



Europe-wide outbreaks of common voles in 2019

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Received: 27 September 2019 / Revised: 13 January 2020 / Accepted: 20 January 2020 / Published online: 28 January 2020
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Abstract

Common voles (*Microtus arvalis*) are widespread in the European agricultural landscape from central Spain to central Russia. During population outbreaks, significant damage to a variety of crops is caused and the risk of pathogen transmission from voles to people increases. In 2019, increasing or unusually high common vole densities have been reported from several European countries. This is highly important in terms of food production and public health. Therefore, authorities, extension services and farmers need to be aware of the rapid and widespread increase in common voles and take appropriate measures as soon as possible. Management options include chemical and non-chemical methods. However, the latter are suitable only for small and valuable crops and it is recommended to increase efforts to predict common voles outbreaks and to develop and field test new and optimized management tools.

Keywords *Microtus arvalis* · Rodent-borne diseases · Rodent management · Rodent outbreaks · Rodent damage

Key message

- Common vole populations are synchronously rising in several countries indicating a massive European-wide outbreak.
- Non-chemical management options for the protection of large-scale crops are scarce and insufficient in agriculture and forestry.
- Significant damage by common voles in 2019 to crops and negative effects on human health are likely.

- Authorities, extension services and farmers need to be aware of the rapid and widespread increase in common voles.

Introduction

Common voles (*Microtus arvalis*) are the most widespread vertebrate species in the European agricultural landscape (Heroldová et al. 2007), where they mostly inhabit grassland habitats. They are a main food source for a variety of predators and provide important ecosystems services including seed dispersal, soil aeration and fertilization (Jacob et al. 2014). However, during population

Communicated by M. Traugott.

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outbreaks that occur generally in a cyclic manner about every 3–5 years (Tkadlec and Stenseth 2001; Cornulier et al. 2013), populations can reach densities of > 2000 individuals per hectare (Bryja et al. 2001), which leads to enormous damage to millions of hectares of agricultural and forestry crops in the European Union (EU) (Lambin et al. 2006; Luque-Larena et al. 2013).

Rodents can harbour and transmit a variety of pathogens to humans, livestock and companion animals (Meerburg et al. 2009). In common voles such pathogens include *Francisella tularensis* (Luque-Larena et al. 2017; Jeske et al. 2019), *Staphylococcus aureus* (Mrochen et al. 2018), *Leptospira* spp (Fischer et al. 2018), *Echinococcus multilocularis* (Delattre et al. 1988; Guerra et al. 2014) and *Borrelia* spp. (Tkadlec et al. 2019) which all can cause serious symptoms in humans, with associated costs assumed to reach billions of Euros worldwide (Carabin et al. 2005; Budke et al. 2006).

Farmers in most countries of the EU use rodenticides to protect their crops. Products with anticoagulant rodenticidal compounds (delayed action) are not available anymore in most countries of the EU for plant protection purposes, except for bromadiolone in France, the Netherlands and Romania and difenacoum in Portugal. Compounds that generate phosphine gas (acute action) are approved in all EU countries (Jacob and Buckle 2018). Common vole populations can sooner or later recover from acute rodenticide treatments (Hein and Jacob 2016) as it is the case in other small rodent species (Berny et al. 2018). Alternatives to chemical or agrotechnical [e.g. ploughing (Heroldová et al. 2007)] approaches for common vole management include repellents (Fischer et al. 2013; Hansen et al. 2017), traps (Schloetelburg et al. 2019), fence systems (Walther and Felling 2010) and controlled flooding of grasslands (Wymenga et al. 2016), but none of them is suitable for large-scale agricultural fields. Although often advocated, clear, quantitative experimental evidence that bio-control with predatory birds can reduce rodent populations or rodent damage is lacking (Labuschagne et al. 2016).

Spatially synchronous fluctuations are well-documented features of rodent populations (Ranta et al. 1999). Local and regional synchrony can occur through dispersal of individuals between populations (Liebhold et al. 2004) or the effect of mobile predators exerting similar predatory pressure on different populations (Bjornstad 2000). Large scale, even continental-wide, synchronization in dynamics is most likely reflecting similar environmental variability, termed the “Moran Effect” first introduced by Moran (1953).

Materials and methods

Measurements of common vole abundance or common vole activity indices were conducted in 2016–2019 in the Czech Republic, France, Germany, Hungary, Spain and the Netherlands. Measurements of activity were conducted in spring, summer and autumn in most years/countries and reflect abundance. The indices were weighted and then standardized (Z-transformation) for comparative reasons.

