NOTE

The paradox of endangered European rabbits regarded as pests on the Iberian Peninsula: trends in subspecies matter

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ABSTRACT: The European rabbit *Oryctolagus cuniculus* faces a paradoxical situation in its native range on the Iberian Peninsula. While many populations have declined sharply due to a new variant of the rabbit haemorrhagic disease virus (RHDV-b), others remain healthy. The latter populations, which flourish mostly on farmland, cause significant crop damage. We explored if this difference could be related to the existence of the 2 rabbit subspecies (*O. c. algirus* and *O. c. cuniculus*) that coexist allopatrically on the Iberian Peninsula. Potential differences in population trends between rabbit subspecies may also be relevant in assisting the conservation of endangered rabbit-dependent predators which mainly occur in the distribution area of *O. c. algirus*. To test this, we assessed rabbit trends after the outbreak of RHDV-b by an online questionnaire to the senior administrative officers of all provincial official game departments throughout peninsular Spain ($n = 47$). A generalized negative trend was reported by officers in the distribution area of *O. c. algirus*, while a more stable or even positive trend was reported in the distribution area of *O. c. cuniculus*. We point to the need for establishing a long-term rabbit population monitoring programme on the Iberian Peninsula to further confirm the observed patterns, but also to contribute to evidence-based management decision-making. Our results suggest a need to apply different management systems for each rabbit subspecies.

KEY WORDS: Management strategies · *Oryctolagus cuniculus algirus* · *Oryctolagus cuniculus cuniculus* · Peninsular Spain · Questionnaire survey · Rabbit haemorrhagic disease virus · RHDV-b

1. INTRODUCTION

A variety of factors such as environment, competition and disease affect the dynamics of animal populations. Closely related allopatric taxa may exhibit

contrasting population trajectories if the limiting factors affect each taxonomic unit differently. Here, we explored whether the population trends of the 2 known subspecies of the European rabbit *Oryctolagus cuniculus* (*O. c. cuniculus* and *O. c. algirus*) on

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the Iberian Peninsula (IP) differ significantly. These rabbit subspecies originated on the IP following isolation during glacial refuges in the late Pleistocene (Branco et al. 2002). The subspecies are allopatric, separated only by a narrow contact zone where both subspecies coexist (Geraldès et al. 2008) (Fig. 1). Hybrids are present at low frequencies, suggesting some degree of reproductive isolation. Diverse studies have shown significant ecological, morphological and molecular differences between the 2 subspecies (briefly reviewed by Delibes-Mateos et al. 2018b).

According to the International Union for Conservation of Nature (IUCN), the European rabbit is currently considered Endangered in its native range (Villafuerte & Delibes-Mateos 2019). This new status is underpinned by a reduction in population size of $\geq 50\%$ between 2009 and 2019 (IUCN criterion A2), mainly as a consequence of the 2011, and ongoing, outbreaks of a new variant of the rabbit haemorrhagic disease virus *Lagovirus europaeus*/GI.1 or RHDV-b (Delibes-Mateos et al. 2014a, Monterroso et al. 2016). This reassessment may seem puzzling since the species often reaches very high numbers and is considered one of the most harmful vertebrate pests where it has been introduced, e.g. Australia (Thompson & King 1994). Despite rabbits being generally considered threatened on the IP, crop damage caused by rabbits has increased in some regions in Spain in recent years (Delibes-Mateos et al. 2018a), with some farmers strongly opposed to classifying the rabbit as Endangered in its native range. An important farmers' association in northern Spain claimed recently that rabbits are serious pests that threaten both crops and human health (Alba 2019).

Using questionnaires throughout all provinces in peninsular Spain, we assessed whether recorded population trends differ in areas where each rabbit subspecies is found, as well as in the contact zone between both. Our data can allow conservation and game managers to adapt their management strategies in accordance with the situation of each subspecies.

2. MATERIALS AND METHODS

We assessed rabbit trends through a questionnaire survey carried out in 2016, 5 yr after the initial outbreak of RHDV-b in Spain (Dalton et al. 2012). We distributed these surveys to the senior administrative officers of official game departments in the 47 provinces in peninsular Spain. These officials are responsible for the approval of management plans

for all hunting estates under their authority. Each estate must produce a plan every 4–5 yr based on abundance estimates of game species (Ríos-Saldaña et al. 2013) and report game bag records at the end of each hunting season. In addition, in some of the provinces, rabbit population surveys are carried out by the environmental agencies of the regional governments (Piorno et al. 2020). Rabbit trends reported in this study are based on abundance information collated by provincial game officers.

