Pesticide abuse in Europe: effects on the Cinereous vulture (Aegypius monachus) population in Spain

Mauro Hernández · Antoni Margalida

Accepted: 16 January 2008 / Published online: 15 February 2008 © Springer Science+Business Media, LLC 2008

Abstract A survey was carried out to investigate incidents of pesticide poisoning of the Cinereous vulture (Aegypius monachus) in Spain during the period 1990–2006. A total of 241 incidents affecting 464 vultures were investigated to establish their causes: approved use, misuse, or deliberate abuse. Other factors studied were compounds, other species affected by the incident, the mode of application, spatial and temporal variation and reasons for the pesticide abuse involved. Approved use was responsible for only a minor fraction (1.3%) of the incidents whereas up to 98% of the investigated incidents were intentional poisonings. Pesticide mortality mainly affects adult individuals (83%) and the implications of this for population dynamics could be important. Eleven different compounds were involved in these incidents although three compounds accounted for up to 88% of the poisoning cases: carbofuran, aldicarb, and strychnine. Most of the pesticide kills seem to be related to the illegal control of predators. Given the minor impact of labeled-use pesticides, currently approved pesticide use does not represent a problem for the Cinereous vulture. Nevertheless, availability of highly toxic pesticides may exacerbate illegal use. As a few compounds, mainly granular insecticides, are responsible for most pesticide kills, stronger regulation and control of these in the EU could result in a decrease of mortality related to pesticide abuse in several endangered species without a significant effect on agriculture.

Keywords Cinereous vulture · Conservation · Poisoning · Carbamates · Spain

Introduction

It is generally recognized that bioaccumulation of organochlorine pesticides had a devastating effect on raptor populations. The link between population decline and organochlorine pesticide contamination in birds of prey has been largely documented (Ratcliffe 1970; Grier 1974; Wiemeyer et al. 1984; Pain et al. 1999; Bowerman et al. 2003) and organochlorine contamination is still of concern for the recovery of some species in many countries (Helander et al. 2002; Mañosa et al. 2003). Organochlorine pesticides were largely replaced by organophosphorous and carbamate compounds of lower secondary risk. Nevertheless, these compounds although less persistent and less bioaccumulative are more acutely toxic and nowadays both are ubiquitous in agriculture, forestry, and livestock (Barnett et al. 2002). Pesticide risk assessment was not only limited to the danger to human health, but also includes ecological risks. Consequently, modern pesticides could seem to be relatively safe in ecological terms.

In recent years, regulation changes in pesticide approvals or labeling that have progressively regulated or restricted the use of pesticides in order to minimize their health and ecological side effects (Council Directive 91/414/EEC 1991) have been developed by the European Union (EU) and Spain. Nevertheless, mortality from secondary poisoning after labeled-use and abuse has been reported with increasing frequency in Europe (Antoniou et al. 1996;
Affecting most raptor species (Hernández 2006), including the illegal use of pesticides during the last decade is causing a significant decline in their populations. The increase in pesticide abuse in Europe is a concern, particularly in Spain where an increase in the use of pesticides has been observed (Mineau et al. 1999; De Snoo et al. 1999; Guitart et al. 1999; Martínez-Haro et al. 2005). In Spain, the increase in pesticide use has been attributed to the use of pesticides during the last decade (González et al. 2007) or the Bearded vulture (Gypaetus barbatus) (Margalida et al. 2008).

The impact of pesticides on wildlife is at odds with the evaluation of the ecological risk in pesticide approvals or labeling. Although other indirect effects are considered, the availability of highly toxic pesticides exacerbates the persecution problem, has never been evaluated for regulatory changes. At least, pesticide regulation and approvals should include a strongest control of product acquisition and use and a better risk evaluation of management practices to reduce the probability of illegal use.

In this study, we report the results of a survey that estimated the impact of approved pesticides on the population of a rare species that occupy habitats that are relatively free of pesticide use. We offer arguments to judge the availability of highly toxic compounds on the market as another side effect of pesticide approvals.

**Material and methods**

**Sources of information**

The main sources of information were poisoning incidents involving raptors documented by authorities in Spain between 1990 and 2006, including reports from authorized staff and official agents, from records held by wildlife rehabilitation centers, Veterinary Medicine Schools, and public and private laboratories, as well as cases compiled and records held by the Forensic Laboratory of Wildlife (LFVS, Madrid) and by the Ecotoxicology Working Group from the Fauna and Flora Committee (Ministry of Environment, Madrid).

