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Ecosystem Effects of Variant Rabbit Hemorrhagic Disease Virus, Iberian Peninsula

To the Editor: In this investigation, we found evidence for the apparent effects that a new variant of the rabbit hemorrhagic disease virus (RHDV) is having on native wild European rabbit (*Oryctolagus cuniculus*) populations on the Iberian Peninsula, and how this virus could threaten the conservation of endangered predators.

Historically, European rabbits were extremely abundant on the Iberian Peninsula, which is in their native range. However, during the 20th century, the number of rabbits on the peninsula has declined >90%, mainly because of diseases (*1*). The first notable crisis among rabbits occurred during the 1950s concurrent with the arrival of myxomatosis among rabbit populations, which caused mortality rates of ≈90% (*1*), as registered in other regions. During the late 1980s, a calicivirus, RHDV, caused infections that made a strong impact on rabbit populations, causing initial mortality rates of 55%–75% in Iberia (*1*). Since their initial outbreaks, both diseases have become enzootic, and related mortality rates have decreased, in part because of increased host resistance, although the infections still play a major role in the dynamics of rabbit populations (*2*).

In 2011, a new variant of RHDV, which appears to be closely related to an isolate originating in France that was described in 2010 (*3*), caused high mortality rates in some rabbit farms in Spain (*4*) and was also identified in an experimental wild rabbit plot in northern Spain (*5*). Since 2012, the new variant of RHDV has been detected in most rabbit farms in Spain (*6*), and in several wild populations distributed across Spain and Portugal (*7*), suggesting that it has rapidly spread throughout the Iberian Peninsula. This variant affects both of the wild rabbit subspecies (*O. cuniculus cuniculus* and *O. c. algirus*), and unlike the classical form of RHDV, it kills rabbits as young as 11 days of age and rabbits that have been vaccinated against classic RHDV (*6*,*7*). This scenario has raised concern for the survival of wild rabbit populations and its predators in this region.

Data regarding rabbit trends seem to sustain this concern. For example, a long-term monitoring program in Aragón in northern Spain shows a notable decline in rabbit numbers during 2013 in populations that showed both long-term increasing and decreasing trends over the monitoring period (Figure, panels A, B, respectively). A similar trend has been observed in the main areas inhabited by the highly endangered Iberian lynx (*Lynx pardinus*). The lynx relies on rabbits for survival, because they represent >85% of the lynx's diet (*9*). For instance, in Coto del Rey, the area within Doñana National Park in southern Spain that traditionally held the highest rabbit densities and therefore represents the core of Iberian lynx populations in this national park, there was a decline in rabbits of >80% during 2012–2013 (Figure, panel C). Similar declines have been detected in low-density rabbit populations surveyed within Doñana National Park (Figure, panel C). Rabbit numbers have also been progressively dropping in the proximity of the Yeguas River in Andújar and Cardeña Natural Parks in southern Spain, where the largest Iberian lynx population currently lives: rabbit density was >3.5 rabbits/hectare in 2010 and <1 rabbit/hectare in 2013, a decline of ≈75% (*10*). In accordance with field surveys, hunters throughout Iberia claim that the number of rabbits harvested this season has decreased dramatically, pointing to a 70%–80% decline compared to the previous hunting season in some estates (A. Linares, pers. comm.).

The European rabbit is a multifunctional keystone species of the Iberian Mediterranean ecosystem, where it serves as prey for >30 predatory animals, alters plant species composition and vegetation structure through grazing and seed dispersal, its excrement and urine have an effect on soil fertility and plant growth and provide feeding resources for invertebrates, and its burrows provide shelter for different

