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EXTENSIVE PREDATOR PERSECUTION CAUSED BY POPULATION CRASH IN A GAME SPECIES: THE CASE OF RED KITES AND RABBITS IN SPAIN

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Abstract

The European rabbit Oryctolagus cuniculus, *an important game species in Spain, has declined sharply since the arrival of haemorrhagic disease in 1988. As a consequence of this decline, it appears that illegal and extensive persecution of predators has increased. We have assessed the impact of this persecution on red kites* Milvus milvus. *Around 90% of the populations studied have declined during the last 3–10 years, and the species' range has been reduced since 1980, particularly in high rabbit density areas (those most valuable for hunters). Currently, stable or increasing populations of red kites are located in areas of low rabbit density. Their abundance in areas of high rabbit density is similar to that recorded during the 1970s, when, after the spread of myxomatosis over Spain, government-sponsored campaigns of vermin extermination were carried out. Although red kites cannot be considered important predators of rabbits, they are disproportionally suffering the effects of human persecution, because of their susceptibility to shooting and poisoning, and a lack of understanding among hunters. We discuss the management strategies that might be used during population crashes of game species to avoid unjustified persecution of predators.*

Keywords: illegal persecution, *Oryctolagus cuniculus*, *Milvus milvus*, rabbit haemorrhagic disease, Spain.

INTRODUCTION

Persecution of predators to prevent real or perceived damage to game species is a frequent cause of their decline or extinction (Bijleveld, 1974; Newmark, 1987; Reynolds and Tapper, 1996). Although the increasing concern for nature conservation has reduced the traditional negative perception of predators (Kellert, 1985), they are usually blamed whenever human hunting success decreases for whatever reason, and the hunting lobby then demands predator control (Franzmann, 1993). When management agencies do not respond to their requests, confrontations may arise, and an increase of illegal persecutions can be expected.

European rabbits *Oryctolagus cuniculus* are the keystone species in the Iberian vertebrate ecosystem (Valverde, 1967), being a staple prey for at least 29 species of predators (Delibes and Hiraldo, 1981). Rabbits are also one of the main game species in Spain, where hunting is a very important economic activity (> 1 million hunters were estimated to have generated at least $\$1.2\times10^9$ annually; J. Delibes, pers. comm.).

Simultaneously with the outbreak of myxomatosis in Spain during the 1950s, the government-sponsored council for vermin extinction (Junta de Extinción de Alimañas) was responsible for a drastic reduction in predators, e.g. almost 10 000 kites (red kites *Milvus milvus* plus black kites *M. migrans*) killed between 1954 and 1961 (Garzón, 1974). Although rabbit populations remained low for some time after myxomatosis, they probably began to increase in the 1970s (Lloyd, 1981). Legal persecution of predators ended in 1973, and the Spanish government began a strategy of conservation of predators similar to that in other western European countries (Bijleveld, 1974; Garzón, 1977). As a consequence, many threatened predators recovered: wolf *Canis lupus* populations increased notably due to the ban on poison baits (Blanco *et al.*, 1992); populations of Spanish imperial eagle *Aquila adalberti*, black vulture *Aegypius monachus*, and bearded vulture *Gypaetus barbatus*, increased 3–7 fold (Heredia, 1991; González, 1989, 1996); griffon vulture *Gyps fulvus* experienced such a large increase that they are currently considered 'Non-threatened' (Blanco and González, 1992).

Rabbit haemorrhagic disease (RHD) reduced rabbit populations between one-half and two-thirds between 1988 and 1993 (Villafuerte *et al.*, 1994, 1995). This is

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probably the reason why, between 1990 and 1993, hunting licences decreased by *c.* 10%, after having increased for >20 consecutive years (Ministerio de Agricultura Pesca y Alimentación; M.A.P.A., 1993). Although hunters increased their demands for predator control, almost no efforts have been made by regional agencies, probably because of the lack of information on the effects of predators on game species.