Data selection and incident records

Cause of death was established following standard necropsy and pathology procedures, including estimation of post-mortem interval, throughout post-mortem examination by a pathologist, routine bacteriology and histopathology and toxicological investigations. The diagnostic results and conclusion by the pathologists were used to categorize incidents (see Margalida et al. 2008). We used details supplied with the incident record and necropsy reports such as date, number of vultures implicated, their age class, the presence of other species affected in the incident, geographic location of the incident and any other relevant information gathered during the official investigation. These include clinical signs or post-mortem findings, likely route of exposure, pesticides investigated and if other likely causes of death (e.g., disease, electrocution, and shooting) have been eliminated. Further pesticide analysis on baits or carcasses was also considered in order to categorize incidents, to determine possible cause of illegal use of poison and to evaluate the impact on mortality according to different exposure routes. This distinction is important because the solutions are different. Incidents were investigated to establish their causes: approved use, misuse, or deliberate abuse and the likely causes of use or misuse, land use, pesticide treatments in the area, conflicts with human interests, and investigations carried out to identify the likely authors. We extended the time period backward and forward to report other incidents in the area when these offered useful insights.

According to the available information, in 107 incidents (44.4%) clinical signs or post-mortem findings of at least one of the affected vultures, with further chemical identification in tissues, gut contents or bait material or Cholinesterase (ChE) inhibition evidence (plasma or brain ChE determination) supporting post-mortem diagnosis were considered for diagnosis. In 73 incidents (30.3%), investigations were limited to toxic identification in gut contents or bait material. Lastly, in 61 incidents (25.3%) diagnosis was gathered through circumstances clearly indicative of poisoning, such as mass mortality (but no pathological or chemical analysis data available), presence of suspicious bait material, and other causes of death ruled out. The diagnostic results and conclusion by the pathologists were used to categorize incidents (see Margalida et al. 2008).

The population of the Cinereous vulture in Spain were divided into five regions according to their main habitat features and the localization of the main breeding colonies in the Iberian Peninsula (Sánchez 2005, Fig. 1): (1) **Northern area**, including colonies of both Central Mountain System and Sierra de Gredos, and extending to peripheral colonies of Madrid, Salamanca and Guadalajara; (2) **Central area**, including colonies of Montes de Toledo...
and Sierra Morena, located in Toledo, Ciudad Real, Jaén, and Córdoba provinces; (3) Western area, those colonies extending from central Cáceres province to central Badajoz province; (4) Southern area, those colonies inhabiting southern Badajoz and Huelva province and including colonies in the north of Sevilla province, and lastly, (5) Balearic area, pairs inhabiting those islands.

Vultures affected in poisoning incidents were classified according to their age into adults: those vultures with full or nearly full adult plumage characteristics and breeding activity; immatures: as those vultures which were between 1 and 3 years old and distinguished by plumage, and juveniles: those first year vultures after fledging. Since in some incidents, records did not include a clear differentiation between adults and sub adults (>4 years), both age classes were considered as adults.

According to breeding phenology, incidents were grouped into three periods: Incubation (February and April); Chick-rearing (May and August) and, non-breeding period (September–January), partially corresponding to post-fledging and pre-laying periods.

Statistical analyses

Analyses of $2 \times 2$ contingency tables and $\chi^2$ tests were carried out to analyze the dependency between pairs of factors. Observed cell frequencies were considered to be significantly different from the expected frequencies when the absolute value of the standardized residual was greater than $Z_{\alpha/2}$ ($z = 0.05$). We tested inter-group differences using Kruskal–Wallis and the Spearman rank correlation to test the relationship between variables (Sokal and Rohlf 1995). The statistical analyses were carried out using NCSS and PASS software (Hintze 2001).

Results

A total of 241 incidents were registered over the period 1990–2006, affecting a total of 464 Cinereous vultures. A total of 456 vultures were found dead and 8 (1.8%) alive. A mean number of 1.93 ± 2.8 (range 1–38) vultures were found affected in each incident. Age was determined in 376 vultures of which 311 (82.7%) were adults, 42 (11.2%) immatures and 23 (6.1%) juveniles. A total of 42 incidents of nestling mortality related with poisoning have been reported. Nevertheless, nestling mortality was not taken into account in the analyses because causes of breeding failure were out of the scope of the study.

Mortality arising from poisoning increased progressively from 1994 to 1999, subsequently decreasing from 2000 to 2006 (Fig. 2). The number of cases correlated positively with the number of individuals found dead ($r_s = 0.61, P < 0.01$).

