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Recent large-scale range expansion and outbreaks of the common vole (*Microtus arvalis*) in NW Spain

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Abstract

Irruptive populations of rodents cause damage to agriculture worldwide. By the end of the last century, the distribution range of *Microtus arvalis* in NW Spain greatly expanded to encompass agricultural habitats, with the appearance of crop damaging population outbreaks. The absence of long term vole monitoring data has so far precluded outbreak forecasting, which might help mitigating associated bioeconomic costs. We used non-standard and diverse sources of information, including newspaper and national technical reports, to describe the vole expansion and outbreak dynamics in NW Spain since the late 1960s. We illustrate a rapid (<20 years) and large scale (ca. 5 million ha) colonisation of agricultural lowlands, and suggest a pattern of westward expansion emanating from the peripheral mountains. Crop damaging outbreaks directly followed range expansion and our analyses indicate that they have occurred at approximately 5-year intervals since the early 1980s. This is the first description of long term (>40 years) regional scale vole dynamics reported for the Iberian Peninsula. We suggest that expansion from (humid) mountains to (dry) plains may be related to recent changes in land use. If confirmed at a local scale, the apparent cyclicity of outbreaks would provide a basis for forecasting outbreak risk in NW Spain and may help managers adjust current control strategies.

Zusammenfassung

Nagetierpopulationen, die sich explosionsartig vermehren, verursachen weltweit Schäden in der Landwirtschaft. Am Ende des letzten Jahrhunderts dehnte sich das Verbreitungsgebiet von Microtus arvalis in NW Spanien weitläufig aus und es gab Populationsexplosionen, welche die Ernte minderten. Das Fehlen langfristiger Monitoringdaten für die Wühlmäuse schloss bisher Vorhersagen über die Ausbrüche aus, die möglicherweise helfen, die bioökonomischen Kosten zu senken. Wir nutzten nicht-standardisierte und vielfältige Informationen, wie z. B. Zeitungen und nationale, technische Berichte, um die Ausbreitung und Ausbruchsdynamik der Wühlmäuse in NW-Spanien seit den späten 60er Jahren zu beschreiben. Wir beschrieben eine schnelle (<20 Jahre) und großräumige (ca. 5 Millionen ha) Besiedlung des landwirtschaftlichen Tieflandes und vermuten ein Muster der westlichen Expansion ausgehend von den umgebenden Bergen. Ausbrüche, welche die Ernte minderten, folgten

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direkt der Ausbreitung des Vorkommens und unsere Analysen lassen vermuten, dass sie in etwa 5-jährigen Intervallen seit den frühen 80er Jahren auftreten. Dies ist die erste Beschreibung einer langfristigen (>40 Jahren) regionalen Wühlmausdynamik, die von der Iberischen Halbinsel bekannt ist. Wir vermuten, dass die Ausbreitung von den (feuchten) Bergen in die (trockenen) Ebenen mit aktuellen Veränderungen in der Landnutzung zusammenhängen. Wenn das auf einer lokalen Ebene bestätigt wird, könnte die Regelmäßigkeit der Ausbrüche eine Basis für eine Vorhersage des Ausbruchsrisikos in NW Spanien darstellen und könnte daher den Landwirten helfen, die derzeitigen Kontrollmethoden anzupassen.

Keywords: Rodents; Agriculture; Cycles; Rodenticides; Tularaemia; Castilla y León; Iberian Peninsula

Introduction

Rapid human-induced changes in land use are strongly influencing the composition and functioning of ecosystems across Europe (Young et al. 2005). For instance, agriculture intensification is a main driver of biodiversity loss in European ecosystems (Osvaldo et al. 2000). Such changes in biological communities often translate in increases of environmental risks, including the (re)emergence of zoonotic diseases (Jones et al. 2008), biological invasions (Lockwood, Hoopes, & Marchetti 2007) and population outbreaks of species that may then be considered as pests (Singleton, Belmain, Brown, & Hardy 2010). Rodents are among the most important vertebrate pests to agriculture worldwide, and they are often associated with environmental, socioeconomic and health issues (Ostfeld & Mills 2007; Singleton et al. 2010).

In Europe, the common vole (*Microtus arvalis*) is a major vertebrate pest for plant production that can cause important economic losses during outbreaks (Jacob & Tkadlec 2010). Although outbreaks are regularly recorded in Europe (Jacob & Tkadlec 2010), a weakening of cyclic dynamics has been reported for common vole populations in its western range during recent decades (Lambin, Bretagnolle, & Yoccoz 2006). These observations fit a geographically widespread pattern of dampening cyclic dynamics amongst small herbivores across Europe, explanations for which invoke human-induced land use shifts, sometimes coupled with climate change (Ims, Henden, & Killengreen 2008).

In sharp contrast to seemingly fading out of rodent cycles elsewhere in Europe, hitherto unseen outbreaks of common vole populations have erupted in recent decades in agricultural areas of NW Spain (Castilla y León autonomous region, CyL hereafter; Fig. 1A and B), following a regional scale colonisation event at the end of the XXth century (González-Esteban & Villate 2007). Unprecedented socioeconomic impacts are now recurrent in recently colonised agricultural habitats, including significant crop damage episodes (Jacob & Tkadlec 2010) and zoonotic outbreaks of *Francisella tularensis*, the etiological agent of tularaemia (Vidal et al. 2009). As is often the case (Singleton et al. 2010), management of vole outbreaks in CyL mainly relies on rodenticides spread over crops and/or in vole burrows. Such poison-based control practices notoriously produce undesired secondary poisoning of non-target fauna, including protected species (Olea et al. 2009; Mougeot, García, & Viñuela 2011; Sánchez-Barbudo, Camarero, & Mateo 2012). Rodenticides add to the cost of farming by individuals or local governments (Stenseth et al. 2003; Jacob & Tkadlec 2010). For instance, during the 2007 outbreak in CyL, the cost to the public purse of emergency vole management using rodenticides was estimated at 15 million € (Jacob & Tkadlec 2010). In this context, the ability to forecast rodent outbreaks could contribute to reducing their economic and ecological impacts by allowing informed control decisions (Davies, Leirs, Pech, Zhang, & Stenseth 2004).

Long-term data sets of vole abundance are an essential starting point to assess whether outbreaks occur with a regular period and to study their causal factors, two key aspects to developing predictive models and mitigate bioeconomic costs (Stenseth et al. 2003; Davies et al. 2004; Imholt, Esther, Perner, & Jacob 2011). Unfortunately, long-term vole monitoring studies in NW Spain are limited to one study in a non-agricultural mountainous area located in Segovia Province to the south of CyL, belonging to the historical distribution range (Fargallo et al. 2009). This leads to a limited understanding of the emergence of outbreaks in farmland areas, which has so far precluded attempts to predict vole outbreaks.

Here, we used non-standard and complementary data sources to reconstruct the historical *colonisation process* of the region and *regional outbreak dynamics* of common voles in CyL, NW Spain, over 40 years. In the absence of long term monitoring data on vole populations in agricultural areas, such as available elsewhere in Europe, we combined information from public annual agricultural reports and news in a main daily regional newspaper extracted using keyword based search of archives. Combining these sources of information, we provide the first historical reconstruction of past outbreaks in this region and use time series analyses to test for regularity in outbreaks. We also assess whether vole outbreaks have been consistently accompanied by the use of rodenticides and outbreaks of tularaemia.

Materials and methods

Study area

Our study area comprises the region of Castilla y León in the north-plateau of the Iberian Peninsula (Fig. 1), an