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COMMENT

Lack of scientific evidence and precautionary principle in massive release of rodenticides threatens biodiversity: old lessons need new reflections

Pesticides are widely used throughout the world to control agricultural pests (Berny 2007). Owing to their well identified side-effects on wildlife (see for example Newton *et al.* 2000; Brakes & Smith 2005), the release of high quantities of pesticides to the environment should always require responsible use of both science-based information and the precautionary principle (Mason & Littin 2003). However, decision making in wildlife management and conservation is not systematically supported by scientific evidence (Pullin & Knight 2005). This is particularly worrying when decision making involves release of toxic substances to the environment, as often occurs in rodent plague control. Here we describe how poorly-informed management decisions to control a rodent plague can adversely affect wildlife, especially when chemical-based treatments are generically designed and applied on a broad scale, and discuss the high economic cost of such campaigns. We urge the implementation of a more cost-effective evidence-based and environmentally sustainable management to control rodent plagues in Spain. Cases similar to those reported here occurred in the UK a century ago, and throughout Europe in the 1950s (Elton 1942; Chitty 1996). Although abundant scientific information has since been generated about vole cyclic population dynamics and rodent plague control techniques in the world, lessons have apparently not been learned.

Between 2006 and 2007, an outbreak of common voles *Microtus arvalis* occurred in agricultural areas of north-western Spain, which also took place simultaneously at least in parts of France and Germany (U. Mammen & V. Bretagnolle, personal communication 2007). By February 2007, densities approaching 1000 voles ha^{-1} were estimated in the area where the plague apparently started in Spain (J.J. Luque-Larena *et al.*, unpublished data 2007). By that date, farmers' associations claimed that voles were causing severe damage to cereal fields, and started a campaign to promote their case in the media. Under this pressure, the regional government (Junta de Castilla y León, JCYL hereafter) officially declared the vole outbreak as an agricultural plague in 19 February 2007 (AYG/556/2007 order, Official Gazette of Castilla y León, Spain) and financed three extensive campaigns of vole poisoning. However, to our knowledge, there had not been any serious study of vole damage to crops in Spain, even although there have been at least four plagues in this area since the 1980s (Bonal & Viñuela 1998). The first poisoning campaign started in March 2007 and entailed disseminating cereal grain surface-treated with an anticoagulant rodenticide (clorofacinone) at the maximum authorized doses, over an area of *c.* 20 000 ha. This campaign was stopped due to a regional court submission by protectionist groups, which also presented a complaint to the European Commission; this is still under scrutiny [D(2007)ENV.A.2/AGP/17332]. That treatment, however, resulted in tonnes of toxic grain remaining accessible to non-target species over a huge area causing massive mortality of some species such as pigeons, human consumption of which had to be temporarily banned (Sarabia *et al.* 2008). By summer 2007, the vole plague had spread over almost 500 000 ha and, from 20 July 2007, clorofacinone was used again, this time combined with stubble burning and roadside cleaning, affecting 37 000 km of roads and at least 100 000 ha of agricultural land (JCYL personal communication 2007). For this second campaign, the bait was placed inside plastic tubes, in an attempt to preclude access to poison by non-target animals. However, this measure proved to be ineffective, because the grain often fell out of the tubes (widely documented on press releases; our own personal observations), again causing mortality of non-target species (see below, Table 1). Animals found dead in the field by Environmental Protection guards, field naturalists and hunters between February and August 2007 were analysed for the presence of chlorophacinone residues in liver at the Wildlife Toxicology laboratory of IREC (Instituto de Investigaciones Cinegéticas, Ciudad Real, Spain). Chlorophacinone residues were determined by high-performance liquid chromatography (HPLC) with ultraviolet detection at 281 nm (as described in Sarabia *et al.* 2008). In response to further complaints from farmers, a third poisoning campaign was implemented and, from February to April 2008, 169 technical teams of JCYL released tonnes of bromadiolone, a highly toxic rodenticide, introducing poisoned baits (pellets) inside vole burrows over 375 000 ha in 830 municipalities (Diario de León 2008). Tens of tonnes of this compound have also been freely distributed in the form of bagged granules to farmers, who generally applied the baits mainly on field surface (our own personal observations), leaving it thus accessible to non-target species.