Common vole abundances were monitored by different methods. In the Czech Republic, a burrow index was measured by the number of active burrow entrances in alfalfa, clover and permanent grasslands (Tkadlec et al. 2019) in agricultural habitat across the country that resulted in counts per hectare. In France, common vole presence/absence (droppings, cut grass in fresh corridors, etc.) was recorded in the Franche-Comté region along transects in grasslands and the ratio of positive 10-pace intervals and the total number of 10-pace intervals was calculated (Delattre et al. 1999). In Germany, snap trapping was conducted in grasslands in the central German province of Thuringia following a standard protocol (Drewes et al. 2016) and results were converted to number of common voles per 100 trap nights. In southern Hungary, voles were live-trapped in alfalfa crops in the region of Southern Transdanubia and results were converted to individuals per 100 trap nights. In Spain two separate datasets from the same region were available; in both cases (termed E1 and E2) voles were trapped with live traps (converted to individuals per 100 trap nights) in alfalfa, cereals, fallows and their margins in the Castilla-y-León region (Rodríguez-Pastor et al. 2016). In the Netherlands, common voles were monitored in grassland on peat and clay soils in the province of Friesland by counting tunnel entrances and results were converted to number of tunnel entrances per m².

Results

In the Czech Republic, Germany, Spain and the Netherlands increases of common vole populations were considerable compared to previous years (Fig. 1). These were particularly pronounced in the Czech Republic, Spain and the Netherlands where common vole abundances in summer of 2019 were 2.4-fold (Czech Republic), 7.4-fold (E1), 3.3-fold (E2, both Spain) and 5.9-fold (The Netherlands) compared to the mean abundance from spring of 2016 to spring of 2019. In Germany and Hungary, the abundances in summer of 2019 were approximately twofold the mean abundance from spring of 2016 to spring of 2019 (Table 1). In France common vole abundance continued to be low after a period of generally low vole abundance that followed the last outbreak in 2016.