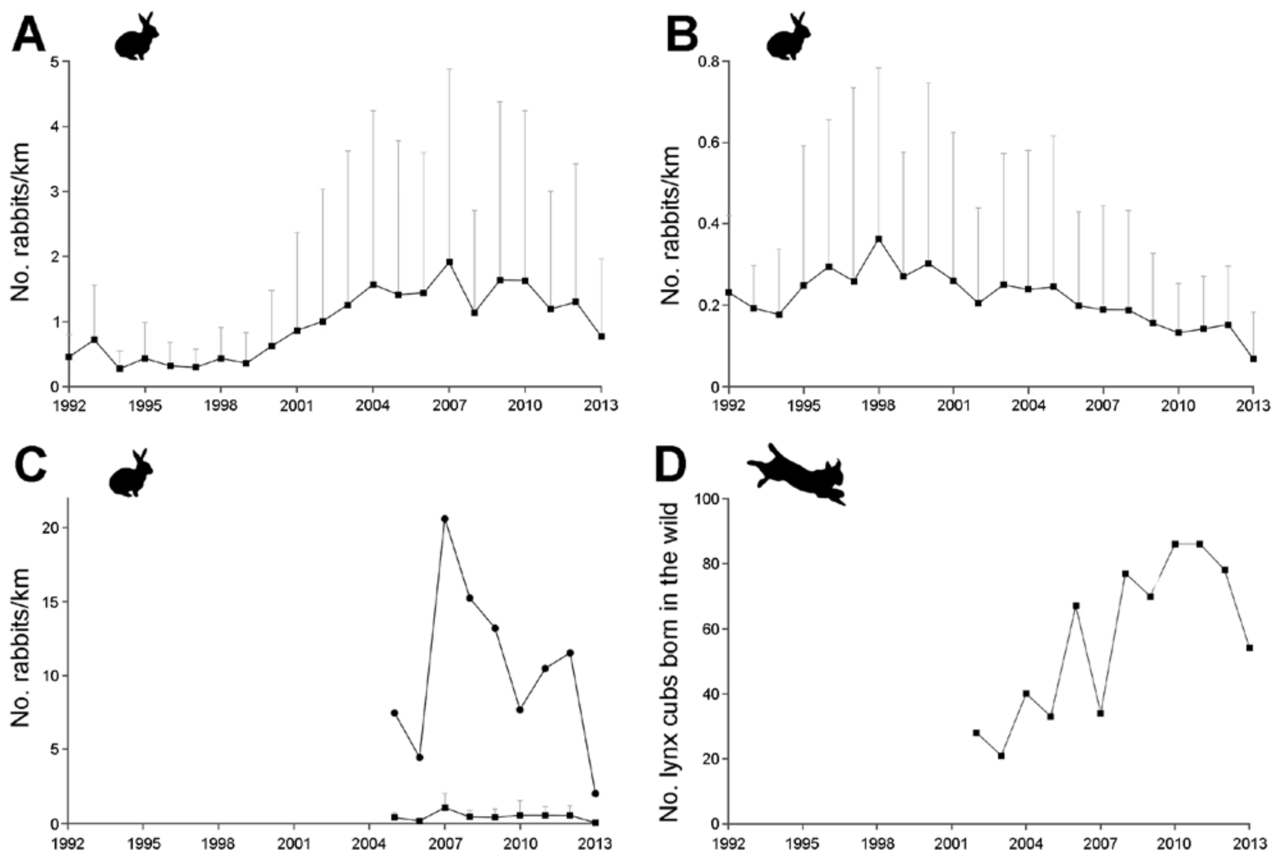

Figure. Trends in rabbit abundance (number of rabbits/km) in Aragón and Doñana National Park, northern and southern Spain, respectively, and in the number of Iberian lynx cubs born in the wild in Spain. A) Average rabbit abundance (+SD) of populations showing long-term increasing trend over the whole sampling period (n = 18) in Aragón (*8*); B) average rabbit abundance (+SD) of populations showing long-term decreasing trend over the whole sampling period (n = 25) in Aragón (*8*); C) rabbit abundance over the study period in Coto del Rey (circles), which is likely the main area for rabbits and lynxes within Doñana National Park; and average rabbit abundance (+SD) over the study period of 7 low-density populations (squares) within Doñana National Park (see details about methods in http://www-rbd.ebd.csic.es/Seguimiento/mediobiologico/conejo/pnd/ProtocoloCensoConejosPND.pdf); and D) total number of lynx cubs born in the wild during 2002–2013 in Spain (data available at http://www.lifelince.org and http://www.juntandeandalucia.es).

species (*9*). Therefore, the decline in rabbit numbers could have potential cascading effects on ecosystem function. In fact, some of these effects may already be apparent on rabbit-reliant animals. On one hand, the sharp reduction in rabbit numbers observed in 2013 in the main lynx distribution area has been accompanied by a notable decrease in the number of lynx cubs born in the wild (Figure, panel D). On the other hand, the number of lynxes killed on roads doubled in 2013 (n = 14) in relation to 2012 (n = 7), and this has been linked to increased lynx displacements related to rabbit scarcity potentially associated with the impact of the new variant of RHDV (http://www.juntadeandalucia.es).

The situation described exemplifies how emerging diseases can affect biodiversity conservation. It also highlights the importance of using wildlife monitoring schemes as detection tools for monitoring the impact of stochastic factors, such as the variant RHDV, on wildlife populations. Urgent management actions, designed within an Iberian rabbit conservation strategy that relies on a multidisciplinary framework, are needed to ensure the conservation of this keystone member of the Iberian Peninsula ecosystem and that of rabbit-reliant predators.

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Molecular Characterization of *Borrelia burgdorferi* from Case of Autochthonous Lyme Arthritis

To the Editor: The first Lyme borreliosis (LB) case reported to be acquired in California occurred in 1978 (*1*). During the past 10 years, 744 confirmed LB cases were reported in California; 419 (56.2%) were likely acquired in-state. The highest incidence of this disease occurs in northern coastal California, in locations such as Santa Cruz County (*2*), where habitat supports yearlong activity of the tick vector *Ixodes pacificus* (*3*,*4*).

Existing data describe the genetic diversity of the LB agent *Borrelia burgdorferi* among ticks in Californa (*5*,*6*), but few instances of direct detection and genetic characterization of *B. burgdorferi* sensu stricto in samples from humans are documented in California. *B. burgdorferi* has been isolated from skin biopsy samples of 3 patients in California in whom LB was diagnosed (*1*). Seinost et al. genotyped strains isolated in the United States, including 7 isolates identified in California from skin, blood, or cerebrospinal fluid, but no documented exposure information was available (*7*). Girard et al. genotyped *B. burgdorferi* in 10- to 12-year-old stored serum samples collected from 22 northern California residents, some of whom were asymptomatic at time of collection. Of 22 PCR-positive specimens, 21 had the single laboratory type strain B31 genotype (*3*).

A 12-year-old resident of Santa Cruz County, California, came to the emergency department of Dominican Hospital in September 2012 with a swollen, painful right knee and mildly painful right hip. The patient's family reported that LB had been diagnosed by a local physician. Illness onset was in May 2010; symptoms consisted of recurrent knee swelling and pain lasting several days every 4–5 months and positive serologic test results for *B. burdorferi* (not available). The patient had not traveled outside of California during the preceding 6 years. In May 2011, an IgG Western blot of the patient's serum that was processed at a commercial laboratory showed immunoreactive bands of 18, 23, 28, 30, 39, 41, 45, 58, 66, and 93 kDa. In both 2010 and 2011, the patient's family had chosen to give the patient unspecified herbal treatments instead of antibacterial drugs.

On physical examination in the emergency department, the patient's right knee was swollen; knee flexion