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Original investigation

SEMICE: An unbiased and powerful monitoring protocol for small mammals in the Mediterranean Region

Ignasi Torre[a,*], Alfons Raspall[b], Antoni Arrizabalaga[a], Mario Díaz[c]

[a] *Museu de Ciències Naturals de Granollers (MCNG), 08402 Granollers, Barcelona, Spain*
[b] *Parc Natural de la Serra de Collserola, ctra. de l'Església 92, 08017 Barcelona, Spain*
[c] *Department of Biogeography and Global Change (BGC-MNCN), Museo Nacional de Ciencias Naturales (CSIC), c/Serrano 115 bis, E-28006 Madrid, Spain*

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ABSTRACT

Schemes to monitor biodiversity change should detect properly target species without harmful effects on individuals and populations, and be powerful enough to detect expected population trends in the face of global change. Targeting is a key aspect of monitoring schemes since there is no single method able to detect unbiasedly all species of any given community, especially the rarest ones. Here we test whether SEMICE (*SEguimiento de MIcromamíferos Comunes de España*), a monitoring protocol for small mammal biodiversity in the Mediterranean Region, fulfil these requirements. The protocol aims at monitoring common species easy to catch with the two most widely used commercial live traps (18 Sherman and 18 Longworth traps alternated in position across 6×6 trapping grids spaced 15 m, brought into operation for three consecutive nights in spring and fall). We used pilot data from twenty-two plots distributed along wide environmental gradients in Catalonia (NE Spain), sampled from 2008 to 2015. The wood mouse (*Apodemus sylvaticus*) was dominant throughout the study period (992 individuals, 39.0%), followed by the white-toothed shrew (*Crocidura russula*, 598 individuals, 23.5%) and the Algerian mouse (*Mus spretus*, 269 individuals, 10.6%). The two most common rodent species experienced strong population declines during the eight-year period (91% for *A. sylvaticus* and 83% for *M. spretus*). Regional community data obtained from diet studies of small mammal predators showed that common keystone prey and seed dispersers were sampled properly. No differences among trap types regarding community parameters and similarity indexes, sampling efficiency, detectability, trap-induced mortality, mean size and sex-ratio were detected, confirming previous results for a smaller pilot study. The method was sensitive enough for detecting expected population changes. We recommended extending the SEMICE protocol to sample common keystone small mammals along wide Mediterranean environmental gradients, since the method was sensitive enough to detect, and even test, expected population trends associated to global change for all them.

Introduction

Changes in biodiversity due to extinctions and range shifts are the result of anthropogenic global change, such as climate change, habitat loss/fragmentation, pollution, invasive species or the interaction of these factors (Sala et al., 2000; Vitousek, 1994). Monitoring biodiversity change has been increasingly required for two main reasons: the need for systematic evaluation of the performance of conservation policies aimed at stopping biodiversity change (EEA, 2010, 2012; Díaz and Concepción, 2016), and to determine how changes in biodiversity impact ecosystem function and structure (Gilman et al., 2010).

Monitoring requires the development of standardised sampling protocols for target groups based on scientific rigor (e.g. Satterfield et al., 2017; Voříšek et al., 2010). Monitoring considerations include variation in detectability of species within sampled groups depending on the monitoring technique used (e.g. Heisler et al., 2016; Satterfield et al., 2017; van Swaay et al., 2008; Watkins et al., 2010), and the harmful effects of monitoring techniques on individuals and populations when active sampling (i.e. trapping) is needed (Spotswood et al., 2012). Usually, there is no single technique able to sample all species within a group with the same degree of accuracy and safety, so that each technique is in fact focused to a smaller group of target species (e.g. passerines and some small non-passerines when using bird point counts or line transects, or walking insects and small vertebrates when using pitfall traps; Sutherland, 2006). Monitoring protocols should ideally consider spatial and temporal variation to prevent low power to

* Correspondence author.
E-mail address: ignasitorre@gmail.com (I. Torre).

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detect changes in relevant parameters such as population abundance or species richness (MacKenzie et al., 2005). Therefore, the use of pilot data is highly recommended to estimate detection probabilities of target species with multiple methods and use this information as a basis for selecting a primary sampling method for future studies (Otto and Roloff, 2011).

This paper addresses whether the small mammal monitoring program we established recently in Spain and Andorra (SEguimiento de MIcromamíferos Comunes de España, SEMICE, Torre et al., 2011) fulfil these requirements. The program aims at monitoring common species with high detectability using commercial live traps (i.e., Longworth and Sherman). Using as small pilot study in Iberia, we have demonstrated that both trap types provided similar estimates of community parameters and similarity indexes, sampling efficiency, species detectability, trap-induced mortality, mean body size, and sex-ratio of the most abundant species when deployed simultaneously (Torre et al., 2016). First, we briefly reanalysed among-trap differences with a larger data set covering the environmental variability of the study region to confirm results obtained regarding trap bias (or lack thereoff) with data. This confirmation is essential in Mediterranean regions because diversity is mostly due to a strong spatial turnover (beta diversity) across mosaic landscapes shaped by altitudinal, climatic and land-use gradients, rather than to high local (alpha) diversity (Blondel et al., 2010; Doblas-Miranda et al., 2015). Spatial variability in small mammal communities may exacerbate detection biases associated to trapping (e.g. Heisler et al., 2016; Sibbald et al., 2006).