We initially contacted all provincial game officers by phone or email to explain the objectives of our study. After officers agreed to participate, we sent the questionnaire by e-mail and followed up with those recipients who did not respond after a certain time. All officers ($n = 47$) completed the questionnaire.

The questionnaire was part of a larger project that investigated how rabbit hunting management has varied since the 1990s in relation to abundance changes (Piorno et al. 2020). In this study, we only considered the question that referred to rabbit trends between 2011 and 2016. We asked officers to rank rabbit trends in their province using a 5-point scale that ranged from marked decline (1) to marked increase (5). We then assigned each Spanish province to either of the rabbit subspecies distribution areas (*Oryctolagus cuniculus cuniculus* = 29 provinces; *O. c. algirus* = 10 provinces) or to the contact zone (8 provinces) when $>50\%$ of its surface was located in 1 of these 3 regions, as previously described (Geraldès et al. 2008) (Fig. 1). We compared the values of the 5-point scale obtained for each province by employing a Kruskal-Wallis test, and used Wilcoxon tests for subsequent pairwise comparisons.

3. RESULTS AND DISCUSSION

Most officers (75.9%, 22 out of 29) in the *Oryctolagus cuniculus cuniculus* distribution area considered that rabbit populations were stable or had increased since the initial RHDV-b outbreak in 2011 (stable: 41.4%, increase: 34.5%; Fig. 1). Only 1 officer in this area considered rabbit populations to have markedly declined. In the distribution area of *O. c. algirus*, all officers ($n = 10$) responded that rabbits had declined after the initial RHDV-b outbreak, with 70% considering that declines were marked (Fig. 1). In the contact zone, 1 out of 8 officers suggested that rabbit populations were stable, whereas all others indicated that the populations had declined during the study

Fig. 1. Iberian Peninsula, showing the current distribution of *Oryctolagus cuniculus algerius*, *O. c. cuniculus* and their contact zone areas (Geraldès et al. 2008). Colours in each Spanish province indicate recent rabbit trends according to the questionnaire responses

period; most officers (62.5 %) considered the decline to be moderate (Fig. 1). Values attributed to rabbit trends varied significantly among the 3 areas (Kruskal-Wallis $\chi^2 = 22.71$, $df = 2$, $p < 0.001$); 2-by-2 comparisons showed differences between *O. c. cuniculus* and *O. c. algerius* distribution areas ($p < 0.001$) and between *O. c. cuniculus* and the contact zone ($p = 0.016$), but not between *O. c. algerius* and the contact zone ($p = 0.13$).

Although questionnaire surveys may be affected by some degree of subjectivity, we are confident that in our study, bias is likely to be small. Spanish senior administrative game officers are generally experienced in wildlife management, and possess the best available information to answer our relatively simple question on rabbit population trajectories (Piorno et al. 2020). As a result, we gathered an unprecedented volume of data on rabbit population trends across mainland Spain, and used these to compare and contrast between subspecies. These data are particularly significant since most monitoring of rabbit popula-

tions has been linked to the conservation of rabbit-dependent predators which are mainly found in the *O. c. algerius* distribution area (e.g. Real et al. 2009). Nevertheless, we point to the need for establishing a long-term rabbit population monitoring programme on the Iberian Peninsula to further confirm the observed patterns, but also to contribute to evidence-based management decision-making.

Our results clearly show divergent trends in the populations of the 2 rabbit subspecies, with an intermediate situation in the contact zone of both subspecies. Reasons for these differences are unknown and deserve further investigation, but we suspect they are primarily driven by socioecological differences (e.g. environmental conditions, diversity and abundance of predators, or hunting pressure) between the distribution areas of both subspecies, along with intrinsic differences between them (e.g. differences in social behaviour and disease impacts). Regardless of the causes, the observed contradictory population trends point to the need for different

management systems for each subspecies, aimed at reducing crop damage caused by *O. c. cuniculus* and conserving *O. c. algirus*. The protection of *O. c. algirus* is paramount, as this subspecies only occurs on the IP and on a few islands in the Mediterranean and Atlantic. Such a management framework would also help reduce existing conflicts over rabbit management between hunters, farmers and conservationists on the IP (Delibes-Mateos et al. 2014b).

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