In Spain, there are more than 30 000 private hunting areas that cover >70% of the country (M.A.P.A., 1993). Many of these areas are fenced and have gamekeepers, and, thus, state wardens restrict surveillance mainly to public areas. Many of the present land owners and gamekeepers are still those that legally reduced predator populations up until 1973. Consequently, a decline in rabbits could easily lead to an increase in illegal persecution of predators (Bijleveld, 1974; De Juana, 1989; Reynolds and Tapper, 1996).

The red kite may serve as a good indicator for assessing the effects of shifts in persecution practices on predator populations in Spain. This relatively abundant species is especially vulnerable to poisoning campaigns, nest robbing and shooting, given that it is a gregarious carrion-eater and opportunistic searcher (Cramp and Simmons, 1980; Lovegrove *et al.*, 1990; Spierenburg *et al.*, 1990; Evans and Pienkowski, 1991), and it is commonly associated with towns, roads, and rubbish dumps (Lovegrove *et al.* 1990; Cortone *et al.*, 1994; Voisin, 1994; Viñuela, 1996). Red kites prey upon rabbits whenever they are abundant and accessible (e.g. Veiga and Hiraldo, 1990), and consequently, unless other factors are acting, we should expect a high density of red kites in areas where rabbits are abundant, as occurs in the case of the black kite (Viñuela *et al.*, 1994).

Our general objective was to evaluate the relationship between changes in abundance and the range of red kites during the last few years and hunting in different regions of Spain. By assuming that the hunting value of an area is proportional to rabbit abundance, we also investigated the possible relationship between some features of hunting areas and rabbit abundance. We expected that illegal control of predators would be more intense in those areas with lower surveillance by government wardens. Finally, we also hypothesized that illegal persecution would be higher in areas with higher hunting value.

METHODS

Red kite surveys

Data on range and population density of nesting red kites were extracted from the National Census carried out during the breeding season of 1994 (Viñuela, 1994, in press). All the distribution area described by Cramp and Simmons (1980) was surveyed, using the U.T.M grid of 10×10 km as the sampling unit. The study area was stratified following habitat and topographic criteria, and the census was conducted by >500 volunteer observers and regional ornithologists. Every stratum was sampled completely when possible, but if there were insufficient observers, a random sample of squares was selected to cover a minimum of 50% of the area of each stratum.

In a sample of 61 10×10 km squares, red kite populations were surveyed simultaneously by road transects and nest searching/detection of territorial pairs (Craighead and Craighead, 1956). We calculated an index of relative density (IRD, no. of kites/100 km of transect; Ferry and Frochot, 1958) for each square sampled. A linear regression of IRDs on estimated populations for the sampled squares explained >85% of the variance in IRDs (Viñuela, 1997). This equation was used to estimate the populations within each square sampled in the national census. High density areas for red kites were considered to be those with IRDs >10 (estimated population >3 pairs/square) or, for the squares sampled by nest searching/detection of pairs, those with >3 nesting pairs. Additional details are given elsewhere (Viñuela, 1994, 1997, in press).

We also sought the views of ornithologists regarding trends in red kites during the last 3–10 years. Surveys during consecutive years (1992–1994) were made in some study areas, to assess possible changes in population size (Table 1). We have included only those reports in which the population changes were clearly confirmed, owing to the existence of surveys in consecutive years or to evident and large changes in population size. We also requested information about known cases of poisoning or shooting.

We compared IRDs of breeding red kites obtained by Meyburg (1973) during the 1970s, when raptor populations had been decimated after many years of systematic legal persecution, with those obtained during the spring of 1994. Data were available for five areas (Southwest Pyrenees, Salamanca, Avila, Extremadura and Toledo, see Fig. 1).

