – *Talpa caeca* – *Talpa europaea* – *Talpa romana*.

INTRODUCTION

Following the increased availability of statistical and digital mapping tools, niche dimensions are now central to ecological biogeography, which focuses on spatial patterns of ecological communities (Lomolino, Riddle & Brown, 2009; Devictor *et al.*, 2010). The ecological niche concept refers either to the response of a species to a given set of variables, considered as resources (Grinnell, 1917), or to the impacts of species on the environment (Elton, 1927). The Grinnellian niche was further extended by Hutchinson (1957), who introduced the concept of the fundamental niche, defined as the portion of the hyper-volume of all biotic and abiotic resources within which a species can maintain a viable population (Hutchinson, 1957). The fundamental niche of a species is the main determinant of its potential distribution (Hutchinson, 1957) and the main driver of evolutionary changes (Voje *et al.*, 2015). Many aspects of the fundamental niche can be conserved over long evolutionary time scales; thus, closely related species are expected to share more of their fundamental niches than are distantly related species (Wiens & Graham, 2005). However, the potential distribution of a species based on its fundamental niche is rarely met, as

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