Decision making by JCYL on release of rodenticides has not been explicitly evidence-based. First, an *ad hoc* scientific commission was formed in September 2007, after the first two poisoning campaigns were implemented. Additionally, great discrepancies emerged between data and methods used by regional administration and scientists working in the area. While methods to estimate vole densities used by scientists were based on live-trapping (Fig. 1) following scientific experience (Gannon *et al.* 2007), those used by

Table 1 Animals ($n = 116$) found dead in the field in Castillay León between February and August 2007 were analysed for the presence of chlorophacinone residues in liver. Haemorrhages were observed in all the animals with detectable chlorophacinone levels ($n = 76.65$ % of corpses). ++ = number of individuals with chlorophacinone residues; n = number of individuals analysed.

Species	*++/n*	*Liver concentration (µg/g wet weight)*	
		Mean ± SE	*Range*
Birds			
White stork (*Ciconia ciconia*)	0/4	–	–
Mallard (*Anas platyrhynchos*)	3/3	1.34 ± 0.43	0.71–2.17
Montagu's harrier (*Circus pygargus*)	0/1	–	–
Buzzard (*Buteo buteo*)	1/3	0.12 ± 0.0	–
Red-legged partridge (*Alectoris rufa*)	0/5	–	–
Great bustard (*Otis tarda*)	0/2	–	–
Lapwing (*Vanellus vanellus*)	0/1	–	–
Black-headed gull (*Larus ridibundus*)	0/1	–	–
Domestic pigeon (*Columba livia*)	64/66	6.6 ± 1.08	0.55–50.11
Calandra lark (*Melanocorypha calandra*)	2/7	1.57 ± 0.53	1.04–2.09
Mammals			
Iberian hare (*Lepus granatensis*)	6/16	4.18 ± 1.41	1.09–9.52
Common vole (*Microtus arvalis*)	1/6	0.96 ± 0.0	–
European polecat (*Mustela putorius*)	0/1	–	–

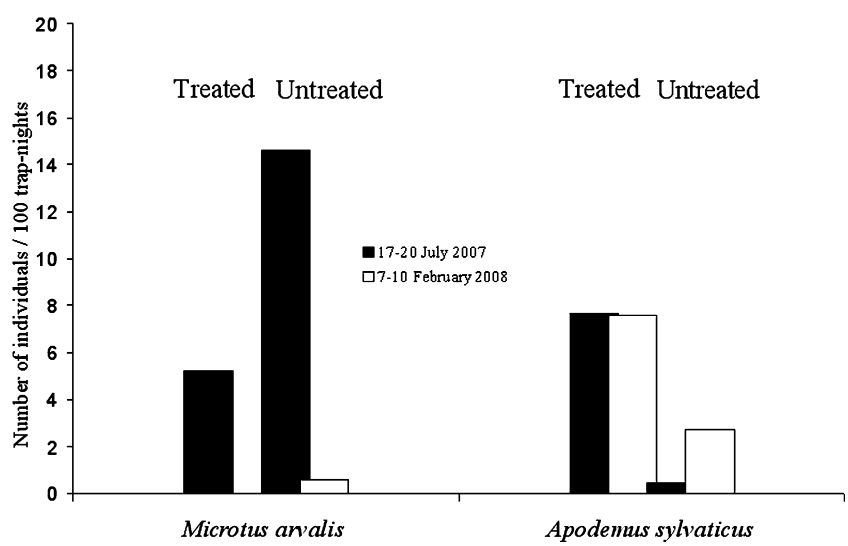

Figure 1 Abundance of individuals (number of individuals / 100 trap-nights) captured by Shermann® traps for each species in two periods (July 2007 and February 2008) in León (north-western Spain). In treated fields there were 248 trap-nights per survey in July 2007 and 251 trap-nights per survey in February 2008. In untreated fields there were 651 trap-nights per survey in July 2007 and 665 trap-nights per survey in February 2008. The decrease in number of individuals of *M. arvalis* captured between July and February was not significantly different between treated and untreated fields (Fisher exact test: $p = 1$), but the population changes for *A. sylvaticus* in untreated versus treated fields was significant (χ^2 with Yates correction = 5.93, df = 1, $p = 0.015$). Note that the number of individuals of *M. arvalis* in treated areas in February 2008 was 0.