Rabbit surveys

We used 1:100,000 maps (Army cartography service) to carry out a 4 km walking transect for systematic sampling of rabbit abundance. A total of 311 transects were completed during June and July 1993 (Blanco and Villafuerte, 1993; Villafuerte *et al.*, 1995). On each transect, observers recorded number of rabbit excrements, rabbits observed, foraging scrapes, and warren entrances. Using these variables, we carried out a principal component analysis to generate a new variable (RA) to provide the best overall measure of abundance. The RA values were plotted on a map and lines with equal values were drawn using commercial software (SURFER, Golden Software Inc.). In each survey were noted the type of land (private or public), presence/absence of fences, and the abundance of carnivores by counting all the scats found along the transect. Because hunting pressure in Spain has not been accurately determined

Table 1. Population trends of red kites in several local populations during 1984–1994, and rabbit abundance (RA)(x100) in the same areas (see Fig. 1)

Study area	Population trend	RA
Asturias (1)	Apparently extinct	23·3
Galicia (2)	Almost extinct	7·2
Sanabria (3)	Apparently extinct	6·8
León (4)	Strong decline (> 50%)	3·7
Alava-North Burgos (5)	Decline	7·8
Navarra (6)	Stable or increase	31
Zaragoza (7)	Increase (> 100%)	1
NW Huesca (8)	Increase (> 100%)	1
Valladolid (9)	Decline	83·3
Aranda de Duero (10)	Apparently extinct	5·5
Duratón (11)	Strong decline (70%)	45·3
Rio Moros (12)	Strong decline (> 50%)	3·8
SW Salamanca (13)	Decline	7·9
Béjar-Guijuelo (14)	Decline	9·6
El Tiemblo (15)	Strong decline (> 50%)	0·8
Madrid (16)	Strong decline (40–100%)	73·9
South Avila (17)	Strong decline (40–80%)	15·4
Navas del Marqués (18)	Decline (> 30%)	786·2
Hervás (19)	Decline	32·5
Central Cáceres (20)	Stable	79·9
Tietar Valley (21)	Strong decline (> 40%)	45·4
Toledo Mounts (22)	Apparently extinct	2·2
Alcudia valley (23)	Strong decline	65·4
SE Ciudad Real (24)	Extinct	367
Córdoba (25)	Apparently extinct	451
Jaén-Granada (26)	Almost extinct	430
SW Albacete (27)	Apparently extinct	2
W Andalucía (28)	Strong decline (> 40%)	32·1
Doñana (29)	Slight decline (10–20%)	178

Sources[a]: (1) C. M. Alvárez, L. M. Arce; (2) A. Villarino; (3) T. Rivero, H. Hernández, own data; (4) A. Onrubia, I. Sim, own data; (5) A. F. Rodríguez, G. Artíguez; (6) A. Senosiaín, Elósegui (1985), J. I. Deán, 1994 census; (7) F. Compaired; (8) Kostrzewa *et al.* 1986, 1994 census; (9) J. Fernández, A. Balmori; (10) AFFA; (11) V. Garza; (12) own data; (13) J. Martín; (14) L. Bejarano, J. Gómez-Labrador; (15) J. L. Robledo, own data; (16) E. Soto-Largo, C. Sunyer, A. Rodríguez, J. A. Diaz, own data; (17) Sansegundo (1987), 1994 census, own data; (18) C. Jarque, own data; (19) J. Sánchez; (20) P. Mateo, P. Fernández, I. Sim, own data; (21) A. Acha, L. S. Cano, own data; (22) M. López, own data; (23) R. Palomo; (24) T. Gullick; (25) Torres *et al.* (1981), F. Cabello, J. Bustamante; (26) J. Muñoz, J. M. Gil; (27) J. Escudero; (28) F. J. Avila, F. Hiraldo, M. C. Pérez; (29) F. Hiraldo, own data.
[a]Personal communications except where dates refer to published sources.

and is only available on a provincial scale (M.A.P.A., 1993), we considered also the number of cartridge cases found along the survey as an index of hunting pressure.

RESULTS

Red kite range and trends

The range of red kite has been reduced in recent years, and is currently less than half that described by Cramp and Simmons (1980) during the 1970s (Fig. 1). This reduction has been especially noticeable during the last 3–10 years, affecting 25 of the 29 populations for which we have estimates (Fig. 1, Table 1). In all these areas, direct persecution through poisoning or shooting has been claimed by local ornithologists as the main reason for the declines.

