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Original research article

Large-scale semi-automated acoustic monitoring allows to detect temporal decline of bush-crickets[☆]

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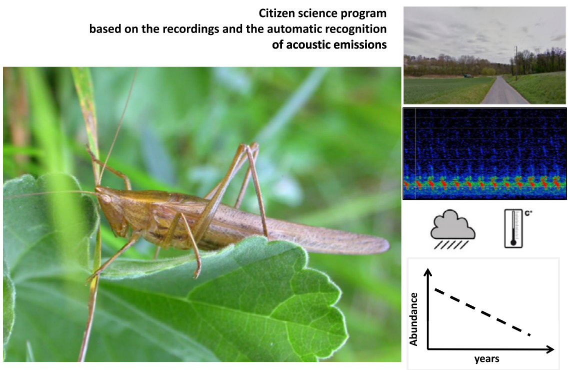
HIGHLIGHTS

- We assessed the relevance of a method to detect Orthoptera trends at large scale.
- We used acoustic monitoring coupled with automatic recognition of species sounds.
- The spatial variations were explained by the geoclimatic conditions and land use.
- The temporal variations were correlated to the climatic conditions of the year.
- Such method offers several advantages for assessing Orthoptera biodiversity trends.

GRAPHICAL ABSTRACT



A relevant way to monitor Orthoptera species at large scale

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ABSTRACT

Monitoring biodiversity over large spatial and temporal scales is crucial to assess the impact of global changes and environmental mitigation measures. However, large-scale monitoring of invertebrates remains poorly developed despite the importance of these organisms in ecosystem functioning. The development of new recording techniques and new methods of automatic species recognition based on sound detection and easily applicable within a citizen-science framework, offers interesting possibilities. However, the value of such protocols has not been tested for the study of temporal trends on a large spatial scale.

We used an acoustic region-wide citizen-monitoring program of Orthoptera, conducted along roads, to assess the relevance of automatic species recognition methods to detect temporal trends while taking into account spatial and seasonal patterns of two Orthoptera species activity (*Tettigonia viridissima* Linnaeus, 1758, and *Ruspolia nitidula* Scopoli, 1786)

☆ Alienor Jeliazkov and Yves Bas have equally contributed to the paper and are both first authors.

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at a large scale. Additionally, we tested the effect of climate and land-use variables on spatio-temporal abundance patterns using generalized linear mixed models. We found negative temporal trends for the two species across the survey period (2006–2012). The spatial variations were largely explained by the geoclimatic conditions and, to a lesser extent, by land use (negative effects of urbanization). The temporal variations were highly correlated to the climatic conditions of the year, and of the previous year (nonlinear effect of temperature, precipitation).

To our knowledge, this paper describes the first successful attempt to calculate large-scale temporal trends of insect populations on the basis of an automatic identification process of acoustic data. We argue that acoustic monitoring along roads, coupled with the automatic recognition of species sounds, offers several advantages for assessing Orthoptera biodiversity response to global changes and environmental measures.

1. Introduction

Large-scale standardized monitoring schemes are crucial to assess changes in species distributions and abundances and to predict long-term biological responses to global changes, especially anthropogenic pressures (Balmford et al., 2003; Pereira and Cooper, 2006; Balmford et al., 2005; Green et al., 2005; Jones et al., 2011). These programs have been increasingly developed in recent decades (Devictor et al., 2010; Theobald et al., 2015) and have been helpful to highlight ongoing community changes facing land use and climate changes (Devictor et al., 2012).

Large-scale monitoring schemes are, however, largely focused on plants and vertebrates (especially birds). Few programs monitor terrestrial arthropods and, almost solely focus on butterflies (Thomas, 2005; Theobald et al., 2015) and, to a lesser extent, on pollinators (Deguines et al., 2012). However, insects constitute over 50% of species diversity and significant biomass, playing a crucial role in ecosystem functioning (Weisser and Siemann, 2004). Even though their conservation status is still a low priority, insect conservation is of increasing concern (Dunn, 2005; Régnier et al., 2015). More importantly, the study of insect spatio-temporal trends may be informative and complementary to those of more long-lived species, such as vertebrates, in understanding the mechanisms underlying biodiversity responses to global changes. Insect abundances and community composition are known to vary in response to both intrinsic and extrinsic factors (notably temperature and precipitation), but understanding the relative roles of each factor in population and community processes is a long-standing problem in ecology (Turchin, 2003). The improved assessment of insect dynamics will finally help to predict their future trends in regard with environmental changes, which is of great concern for decision-makers and practitioners due to the role of insects in ecosystem functioning and their importance in ecosystem services (pollination, biological control) and damages (in crops).

To date, most of the existing insect surveys generally focus on particular habitats and single species, or small groups of species providing services or causing damages, for example, the oak processionary moth (Wagenhoff and Veit, 2011; Williams et al., 2013) in forests, or butterflies in grasslands (van Swaay et al., 2008). Agricultural landscapes gather the largest number of long term surveys—for example, on pollinators, such as bees (Genersch et al., 2010), and agriculture pests, such as aphids (Wang et al., 2014) or Orthoptera (Acrididae) (Fielding and Brusven, 1990; Jonas and Joern, 2007). While these monitoring programs allowed the survey of population changes within these habitats, relatively few programs allow the assessment of nation- or region-wide trends, especially across diverse habitats (but see Deguines et al., 2012). Finally, most programs focused on low trophic levels (phytophage), while global changes that affect communities and ecosystem functions are expected to affect species interactions within and among trophic groups (Wisz et al., 2013; Blois et al., 2013). Developing complementary nation- and region-wide monitoring programs on insects of intermediate trophic level (feeding on smaller insects), whose population and community dynamics are expected to rapidly reflect the dynamics of the lowest level, is crucial to better assess the mechanisms underlying biodiversity dynamics.

Monitoring based on standardized collected data of insect population abundance is likely the best approach to estimate population trends (Yoccoz et al., 2001). However, it implies being able to develop a large temporal and spatial effort to improve detection, and the precision of trends estimation (Yoccoz et al., 2001; Nielsen et al., 2009; Lindenmayer et al., 2011). Citizen-monitoring schemes with standardized and designed protocols are thus considered to be a powerful solution to collect large amounts of data (Dickinson et al., 2010, 2012; Bonney et al., 2014; Theobald et al., 2015). Digital technologies, such as photographs, videos and sound recordings, could substantially increase the amount of data collected and reduce the bias due to variation in the observers (Sueur et al., 2008; Dickinson et al., 2010; Penone et al., 2013b). Digital technologies are noninvasive techniques, they also reduce the need for human interpretation compared to traditional methods, and allow subsequent data validation by experts. Furthermore, some of these technologies can be coupled with automated signal recognition (Blumstein et al., 2011) to further reduce both observer bias and the time spent on data analysis. Acoustic techniques may be particularly useful for monitoring (Mankin et al., 2011; Marques et al., 2013) the insects which produce loud and species specific sounds. This is the case of Orthoptera, which produce mating calls (Ragge and Reynolds, 1998)