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Citizen science data as an efficient tool for mapping protected saproxylic beetles

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ABSTRACT

Global change imposes rapid assessments to obtain reliable and updated distribution data to implement conservation measures. This task is undoubtedly unaffordable for numerous invertebrate species, both in terms of time and economic resources, because they are often elusive, detectable life stages are present for a restricted time and ecological data are scarce. Citizen science might be able to provide a large number of records and these data might facilitate the evaluation of extinction risks. Large saproxylic beetles represent an ideal group to assess the potential of citizen science to map distributions on a large scale geographic distribution. The data presented were collected during a citizen science program developed within the LIFE Project "Monitoring of Insects with Public Participation", which used a website and a mobile app to involve citizens. We selected three pan European species protected under the Habitats Directive: *Lucanus cervus*, *Morimus asper*/*funereus* and *Rosalia alpina*, and we compared the data gathered by the citizen science project with distributional data from the official national species inventory. For all species we found a low overlap of occupied cells and the integration of the two datasets resulted in an increase in the distributional ranges of up to one third. Furthermore, taking into account the time frame of data collection, we found that the extent of occurrence obtained in 10 years of records present in the national dataset was comparable to data collected in only two years of the citizen science data project. Similar results were obtained for the estimates of spatial parameters for the IUCN Red List assessment. Our study shows the potential and the efficacy of citizen science projects as rapid tools to provide reliable distributional data for neglected species of high conservation priority.

1. Introduction

Range shifts in the distribution of species are one of the main fields of research when dealing with the effects of global change (Bellard et al., 2012; Dormann, 2007; Hijmans and Graham, 2006). Extinction risk of species can be predicted by modelling habitat modification at different climate change scenarios, and the resulting effect on distribution (Dawson et al., 2011; Keith et al., 2008; Pereira et al., 2010). Thus, monitoring changes in the distribution of species could be used as early warning signals. Ideally, assessments of species distributions should be reliable, rapid, economic and up to date. While this seems feasible for a few, large and easily recognizable animal species, such as certain birds and mammals, this is undoubtedly much more difficult for the huge number of invertebrate species. The distribution of terrestrial invertebrates is far more finely patterned than is the case for either vertebrates or vascular plants (Oliver et al., 2000).

Invertebrates constitute the large majority of biodiversity, accounting for >80% of the species described. Indeed, among multicellular organisms, invertebrates are dominant in terms of richness, abundance and often biomass (Cardoso et al., 2011b) and occupy most niches and food-web nodes. Thanks to their species richness, diversity and ecological roles, invertebrate provide a full array of ecosystems services, which range from provisioning (e.g. food and pharmaceuticals) to regulating (e.g. pollination), cultural (e.g. tourists attraction of corals or butterflies) and supporting services (e.g. nutrient cycling and soil formation) (Cardoso et al., 2011b). These services have been estimated to value around US$33 trillion per year all over the world (Costanza et al., 2007). Unfortunately, invertebrates are experiencing high extinction rates and proportions of threatened species are higher than those of other better known taxa such as birds and mammals (Cardoso et al., 2011a; MacKinney, 1999; Moir et al., 2010; Stork and Lyal, 1993; Thomas and Morris, 1994).

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Preserving invertebrates is of crucial importance to preserve biodiversity. Nonetheless, invertebrates are mostly underrepresented in international conservation measures and have largely been neglected in the literature on conservation, a result of a taxonomic bias (Cardoso, 2012; Clark and May, 2002; Kremen et al., 1993; New, 1999; Zamin et al., 2010). The Habitats Directive (European Union, 1992), which lists the protected species in the European Union, is dominated by vertebrates, with few arthropod species (Haslett, 2007) and is in need of an urgent revision, according to Cardoso (2012).

Many impediments, from funding shortage to a lack of public awareness, can be identified as concurrent explanations for this underrepresentation of arthropods in conservation measures (see Cardoso et al., 2011b). Among these, one key limitation is the so called Wallacean shortfall, a reference to the biogeographer Alfred R. Wallace (Lomolino, 2004; Cardoso et al., 2011b), which indicates inadequate knowledge of the distribution of species. Compiling good distributional data is the first stage of any systematic conservation planning exercise (Margules and Pressey, 2000). Obviously, the lack of reliable information about where certain species live makes it impossible to assess their conservation status and to focus conservation efforts on the most appropriate sites. However, obtaining consistent distribution data for insect species can be particularly difficult. Even if for certain vertebrate species distributions have been correlated with habitat complexity (Coops and Catling, 1997), identifying attributes of habitat structure that act as surrogates for invertebrate biodiversity is feasible only at a very coarse level (Newell, 1997; York, 1999). Thus, obtaining specific information on the distribution of invertebrates requires direct monitoring.