We compiled 91 confirmed cases of red kites dead from human persecution, 77 of which were from poisoning. Three other cases involving a high but undetermined number of poisoned red kites have also been reported.

Present rabbit abundance

Rabbits occur throughout Spain, except in the higher ranges of the Pyrenees (Flux, 1994). However, there is great variation in population densities as expressed by our abundance index (RA mean 0·54, SE = 0·06, range 0–7·87). High densities of rabbits are found in central and southern Spain, while the rest of the country may be considered a low density area (Fig. 2). According to these results, the average value of RA per province was correlated ($r = 0{\cdot}446$, $n = 47$, $p = 0{\cdot}002$) with the number of rabbits killed per km^2 in each province during 1993 (M.A.P.A., 1993).

Relationships between red kites and rabbits

Red kite populations located within high density rabbit areas have either disappeared (Nos 20 and 23 in Fig. 1), or suffered alarming declines (e.g. Nos 9, 10 13, 14, 15,

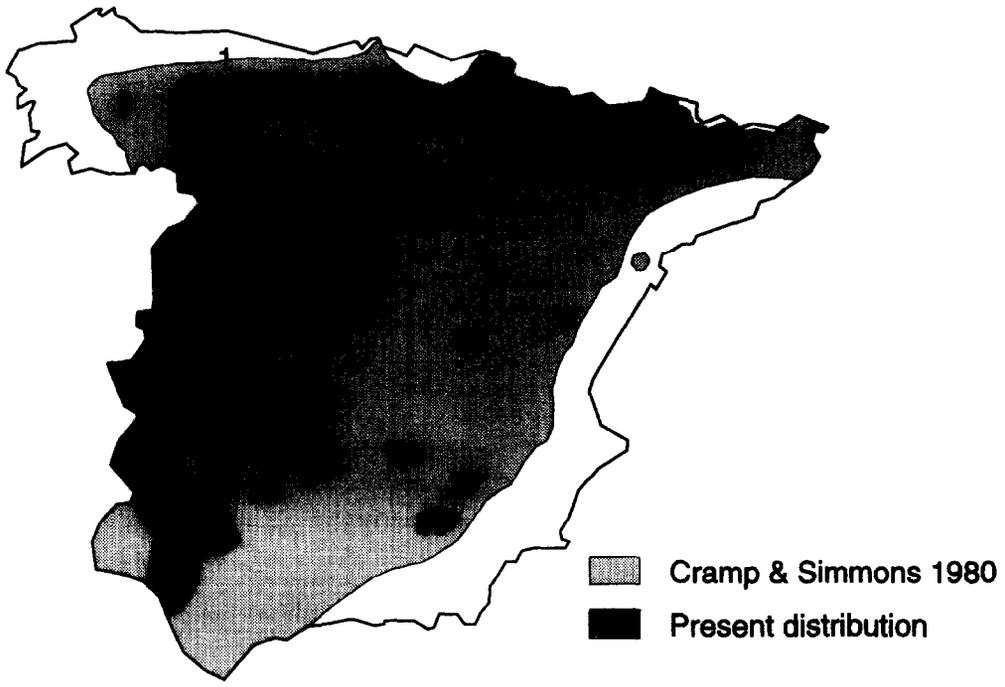

Fig. 1. Past (Cramp and Simmons, 1980) and current (National Census of 1994) distribution of red kites in Spain. Numbers indicate location of local populations for which recent information on population trends is available (population declines in all except numbers 5, 6 and 18, see Table 2). Question marks indicate localities where the species may still breed, but unconfirmed during the census. Letters and numbers are areas referred to in the text and Tables (A, Avila; E, Extremadura; S, Salamanca; SWP, Southwest Pyrenees; T, Toledo).