technical personnel in the Administration were based on an indirect abundance index not previously used in this area (J.J. Luque-Larena, personal communication 2008). Live trapping sessions occurred just before chemical treatments were applied in the area (chlorofacinone applied August 2007 and bromadiolone applied second fortnight in February 2008. Traps were set on three consecutive nights and in the same position in both periods (summer and winter) on 22 crop fields and field margins where chlorofacinone was applied (Treated, six fields) or not (Untreated, 16 fields) over and are of 750 km^2. Contrary to information used by JCYL, empirical evidence showed that most vole populations had already collapsed before the third poisoning campaign started, and this occurred equally in treated and untreated areas (Fig. 1; J.J. Luque-Larena & J.J. Fargallo, personal communication 2008). Importantly, this population collapse in both chemically treated and untreated areas had already been previously documented in past vole plagues in the area (Ministerio de Agricultura, Pesca y Alimentación 1989–1996) and it is widely known that natural decline usually occurs within a timeframe similar to that of treatment (Elton 1942; Chitty 1996; Singleton *et al.* 2007). Secondly, anticoagulant rodenticides invariably cause secondary poisoning of non-target species, and bromadiolone particularly is known to affect predators and scavengers (see Berny 2007). Thirdly, high percentages of individuals killed by rodenticides were found in the study area for some species, particularly pigeons (96% mortality) and hares (38%) (see Table 1). Additionally several threatened species were also affected by rodenticides (for example the calandra lark *Melanocorypha calandra* and great bustard *Otis tarda*; Table 1, and reports from several toxicological labs in Spain and summarized in the complaint to the European Union; La Opinión de Zamora 2008). These control campaigns could also have a negative impact on populations of some non-target species, at least in field mouse *Apodemus sylvaticus* populations, which showed markedly different dynamics in treated and untreated areas (Fig. 1); hares have also disappeared over wide treated areas (for example see Norte de Castilla 2008; our own unpublished data).

The application of rodenticides was based on economic reasoning not well grounded in evidence. First, there is little or no evidence that the rodent plague adversely affected agricultural production. Indeed, in 2007 (the year of the plague) in this area, production of crops claimed to be damaged by voles, such as cereal, potatoes and vineyards, was the highest recorded over the last 10 years (JCYL 2008), even although the second and third vole control campaigns started after harvesting. Second, the cost of the control campaign (*c.* € 24 million; € 1 = US$ 1.41, December 2008) has been higher than the compensatory payments for crop damages (*c.* € 5.5 million, JCYL unpublished data 2008). These chemical treatments negatively affecting biodiversity conservation can hardly be integrated within the new payment schemes of the European Union Common Agricultural Policy (CAP), which demands the fulfilment of eco-conditionality measures for the payment of subsidies.

A precautionary principle criterion should have prevailed over the pressure exerted by farmers in decision-making since: (1) the area treated with rodenticides included five Natura 2000 Bird Special Protection Areas (SPAs); (2) non-target small mammal species were expected to have reduced abundance after poisoning further reducing prey availability for predators (Fig. 1); and (3) high uncertainty remained on the potential direct and indirect effects of massive use of anticoagulants in this agrarian ecosystem (Table 1). Accordingly, managers should have determined the appropriate level of precaution to apply based on the evidence, and implemented a programme to investigate the collateral effects of vole treatment on wildlife.

These chemical-based environmentally-aggressive management campaigns in Castilla y León may be taking a backward step of decades in terms of public awareness of the collateral effects of poisoning programmes, an issue now considered as one of the main conservation problems for predators in Spain (Worldwide Fund for Nature/Adena 2006). Moreover, society is exerting growing pressure for more humane rodent culling programmes (Singleton 2007). Neglect of scientific evidence by decision-makers is often not deliberate (Pullin & Knight 2005), and identification of the best management practices requires an in-depth understanding of the pest-species ecology and ecosystems, as well as the social, economic and technical contexts in which rodents are pests (Singleton *et al.* 1999). The necessary strong links between managers, farmers and scientists can hopefully be attained with the recently released Vole Plague Control National Programme developed by the Spanish national government (409/2008RD, 28 March 2008, Official Gazette of the Spanish government). The next voles population explosion could be expected as soon as 2010 (Lambin *et al.* 2006), and the National Programme should urge integrated plague management based on scientific evidence and ecological control (Singleton *et al.* 1999, 2007), a well-informed benefit/cost (risk) balance, including the sanitary risk of contact with rodents by rural people, and the cooperation/supervision of international and local authorities when, as has been the case, enormous quantities of poison are released in the environment. These measures should lead to better-informed management decisions that control the pest species while minimizing impacts of unwanted ecological side-effects.

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