Diet analyses of generalist small mammal predators can be used to establish the composition of small mammal communities (Torre et al., 2004), as far as the spatial and temporal extent of diet sampling compensates for bias due to predator's variation in foraging behaviour (Embar et al., 2014). Diet of generalist owl and carnivore species have been recently used to analyse small mammal communities in our study area (Torre et al., 2013, 2015a,b). We took advantage of the availability of these data to ascertain to what extent the SEMICE protocol undersampled these communities at regional scales (Torre et al., 2004). This explicit comparison allowed us to define more precisely the list of species properly sampled by the SEMICE protocol.

Finally, we tested the power of the monitoring protocol to detect the population trends of all species properly sampled, in order to evaluate its usefulness to monitor biodiversity change and validate model predictions of how changes in climate and land use may influence biodiversity change (Doblas-Miranda et al., 2015). Range borders of many species lie through the Mediterranean region because of its transitional nature between temperate and tropical regions (Blondel et al., 2010). Population trends rather than dynamic stability, and even range shifts, are to be expected in the near future due to climate and land use changes (Araújo et al., 2011; Torre et al., 2015a).

Material and methods

Field work was carried out within six Natural Parks (Montseny, Montnegre-Corredor, Sant Llorenç del Munt i l'Obac, Serralada de Marina, Collserola, and Garraf) of Barcelona province (Catalonia, NE Spain), located on the eastern side of the Iberian Peninsula (Fig. 1). Woodlands (i.e., pinewoods, holm oak, deciduous and fir forests) represented the main habitats in the region (65%), followed by open natural habitats (shrublands and grasslands, 22%), and with

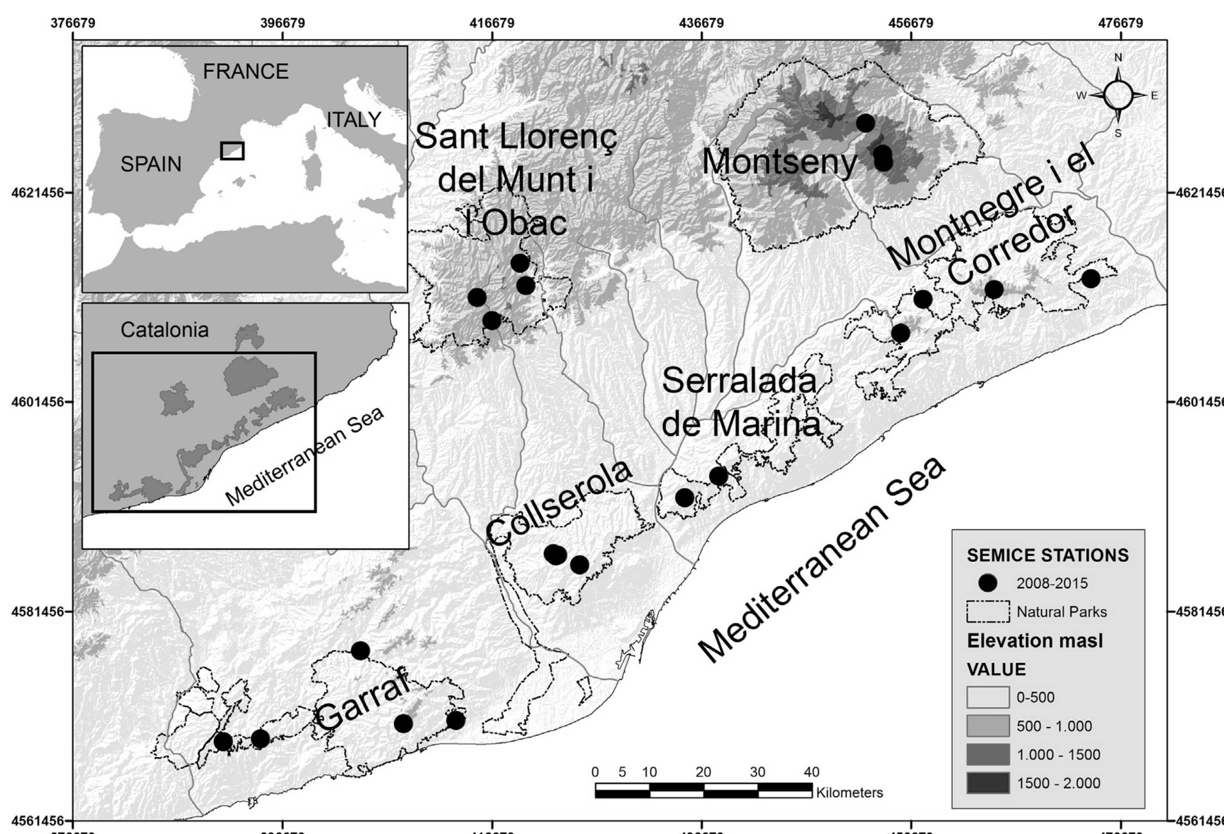

Fig. 1. Map showing the location of the study area and the sampling plots according to elevation. The habitats sampled in every Natural Park were: P.N. Garraf (3 post-fire shrublands-Quercus coccifera, and 2 pinewoods-Pinus halepensis), P.N. Collersola (4 holm-oak/pine mixed woodlands- Quercus ilex/Pinus pinea), P.N. Serralada de Marina (1 holm oak/pine mixed woodland Quercus ilex/Pinus pinea, 1 post-fire shrubland), P.N. Montnegre-Corredor (1 riverbed, 2 holm oak-Quercus ilex, 1 canary oak woodland-Quercus canariensis/Q.ilex), P.N. Montseny (1 shrubland-Juniperus communis, 1 fir forest-Abies alba, 1 poplar with meadows), P.N. Sant Llorenç del Munt i l'Obac (3 holm oak/pine mixed woodland, 1 post-fire shrubland).

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