Public participation in ecological studies has recently become a pillar of research on biodiversity conservation (Dickinson et al., 2010). While reports from amateur naturalists played an important role in past centuries, in recent years citizen science (CS) projects, where a non-expert “collects and/or processes data as part of a scientific enquiry” (Silvertown, 2009), emerged as a valuable tool for exploring and tracking spatial and temporal patterns of several taxa all over the world (Dickinson et al., 2010, 2012; Tulloch et al., 2013). A recent review quantified the potential of biodiversity-related CS projects and found that currently about 1.3 million volunteers participate, contributing up to $2.5 billion in-kind annually, exceeding most federally-funded studies in both spatial and temporal extent (Theobald et al., 2015). The experience accumulated so far, especially on large, common and charismatic species, showed that most CS projects 1) are feasible (i.e. a project manages to engage with a large number of citizens in the scientific activity), and 2) allow to quickly gather a large amount of data which are reliable and novel (reviewed in Devictor et al., 2010; Dickinson et al., 2010; Dickinson et al., 2012). CS projects may thus present an important new tools for gathering data that would be too expensive or time consuming to be collected relying solely on paid expert personnel (Braschler, 2009; Cohn, 2008).

The adoption of CS projects aimed at monitoring the distribution of invertebrates may have the potential to fill the gaps left by traditional scientific endeavour that hamper the evaluation of extinction risk for neglected and hard to assess taxa. A key question is however whether CS is also able to provide fast, reliable and informative data for invertebrate species, such as saproxylic insects, less attractive than the taxa commonly targeted by CS projects. Several characteristics make saproxylic beetles, i.e. species that depend on deadwood in at least one phase of their life cycle (Stokland et al., 2012), especially difficult to be monitored exclusively by experts on a large scale. Therefore this ecological group might be suitable for a citizen science program. Saproxylic beetles show a high ecological diversity in terms of trophic attitudes (xylophagous, mycetophagous, predators, parasites, parasitoids, detritivorous, etc.) and habitats (Speight, 1989). The elusive larval stages are generally poorly known and associated with specific microhabitats, that are often localized, rare and isolated (Stokland et al., 2012). In contrast, the adults of some species are easily observed during specific times of the year and the majority of faunistic data generally is gathered by observing adults. Here we test if the data gathered in two years during a citizen science project (Project LIFE NAT11/IT/000252 MIPP Monitoring of Insects with Public Participation, Mason et al., 2015) provide accurate information on the Italian distribution of three pan European saproxylic beetle species protected under the Habitats Directive: *Lucanus cervus*, *Morimus asper/funereus* and *Rosalia alpina*.

In this paper we test if a CS project can provide reliable data on the distribution of saproxylic beetles, quantifying the effort of participation by citizens and estimating the accuracy of identification of the species. Moreover, we test if the data collected during two years by a citizen science project (CSD) allows to reliably draw distribution maps, when compared to national inventory data (NID) gathered over longer periods (10–25 years). We also analyse if the CSD addes new information on the distribution of the species. Finally, we explore if CSD are suitable for assessing the Red List Status of species comparing the extent of occurrence and the area of occupancy obtained with CSD and NID.

2. Materials and methods

2.1. Species selection

We selected three pan European beetle species (*L. cervus*, *M. asper/funereus* and *R. alpina*) that are charismatic representatives of the saproxylic guild (Drag et al., 2011). Solano et al. (2013) found that the 2 species *M. asper* and *M. funereus* actually belong to the same species, thus here we adopted the name *M. asper/funereus* and we considered the distribution of the species as defined by Solano et al. (2013). The three target species are easily recognizable, relatively large (15–83 mm), appealing, and have been considered flagship species (Duelli and Wermelinger, 2005; Lachat et al., 2013; Rink and Sinsch, 2007; Russo et al., 2015). Furthermore the conservation of these species is enforced by the Habitats Directive, which lists them in the Annexes II (*L. cervus*, *M. funereus*, *R. alpina*), IV (*R. alpina*) and as priority species (*R. alpina*). Additionally, they are classified as Least Concern (*L. cervus*, *M. asper*), Near Threatened (*R. alpina*) and Vulnerable (*M. funereus*) in the national IUCN Red List (Carpaneto et al., 2015). Habitats of the above species range from urban remnants of historic woodland (*L. cervus*) to well preserved old-growth forests (*R. alpina*). The distribution of these saproxylic beetles depends on the availability of dead wood, a resource which has been dramatically reduced by forestry (Müller and Bütler, 2010).

2.2. Data collection

We compared two Italian datasets. CSD were collected during two years (2014–2015) within the MIPP project (Mason et al., 2015). This project represents the first attempt to collect records of saproxylic beetles listed in the Annexes of the Habitats Directive (European Union, 1992) by employing a website and a mobile app. Citizens used these tools to send records of the target species, which were accompanied by a photograph that allowed validation by experts. Coordinates were specified using GPS data (mobile app) or online mapping tools (website). We considered all records received before the 27th September 2015.

NID was derived from the dataset CKmap (Stoch, 2005), based on data collected by experts on more than 10,000 terrestrial and freshwater species, mapped on the UTM 10 km^2 grid. CKmap is a database developed to study national distributions, allowing the identification of biodiversity hotspots (Ruffo and Stoch, 2006). For our study, we selected the records for the three target species, retaining only those that had precise coordinates (precision A).

2.3. Data analysis

For the three species, we compared the distributions obtained by means of CSD and NID (all records, no time restrictions), using the