Causes

The causes were determined in 196 of studied incidents. This represents 81.3% of the Cinereous vulture kills. All but three incidents were categorized as deliberate abuse of pesticides. This represents 98.5% of the investigated incidents. There were only two incidents arising from the approved use of pesticides. In these two cases lindane, an authorized veterinary topical insecticide was identified as the likely cause of poisoning. The third incident was diagnosed as acute lead poisoning.

Pesticides involved in mortality incidents

Pesticides involved were determined in 167 incidents (69.3% of those registered). In the remaining incidents either sufficient information or suitable tissues were not available. This represents 29.5% of the poisoning incidents. Eleven different compounds were involved in these incidents. The three compounds found to be most abused in incidents which account for 88.2% ($n = 150$) of the poisoning cases were carbofuran (31.2% of incidents, $n = 53$), aldicarb (30.6%, $n = 52$), and strychnine (26.5%, $n = 45$). Other compounds involved in incidents include fenthion and chlorfenvinphos (each 2.4% of incidents, $n = 8$), parathion (1.2%, $n = 2$), monocrotophos, dimetoate, phosphamidon and metomyl (each 0.6% of incidents, $n = 4$). In three of these incidents more than one compound was involved: in one case...
strychnine and fenthion, in the other case aldicarb and carbofuran. There were two incidents where veterinary products (lindane) were found to be involved. One single case was diagnosed as acute lead poisoning. The average number of individuals that died in each incident differed significantly according to pesticides involved, being aldicarb the most lethal (aldicarb: $2.58 \pm 0.46$ vultures/incident; strychnine: $2.12 \pm 0.53$, carbofuran: $1.48 \pm 0.48$, Kruskal–Wallis $H_2 = 11.496, P = 0.0031$).

**Route of exposure**

Of the 241 cases, in 179 (74.3%) the route of exposure could be identified. Pesticide-laced raw or processed cold meat were found in 110 cases (61.4%), small ruminant pesticide-laced carcasses in 31 (17.3%) and pesticide-laced carcasses of small game species in 27 (15.1%). The remaining 11 cases (6.1%) baits used were poison-laced eggs (six cases), pesticide-laced carcasses of large domestic animals (three cases), pesticide-laced carcasses of wild ruminants (two cases) and in two cases, vultures were poisoned through the consumption of carcasses of previously poisoned animals (secondary poisoning).

**Mortality of other species**

In 56 incidents (23.2%, $n = 241$) other species were found dead together with Cinereous vultures. In 39% of the incidents Eurasian Griffon vultures (*Gyps fulvus*) were found ($n = 22$), in 12.5% Egyptian vultures (*Neophron percnopterus*) ($n = 7$), in 12.5% dogs/foxes ($n = 7$), in 12.5% others ($n = 5$) (including Falconiformes, cats, and Mustelidae), Corvidae in 8.9% ($n = 5$), *Milvus* sp. in 7.1% ($n = 4$), and Golden eagles (*Aquila chrysaetos*) in 7.1% ($n = 4$). If we take into account the number of individuals ($n = 224$), the Griffon vulture with 84 individuals (37.5%) was the most affected, followed by *Milvus* sp. with 79 (35.3%), *Corvus* sp. with 16 (7.1%), dogs/foxes with 15 (6.7%), Egyptian vultures with 13 (5.8%), others with 13 (5.8%) and Golden eagles with 4 (1.8%).

**Spatial and temporal variation in mortality**

The comparison in 4-year periods (except the last period which includes 5 years) of the use of pesticides shows the existence of significant differences ($\chi^2_6 = 103.3, P < 0.0001$, Table 1). During the first two periods (1990–1993 and 1994–1997) in 92.9% ($n = 14$) and 80% ($n = 20$) of the incidents, respectively, strychnine was identified as the cause of death in a great proportion of birds, while in the last two periods (1998–2001 and 2002–2006) its importance decreased to 21.3% ($n = 74$) and 0%, respectively. Similarly, a significant increase was observed in the use of carbamates, such as aldicarb (mainly in the last 5 years with 88.5% of the cases) and carbofuran in the

