Large-scale range expansion and eruption of common vole (*Microtus arvalis*) outbreaks in agricultural plains of NW Spain: historical reconstruction and novel impacts

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Abstract

By the end of last century the distribution range of *Microtus arvalis* in NW Spain greatly expanded and outbreaks began to be reported in recently-colonised agricultural habitats. Ever since, novel impacts to regional farming, biodiversity conservation and public health have recurrently been associated to vole outbreaks. Here we present the first attempt to reconstruct recent changes of common vole dynamics and distribution in the NW of the Iberian Peninsula. We compile published information for the last 50 years and describe a new methodological approach based on semi-quantitative data obtained from complementary sources. Our results show how, from late-1970s, the entire lowland plains of Castilla y León region were rapidly (< 20 years) filled in by expanding populations. Analyses of outbreaks also suggest a 5-year cyclic pattern from late-1970s onwards, contrasting with the typical 3-year cycle described in most populations of this species. Our results contribute to improve the current knowledge of rodent dynamics in Europe and may serve as a baseline to local pest management programmes.

Keywords: agriculture, Castilla y León, cycles, *Microtus arvalis*, outbreaks, range expansion, Spain

Introduction

In Europe, *Microtus arvalis* is a major vertebrate pest for plant production that can cause important economical losses to farming during population outbreaks (Jacob and Tkadlec, 2010). Recently, hitherto unseen dynamics of common vole populations have erupted in agricultural areas of NW Spain (Castilla y León region, CyL hereafter). By the end of 20th century, periodic vole outbreaks in agricultural plains followed a massive regional-scale colonisation event in CyL (González-Esteban and Villate, 2007). Unprecedented socio-economical impacts are now endemic in recently colonised habitats, including significant crop damage episodes and zoonotic outbreaks. Time series of vole fluctuations are essential for assessing the mechanisms behind outbreaks and planning management practice that could mitigate outbreaks. Unfortunately, the absence of any long-term vole monitoring data impedes quantitative analyses of vole outbreaks in NW Spain. In this study, we build a spatial-temporal model for both range expansion (*regional colonisation process*) and population fluctuations (*outbreak dynamics*) of common voles in Spain. In addition, we evaluate patterns of zoonotic outbreaks and environmental (chemical control campaigns) impacts in the region and their relation to rodent dynamics. We describe a new methodological approach to tackle the historical reconstruction of recent vole dynamics.

Methods

Reconstruction of vole dynamics from 1960 onwards was based on both quantitative and semi-quantitative data from scientific and other sources, provided they reported explicit, spatial (province, sub-province (i.e., *comarca*)) and/or temporal (year, month), information on common vole presence and/or occurrence of outbreaks (unusually high vole densities). Data were compiled from three different sources: (a) scientific papers published in local (Spanish) peer-reviewed journals (Spanish Scientific Journals: SSJ); (b) national technical reports from annual series on plant protection and pest control (i.e., *Reuniones Anuales de los Grupos de Trabajo Fitosanitarios*) published by the Ministry of Agriculture (Ministry of Agriculture Reports: MAR); and (c) digital archives of daily issues of the main regional newspaper, *El Norte de Castilla*, which is one of the oldest (>150 years) in the country (Norte de Castilla News: NCN).

Results

Regional colonisation process: Maps from SSJ allowed recreating vole expansion dynamics in sub-provinces. Up to early-1970s, *M. arvalis* was limited to mountainous peripheral landscapes in CyL. However, between late-1970s and mid-1990s the entire region was rapidly filled in by expanding populations (>85% of sub-regions with voles during first large-scale outbreak in 1988) (Figure 1). *Outbreak dynamics*: Outbreak data from SSJ, MAR and NCN were highly correlated. Eruption of periodic outbreaks in CyL correlated in time with the range expansion process (Figure 1).

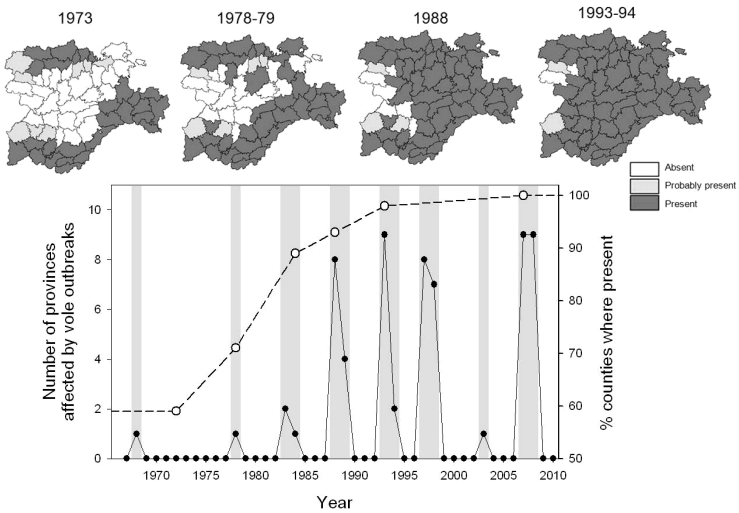

Fig. 1 Reconstruction of colonisation process and outbreak dynamics in CyL based on SSJ. MAR and NCN

Major outbreaks affected 6 to 9 of the 9 CyL provinces since 1988, although the extent of reported damage varied between provinces. Wavelet analysis based on semi-quantitative data suggests a 5-year cyclic pattern from late-1970s onwards. Spectral and autocorrelation analyses confirmed 5-year outbreak cycles. *Impacts related to rodent dynamics*: Data from NCN show a strong association between outbreaks and rodenticide campaigns, whose effects (e.g., secondary poisoning of non-target fauna) seem to expand for 1-2 years post-outbreak. NCN data also show that the two tularaemia outbreaks in humans officially declared in Spain (1997 and 2007) were both immediately preceded by large vole outbreaks in the region.

Discussion

Analyses of semi-quantitative data including newspaper archives yielded the following new findings: (1) the first description of long-term time series (> 40 years) of vole fluctuation dynamics in the Iberian peninsula; that represents a new southern limit for outbreaks within the latitudinal range (40º-60ºN) where heaviest rodent damage to plant production are most often described in temperate Europe (Jacob and Tkadlec, 2010); (2) evidence that Iberian vole outbreaks are a recent phenomenon that have paralleled a rapid (<20 years) and large-scale (ca. 5 x 10^6 ha) range expansion, and are almost exclusive to recently-colonised agricultural plains with a climate characterized by aestival droughts. We hypothesise that causes for the massive expansion of voles from (humid) mountains to (dry) plains include the increase of irrigated crops in the region; and (3) Iberian outbreaks apparently fit a 5-year cyclic pattern, which contrasts with the typical 3-year cycles described elsewhere (Lambin et al., 2006); common vole populations from CyL offer thus new opportunities to address global mechanisms and causation of rodent cycles (Lambin et al., 2002). We also suggest that common vole outbreaks in NW Spain are a further example of the common link between pest rodent and disease outbreaks in highly altered ecosystems (Ostfeld and Mills, 2007). Finally, we showed a repeated pattern of rodenticide use and environmental impact after each outbreak since 1988. Both science and common sense urges Spain

to upgrade from traditional control strategies towards more scientifically-oriented management paradigms (i.e., *ecologically-based rodent management*).

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