19, 21 in Fig. 1). Most of these populations are in a very precarious situation, being represented by isolated pairs or small numbers. Most of the secure populations are located in areas of low rabbit density (Fig. 2), though even here, some populations are also suffering severe decline (Nos 1, 2 and 4, Fig. 1). Grouping the red kite populations trends in three categories (extinct or almost extinct, sharp decline, and stable or increasing; see Table 1), we found a marginally significant difference in RA between categories (Kruskal–Wallis statistic = 5·64; $p = 0{\cdot}060$; RA means: 0·69, 1·31, 0·20, respectively).

The comparison between the abundance indices obtained during this study with those presented by Meyburg (1973) during the 1970s, indicate that red kite populations have actually increased in areas of low rabbit density (SW Pyrenees and Salamanca, Table 2 and Fig. 1). Similar abundance indices were found in two areas with high density of rabbits, where some of the most significant declines in red kite populations have been recorded (Toledo and Avila, Table 1 and Fig. 1). The only area with high rabbit density where red kites seem to be much more abundant now than 20 years ago is Extremadura.

Table 2. Comparasion between the IRDs (index of relative density, No. of kites /100km) obtained from road transect surveys by Meyburg (1973) during the 1970s with those obtained during spring–summer 1994 in the same ares of Spain (see Fig. 1).

Study area	Number of red kites /100 km	
	Meyburg (1973)	1994
Southwest Pyrenees	3·6	20·1
Salamanca	8·3	22·6
Avila	5·6	5·5
Extremadura	0·7	10·7
Toledo	1·1	1·5

Abundance of rabbits, type of property and hunting pressure

Indices of rabbit abundance obtained on private hunting lands (0·65 ± 0·07, $n = 203$) were higher than those obtained on public lands (0·33 ± 0·09, $n = 108$; ANOVA, $F_{1,309} = 7{\cdot}268$, $p \leq 0{\cdot}01$). Also, rabbit abundance was higher on hunting lands with restricted access (1·22 ± 0·14, $n = 47$), than on lands without restrictions (0·41 ± 0·06, $n = 264$; $F_{1,309} = 28{\cdot}204$, $p \leq 0{\cdot}001$). Hunting pressure (cartridges/km) was also higher on private lands (19·4 ± 2·5, $n = 203$) than on public lands (8·25 ± 3·4; ANOVA, $F_{1,309} = 7{\cdot}01$, $p = 0{\cdot}008$). There were significant correlations between rabbit abundance and hunting pressure ($r = 0{\cdot}478$, $p < 0{\cdot}001$, $n = 311$), and between hunting pressure and the number of carnivore scats ($r = 0{\cdot}124$, $p = 0{\cdot}029$, $n = 311$). There was no correlation between the RA and the abundance of carnivores when all kinds of properties were pooled ($r = -0{\cdot}0001$, $p = 0{\cdot}998$). However, we found a correlation between carnivore numbers and rabbit abundance on public lands ($r = 0{\cdot}257$, $p = 0{\cdot}007$, $n = 108$), but not on private lands ($r = -0{\cdot}053$, $p = 0{\cdot}452$, $n = 203$).