![Fig. 2 Annual variation of the number of poisoning incidents (black columns) and individuals (white columns) of Cinereous vulture found during the period 1990–2006](image)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldicarb</td>
<td>1</td>
<td>7.1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Carbofuran</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Strychnine</td>
<td>13</td>
<td>92.9</td>
<td>16</td>
<td>80</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>100</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>
period 1998–2001 (54.7% of the cases). The annual variation shows how the carbamates starting from halfway through the 90s, progressively substitute strychnine with a point of inflection in 1999 ($r_s = -0.83, P < 0.0001, n = 17$, Fig. 3). When we compare among the five study regions considered, the differences in the use of pesticides were significant ($\chi^2_8 = 63.13, P < 0.0001$, Table 2). The aldicarb was the most frequently used in the Northern area (64.7%, $n = 51$) and Western (60%, $n = 15$), whereas the carbofuran was the most frequently used in the Southern area (67.7%, $n = 31$) and strychnine in the Central area (60.5%, $n = 43$). Nevertheless, in the Central area, where strychnine was predominant, most of the incidents were registered before 2000.

With respect to the breeding phenology, 96 (39.8%) of the cases of mortality were produced during the incubation period, 77 (32%) during chick-rearing and 68 (28.2%) during the non-breeding period (Table 3). During the breeding season, 72% of the mortality cases take place. A total of 131 (87.9%) of the individuals found dead during the incubation period were adults and the remaining 18 (12.1%) were immature. During the breeding period, the percentage of dead adults was 89.4% ($n = 228$), 9.4% immatures ($n = 24$) and only 1.2% ($n = 3$) juveniles. During the non-breeding period the percentage of dead adults fell to 60% ($n = 57$) with that of immature individuals being 19% ($n = 18$) and juveniles 21% ($n = 20$), being differences statistically significant ($\chi^2_4 = 57.19, P < 0.0001$).

**Causes of pesticide abuse**

Most of the kills affecting Cinereous vulture seems to be related to the illegal control of predators in the management of hunting properties (83.2% of incidents of known causes, $n = 176$), mainly in small game hunting properties (74.5% of the incidents, $n = 146$). Large game hunting management ($n = 14$) and conflicts with livestock breeding ($n = 16$) accomplished another two important causes of poison use (8 and 9.1%, respectively).

Conflicts with the administration, especially linked to forest management in protected natural spaces only gave rise to 4.6% ($n = 9$) of the studied incidents.

In 190 (78.8%) incidents ($n = 241$) the cause of pesticide abuse was known. Of these, 127 incidents (67.2%) were as a consequence of the direct consumption of a bait which was not targeted to vultures, in 51 (27%) due to the consumption of a poisoned prey (secondary poisoning), in 9 (4.8%) the bait was directed at scavenger birds, in two cases (1.1%) due to the consumption of a topically-treated prey and another (0.5%) due to the accidental ingestion of lead.

![Fig. 3 Temporal variation of the use of strychnine (continuous line) and carbamates (discontinuous line) in the cases of poisoning registered between 1990 and 2006](image-url)
Differences in mortality according to exposition route

Significant differences were found in the average number of individuals of Cinereous vulture who appeared affected in each poisoning incident in accordance with the type of bait employed (sheep/goat; small game and meat bait, Kruskal–Wallis \( H_2 = 21.94, P < 0.0001 \)). The baits that produced the highest mortality rate were those prepared with parts or whole carcasses of small game species, particularly wild rabbits (3.51 ± 0.59, \( n = 27 \)), in second place cadavers of sheep/goat (2.90 ± 0.56, \( n = 31 \)) and lastly the poison-laced raw or processed cold meat (1.41 ± 0.29, \( n = 110 \)). By age classes, no significant differences were found when we compared the three most important baits used (\( \chi^2_4 = 7.74, P = 0.102 \), Table 4).

Discussion

The illegal use of pesticides to kill wildlife species is a problem where conservation issues are concerned since several wild and domestic species are targeted by poisonings and birds of prey are inadvertently killed. The loss of birds of prey to ChE-inhibiting pesticides can be significant as current levels of mortality from abuse and criminal use of pesticides are high enough to affect local populations (Henny et al. 1987; Mineau et al. 1999; Barnett et al. 2002). In this sense, side effects of pesticide misuse should be considered in the evaluation of ecological risk in pesticide approval or labeling and in post-registration surveillance of pesticide use (Noer and Secher 1990; Newton and Wyllie 1992; Barnett et al. 2002).