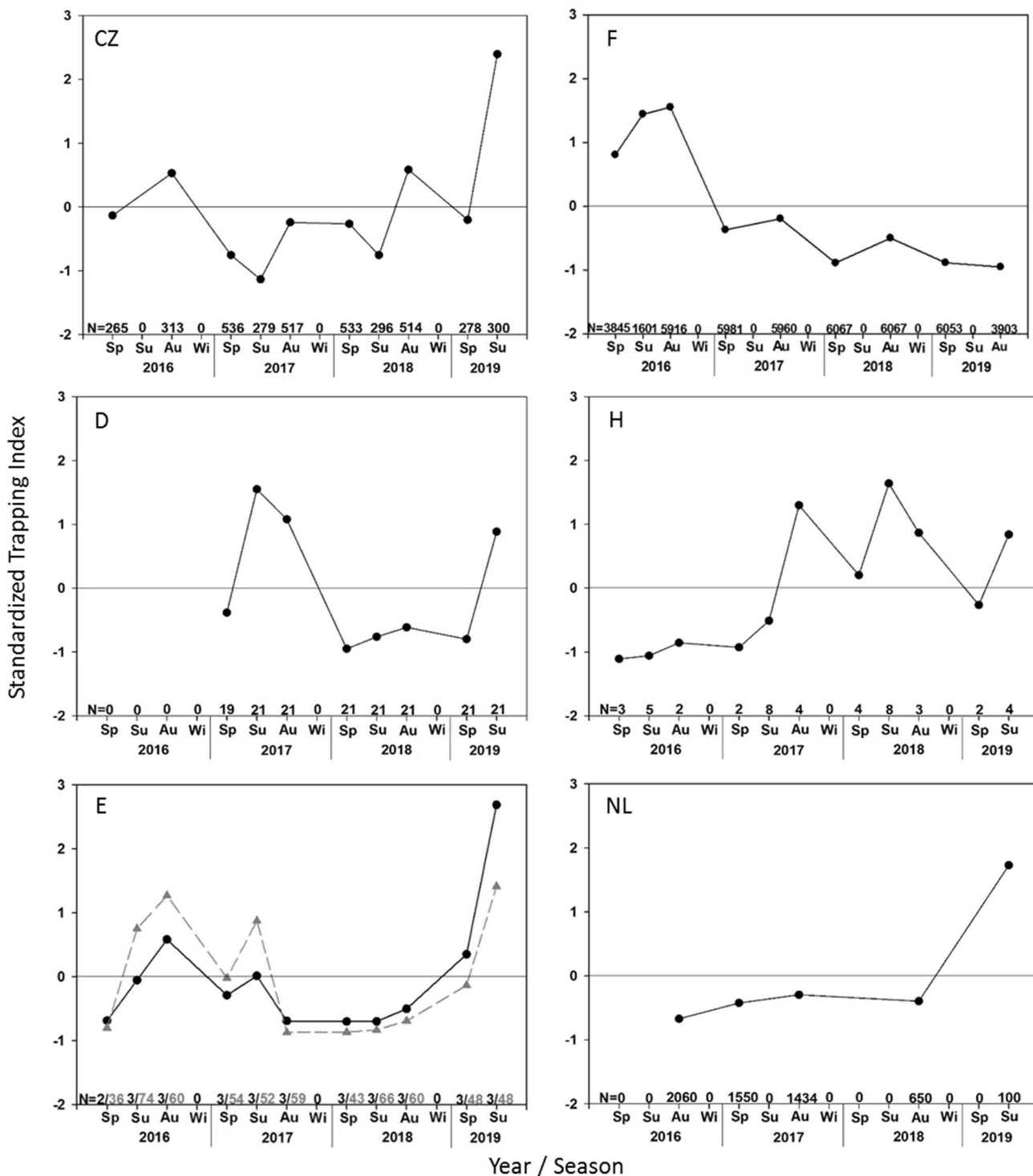


Fig. 1 Z-transformed common vole abundance indices per country per season from spring of 2016 to summer of 2019 (solid line represents mean of period). The x axis shows the number (N) of monitoring sites per season (Sp spring, Su summer, Au autumn, Wi winter)

and year. Different monitoring methods were used (for details see text). CZ Czech Republic, F France, D Germany, H Hungary, E Spain [E1 = Circle (black), E2 = Triangle (grey)], NL Netherlands

In addition to monitoring data, there are unquantified reports from countries including Austria [pers. comm. M. Weinhappel, Chamber of Agriculture Lower Austria; (Die

Presse 2019)], Belgium [pers. comm. K. Baert, Research Institute Nature and Forest; (Smets 2019)], Poland (Z. Borowski, Forest Research Institute) and Switzerland (pers.

Table 1 Common vole abundance indices for summer 2019 across plots per country and mean from spring 2016 to spring 2019 across years per country \pm SE

	Czech Republic	Germany	Hungary	Spain		The Netherlands
				E1	E2	
Summer 2019	1014 \pm 98	14 \pm 3.4	9.5 \pm 1.4	52 \pm 17	23.9 \pm 11.9	5.9 \pm 4.9
Spring 2016–spring 2019	426 \pm 40	6 \pm 2.5	5 \pm 1.4	7 \pm 2.2	7.3 \pm 8.7	1 \pm 0.2

Different monitoring methods were used (for details see text)

comm. B. Beuret, Fondation Rurale Interjurassienne) that also indicate a pan-European increase in common vole abundance in 2019.

Discussion

Monitoring data and anecdotal evidence from ten European countries indicate that synchronous population outbreaks of common voles are occurring in many countries. This is of concern because high population densities of this species cause devastating damage to many crops (e.g. Babinska-Werka 1979) and they can pose considerable zoonotic disease risks (Meerburg et al. 2009; Luque-Larena et al. 2017).

The concept of spatial synchronization in populations has received attention for many decades, but continental-wide phase-locking dynamics of spatially separated populations remain poorly understood. The presented data indicate such an overall trend for the common vole in Europe, though the manifestation of this effect can differ between spatial scales and might reflect local drivers like landscape or agricultural practices that were not considered in this study. Nevertheless, our knowledge on rodent ecology is substantially increased when monitoring data are compared among countries (Cornulier et al. 2013). Coordination of monitoring programs among European countries and predictive tools could help refine pest management.

Despite many changes in cropping systems, particularly in land use intensity, choice of crops, fragmentation, mechanization, climate, etc., the general patterns of common vole outbreaks such as frequency and amplitude range have not changed drastically (see Delattre et al. 1992). There are very few examples of outbreaks spreading to areas where they did not occur in the past (Van Wijngaarden 1957; Luque-Larena et al. 2013; Jareño et al. 2014). This indicates that common vole outbreaks are inherent to the European agricultural landscape similar to lemming outbreaks in northern Europe.