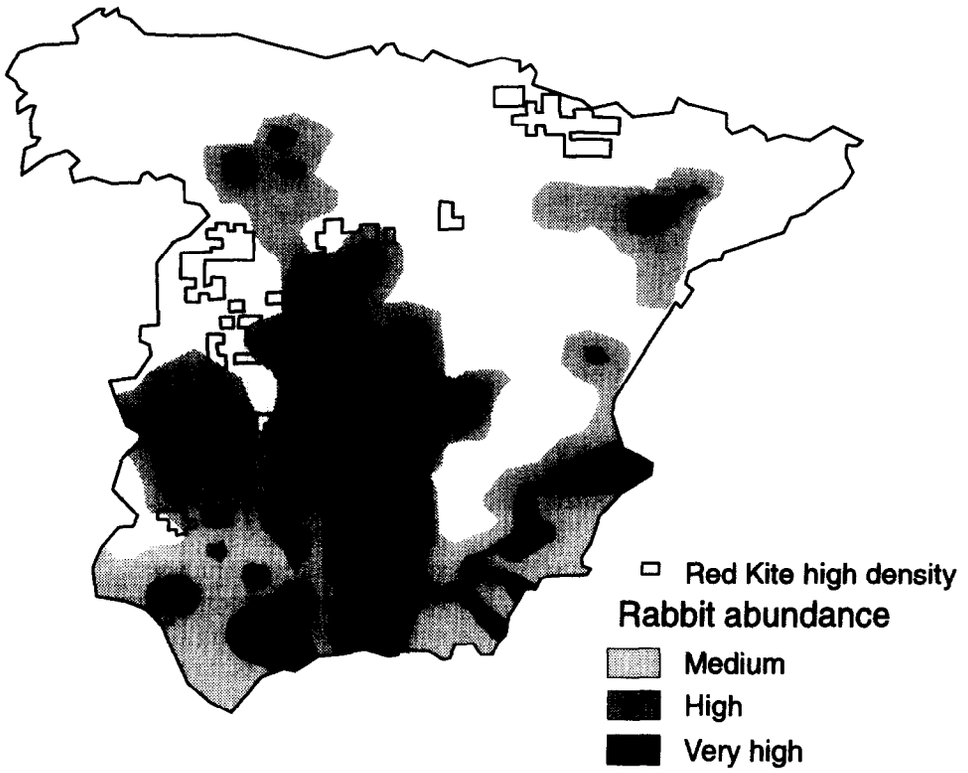

Fig. 2. Areas of high density of red kites (>10 kites/100 km of transect, estimated population >3 pairs/100 km^2; data from National Census of 1994), and density distribution of rabbits (abundance indexes higher than the average for the country) in Spain. The rest of the country is considered to have lower than average rabbit density.

DISCUSSION

Red kite populations experienced dramatic declines during the 19th century and first half of this century, mainly due to persecution (Bijleveld, 1974; Evans and Pienkowsky, 1992). Their populations in Central Europe have recovered in recent decades (Tucker and Heath, 1994), but declines still persist in the Mediterranean basin, also mainly due to persecution (Viñuela, 1996). Currently, in Spain, they are very scarce within areas of high rabbit density, but this is probably not related to the decline of rabbits (see below). Only those populations of red kite outside high rabbit density areas have experienced stability or an increase.

The current rabbit range is not very different to that before irruption of myxomatosis, because climatic conditions (e.g. rain and temperature) and/or soil structure (i.e. suitability for warren building) are two of the most important factors affecting rabbit distribution (Blanco and Villafuerte, 1993). Furthermore, because of their economic importance, most of those areas where rabbits were specially abundant in the past have being maintained as hunting areas up to the present, even by restocking with rabbits from other areas (Calvete *et al.*, 1997).

Generalist predators may be affected by RHD, through reduction in litter size (Villafuerte *et al.*, 1996), or productivity (Fernández, 1993). However, the appearance of dead or ill rabbits affected by RHD may even have been favourable for kites, because they gain access to adult rabbits, an otherwise unavailable prey (Viñuela and Veiga, 1992; Villafuerte and Viñuela, unpublished data). In fact, the highest productivity of breeding red kites in Britain between 1951 and 1960 was 1954, when myxomatosis spread (Lovegrove *et al.*, 1990). Furthermore, even in a high rabbit density area, such as Doñana National Park, the percentage of rabbits in the diet of red kites before the irruption of RHD was relatively low (Veiga and Hiraldo, 1990). More importantly, many population declines have occurred in too short a time period (in many cases 2–3 years, pers. obs.), to be explained by a reduction in productivity.

An alternative hypothesis to explain this reduction could be competition with other raptors more specialized in rabbit consumption, so there could be a case of control by top predators (Palomares *et al.*, 1995; but see Litvaitis and Villafuerte, 1996). However, in Doñana (No. 25 in Fig. 1), where rabbits are very abundant (Moreno and Villafuerte, 1995), a dense population of red kites coexists with one of the most diverse communities of raptors in Europe (Valverde, 1967; Veiga and Hiraldo, 1990; pers. obs.), including a dense population of the Spanish imperial eagle, which occasionally kills kites (Ferrer, 1993).