Table 3 Frequency of the causes of mortality and individuals affected in accordance with the time of the year, studied separately for the different age classes

<table>
<thead>
<tr>
<th></th>
<th>Cases</th>
<th>Individuals</th>
<th>Adult cases</th>
<th>Immature cases</th>
<th>Juvenile cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incubation</td>
<td>96</td>
<td>173</td>
<td>76 (131)</td>
<td>13 (18)</td>
<td>0</td>
</tr>
<tr>
<td>Chick-rearing</td>
<td>77</td>
<td>164</td>
<td>63 (97)</td>
<td>6 (6)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Non-breeding</td>
<td>68</td>
<td>100</td>
<td>40 (57)</td>
<td>15 (18)</td>
<td>10 (20)</td>
</tr>
<tr>
<td>Total</td>
<td>241</td>
<td>437</td>
<td>179 (285)</td>
<td>34 (42)</td>
<td>13 (23)</td>
</tr>
</tbody>
</table>

The number of individuals by age class appears in brackets

Table 4 Frequency of the most common causes of mortality in accordance with the type of bait used, studied separately for the different age classes

<table>
<thead>
<tr>
<th></th>
<th>Adult</th>
<th>Immature</th>
<th>Juvenile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheep/goat</td>
<td>23 (18.1)</td>
<td>3 (15)</td>
<td>0</td>
</tr>
<tr>
<td>Small game species</td>
<td>24 (18.9)</td>
<td>0</td>
<td>2 (16.7)</td>
</tr>
<tr>
<td>Raw/processed cold meat</td>
<td>80 (63)</td>
<td>17 (85)</td>
<td>10 (83.3)</td>
</tr>
<tr>
<td>Total</td>
<td>127</td>
<td>20</td>
<td>12</td>
</tr>
</tbody>
</table>

Percentages appear in brackets

Our results suggest that the majority of the pesticides that are affecting the Cinereous vulture are ChE-inhibiting insecticides (carbamates and to a lesser extent, organophosphorous pesticides) approved for agricultural use despite Cinereous vulture’s habitat seems to be relatively free of pesticide use. However, in agreement with the exposure route, type of food, concentration of toxicant and the place of discovery of the carcasses, it has not been possible to link its presence with legal use (labeled or misuse) in agriculture. In this sense, with the exception of the two accidental lindane poisonings and the case of lead poisoning, all studied cases are intentional poisonings. The main source of exposure of the Cinereous vulture to the pesticides was the direct consumption of a meat source that had been treated or contaminated with a toxic product. Thus, the illegal use of poison in order to control predators, independently of what activity caused this control was the main responsibility for the poisoning of Cinereous vultures. Given the lack of labeled-use incidents, the current approved pesticide use does not represent a problem for Cinereous vulture and other endangered species in Spain and this suggests that current regulation and control measures are not enough for fitting standards of pesticide risk assessment.

Only a few products and/or formulations are responsible for most pesticide kills, although a huge number of pesticides are marketed in Europe for use in agriculture (Council Directive 91/414/EEC 1991). Amongst pesticides involved in Cinereous vulture kills, carbofuran and aldicarb, two granulated carbamates, accounted almost 62% of the incidents. Granulated carbamates are extremely concentrated sources of insecticides and in the present study no kills resulted from labeled pesticide use. A strongest regulation and control of a few products in the EU, such as granular carbamates, could result in a decrease of mortality related to pesticide abuse in several endangered species without a significant effect on agriculture treatments (Noer and Secher 1990). This regulation is feasible at little or no cost for farmers or society and could be effective in the reduction of the mortality by poisoning of the Cinereous vulture and other endangered species.
The studies based on passive systems of gathering information have the disadvantage that the results obtained only represent a fraction of those really produced (Mineau et al. 1999). This underestimation means that the number of vultures found as well as the incidents detected are far below the real mortality figures, especially considering that the final result of a number of exposures is not the death of the individual (Fry et al. 1998; Hooper et al. 1989). In this sense, some individuals exposed to the toxicants may not die or they may not present detectable clinical symptoms (Porter 1993), which suggest that the percentage of live individuals found in the cases studied (1.8%) would also be underestimated. Another bias could also be motivated by the fact that, in some cases, death may occur far away from or sometime after exposure. These cases are more likely to be overlooked or being attributed as belonging to a different incident. In addition, cases of illegal use of pesticides are more likely to be reported than other cases of pesticide use (e.g., labeled or abusive agricultural use) since baits often contents high concentration of pesticide and thus, death occurs nearby the site of placement and shortly after exposure (Mineau et al. 1999).