Pest rodent management needs to balance management, social and environmental needs. It is most effective when early action is taken (Singleton et al. 2003). This requires that farmers are well informed of outbreak risks or population build up and are aware of the appropriate ways for monitoring of vole abundance and/or forecast tools. This could also benefit other studies and management of other

rodent species because there is considerable co-variance of spatio-temporal dynamics among rodent species (Carslake et al. 2011). Studies show that landscape and soil properties are linked to the general occurrence of common vole outbreaks (Delattre et al. 1992, 1999; Blank et al. 2011). In addition, weather conditions with a time lag of several months are related to outbreak risk (Imholt et al. 2011; Esther et al. 2014) and can be used for regional predictions for annual and perennial crops (Esther et al. 2014; Giraudoux et al. 2017) in many areas. However, so far forecast systems are specific for particular regions (Giraudoux et al. 2019) and cannot be used at the national level alone at the European scale.

During the last 10–15 years, there was a major decrease in the availability of chemical management options for common voles and other agricultural rodent pest species across the EU (Jacob and Buckle 2018). Therefore, it is increasingly difficult for farmers to manage rodent populations to prevent massive increases in abundance and the associated crop damage. New restrictions on use of zinc phosphide have been imposed recently by German and Czech authorities that make chemical management impossible in most regions where outbreaks occur. Generally, there are some preventative and non-chemical methods available. However, none of these are unconditionally effective, practicable and environmentally safe. For instance, bio-control, repellents and diversion feeding were considered ineffective by German farmers (an der Heiden et al. 2017). This leaves agrotechnical measures (e.g. ploughing) as the sole tool to reduce vole numbers. In the Dutch province of Friesland, farmers started to flood vole-infested grasslands and developed innovative techniques to cover large areas with reasonable input of labour and costs. Non-chemical techniques such as repellents are rarely tested (or effective) in management, let alone in realistic field scenarios (Hansen et al. 2016). The same is true for bio-control with avian predators (Labuschagne et al. 2016).

Some existing non-chemical methods that are supposed to be effective such as ploughing and keeping vegetation of margins low are as a whole antagonistic to soil and biodiversity conservation (Garcia-Orenes et al. 2009). In southern regions of Europe, such as Spain, the use of fire, which is completely regulated by law, is commonly claimed by farmers as an effective weed and vole managing tool, though scientific evidence on the efficiency is lacking. Fertility

control of rodents has been tested using hormones, plant compounds, immuno-contraception and other techniques (Jacob 2008), but there are no registered products available in the EU and some of them are likely to be problematic (practicability, efficiency, biological risks, ethics) if applied on a large scale.

Following the concept of ecologically based rodent management, which values the important role of voles for biodiversity and ecosystem services, alternative methods, either alone or in combination, should be tested thoroughly in field trials to obtain robust information about efficacy, environmental and ecological impact, and benefit–cost ratios. In addition, existing chemical and non-chemical methods should be optimized and new techniques developed to be added to the existing (small) tool box. Such an integrated approach has proved to be effective and cost-efficient for the water vole (*Arvicola terrestris*), a grassland species living in the same habitat as the common vole (Giraudoux et al. 2017).

The decreased availability of chemical methods and the lack of suitable and/or tested non-chemical methods leave farmers running integrated or organic farms with few options for common vole control other than physical barriers and trapping that are unsuitable for application in large-scale cropping. This is a major concern given the massive damage and yield loss caused by common vole outbreaks in many countries of the EU and health implications due to the transmission of zoonotic pathogens from voles to people. Despite their ecological importance, common vole outbreaks are a real burden to European societies and economies and require solutions from and supported by research, administrations and policy makers.

We emphasize that there are major common vole outbreaks occurring in many countries of Europe and therefore appropriate management strategies are urgently needed. Investment in research and development is required for management of the current and future common vole outbreaks. History shows that common vole outbreaks will not go away.

Author contributions

JJ conceived the idea. CI, GH, ET, EW, PG, SHC, JJLL and CCS provided data. All authors wrote, read and approved the manuscript.

Acknowledgements Open Access funding provided by Projekt DEAL. The authors thank Aurélien Levret and Dominique Rieffel for their help in the field, María Carmen García Ariza for her assistance in coordinating field works and the Zone atelier Arc Jurassien for various support (<https://zaaj.univ-fcomte.fr>).

Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

Ethical approval Relevant animal ethics permission were issued for work in Germany (22-2684-04-15-105/16), Spain (Ethical Committee University of Valladolid (CEEBA), authorization code: 4801646), SHC, JJLL and CCS held official trapping permits from DGMN, Junta de Castilla y León, as well as national certificates (B and C categories) to manipulate animals for research.

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