Red kites are probably being affected also by other human impacts, such as the increase in the number of electric power lines, use of pesticides, destruction of nesting habitat, or a decline in abundance or accessibility to rubbish tips and abattoirs (Viñuela, 1994, 1996, in press). However, these factors are more closely related

to settled areas than to hunting areas, and cannot explain the striking relationship between rabbit and red kite abundance.

Blanco and Villafuerte (1993) found that many hunters believed that predators were the main cause of the decrease in rabbit numbers, and some even admitted the use of illegal methods to kill predators. Accordingly, we found that there was no correlation between rabbit densities and carnivore abundance on private hunting lands, in contrast to public hunting lands, albeit the former held the largest numbers of rabbits, a result difficult to explain by reasons other than illegal persecution.

Furthermore, there is a general impression among hunters that there are 'too many kites' in Spain. This is because large numbers of kites are present throughout the year: around 60 000 wintering red kites (October–February, Viñuela, 1997, in press), and at least 10 000 pairs of breeding black kites (February–August, Viñuela and Sunyer, 1994). Unfortunately, the lower number of resident nesting red kites (about 3500 pairs, Viñuela, 1997, in press) seem to be suffering disproportionally the effects of persecution.

Spain may be experiencing a situation resembling that which occurred during the myxomatosis crash, when the vermin extermination campaigns reduced the numbers of predators. In fact, we found that in areas of high rabbit density the present abundance indices for red kites are similar to those found during the vermin campaigns, while in areas of low rabbit density, the populations of red kites seem to be much higher now than before (Table 2).

Other recent studies have reported an increase in the number of cases of poisoned or shot raptors in Spain (e.g. Blanco, 1995; González, 1996). Indirect poisoning (B. Artíguez and A. F. Rodríguez, pers. comm.) seems also to be playing an important role in northern Spain (numbers 1, 2, 4 in Fig. 1), outside the high rabbit abundance area, where bait is being used against wolves (Blanco *et al.*, 1992), because of conflicts with livestock producers.

In Extremadura, an area of high density of rabbits, populations of red kites are apparently stable (Table 1), and much higher than in the times of vermin extermination (Table 2). A controlled persecution of generalist carnivores is allowed in some areas of this region, and illegal persecution is severely penalized (A. Sánchez, Environmental Agency of Extremadura, pers. comm.). Other undetected factors may also contribute to the good health of the kite population in Extremadura.

In Scottish estates, shooting and nest destruction are the most important factors reducing nesting populations of hen harriers *Circus cyaneus* (Bibby and Etheridge, 1993). Gamekeepers, concerned over the increase in hen harrier numbers and their possible effect on grouse populations (Redpath, 1991), are responsible for this persecution. As in the case of red kites in Spain, the only dense populations of hen harriers in Scotland are currently those outside shooting estates (Bibby and Etheridge, 1993).

In Spain, the effect of predators on game species is currently unclear, although gamekeepers and hunters seem to be convinced of their influence. When a decrease in hunting success is perceived, predators are usually blamed (Franzmann, 1993), and hunters may start to use illegal, but easy, fast, and cheap methods of predator control, such as poison, that could affect 'non-guilty' but vulnerable species, such as red kites. In Britain, Reynolds and Tapper (1996) explained the lower number of illegal practices against carnivores when compared with raptors, because of the existence of 'efficient and satisfactory' legal methods to control targeted mammalian predators.

It is always better to accept a regulated and monitored control of predators than uncontrolled illegal actions. However, studies to gather information on the real effect of predators on game population are urgently required. If necessary, a reliable methodology should then be found to compensate for the effect of predators.

Finally, and more importantly, information campaigns at the very early stage of a population crash in a game species can prevent misconceptions that will be very difficult to erradicate in the future. This will allow conservationists and wildlife managers to take the initiative in preventing extensive predator persecution, especially for the most endangered and sensitive species.

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