Only in 4.8% of the cases was the bait directed specifically at scavenger species, which shows the scarce selectivity of the illegal, indiscriminate use of poison for the control of wild populations, whether they may be due to damage to hunting, to agriculture, or livestock. In addition, the high number of secondary poisonings (27%) caused by the consumption of poisoned animals (intentionally) registered, also reflects the impact that illegal, indiscriminate use of poison produces superior links in the tropic chain. This effect that was traditionally attributed exclusively to strychnine, occurs in a similar way with ChE-inhibiting insecticides, especially with carbamates (Allen et al. 1996; Elliot et al. 1996; Wobeser et al. 2004). It has been possible to confirm this effect in the case of poisoned eggs, in which 100% of the Cinereous vultures poisonings have been produced due to the consumption of a poisoned animal.

In the case of threatened species, such as the Cinereous vulture, the increase of pesticide-related mortality could be a determining factor in its population dynamic, since it is mainly affecting adults (83%). It has been shown that in the poisoning or exposures to poisons in birds of prey, the direct effect of adult mortality is of much more devastating for the dynamic of the population than the indirect effects on the reproduction (Real and Mañosa 1997; Whitfield et al. 2004) and it has been suggested as the most probable cause of the decline in some raptors, including the Cinereous vulture (Noer and Secher 1990; Antoniou et al. 1996) and the failure in the recolonisation of old distribution areas (Elliot and Avery 1991). As has been documented in other vulture species (see Margalida et al. 2003), mate loss favors the incorporation of younger less experienced individuals, affecting fecundity as has been found in other raptor species with a high proportion of mixed pairs (see Margalida et al. 2007). In this sense, Sánchez (2005) found that those colonies suffering higher adult mortality rates showed lower productivity and breeding success. In addition, colonies with higher adult mortality showed higher number of pairs with sub adult and immature individuals (Sánchez 2005).

The increase in the use of carbamates parallel to the disappearance of more classically used toxicants (strychnine) has also been verified in other countries (Mineau et al. 1999; Barnett et al. 2002). Strychnine was banned in 1998 in the EU (Biocidal Products Directive 98/8/EC 1998). Lack of significant differences in pesticides involved in Cinereous vulture kills between regions is a reflection of carbamate broad use as well as their inherent toxicity (Mineau et al. 1999). Availability of highly toxic pesticides undoubtedly exacerbates the wild species persecution problem (Mineau et al. 1999) and this aspect is rarely taken into account in pesticide reassessment and post-registration surveillance of pesticide use. At least, pesticide regulation should take into account the control of product acquisition and use and approvals should rely on implementation of better risk management practices to reduce the probability of illegal use. Also critical is the ability of the regulatory system to respond to conservation problems that are identified (Mineau et al. 1999) at least, in the case of threatened species. Recent EU regulations banned Aldicarb by July 2007 (DOCE 2003), but this decision was based on passerine mortalities resulted from labeled-use. Similar regulatory measures could be effective in reducing criminal use of pesticides, especially granular carbamates, and could result in a significant decrease of Cinereous vulture and other endangered species kills. Paradoxically, strychnine has been substituted in criminal cases by more acutely toxic organophosphorous and carbamate pesticides. Aldicarb and carbofuran resulted more lethal when used to lace baits than strychnine.

Since the information available in each region and period may sometimes be uneven, a passive incident report system is subject to several limitations. For example, some of the observed time-trends may be the result of different research or monitoring efforts made to document mortality. Nevertheless, some trends seem an obvious result of specific conservation efforts. The reduction of the cases of poisoning starting from the year 2000 could be the result of the application of specific measures, legislative as much as preventative and sanctioning in order to minimize the illegal use of poisoning and its impact (Hernández 2006). In particular, in Andalusia and the Balearic Islands, these specific measures (together with the actions undertaken in other Autonomous Communities) seem to be effective.
because a reduction of the mortality by poisoning of the Cinereous vulture has been documented (Hernández 2006).

Lastly, the results suggest that the impact of the illegal use of poison on the Cinereous vulture is conditioned by the type of bait used and the toxicant chosen. In this way, the toxicant has proven to be the most lethal is the aldicarb and the most lethal bait are carcasses or parts of small game animals (especially rabbit). The effect of both factors, type of bait and chosen toxicant, reveals that there are combinations that are especially lethal, having caused the most serious case of poisoning of the Cinereous vulture registered in a developed country in various decades (38 individuals).

Disturbance at nesting sites has been considered the most important factor of non-natural breeding failure in Cinereous vultures (Donázar et al. 2002; Morán-López et al. 2006). As our results suggest, the effects of poisoning in the mortality of the adult breeding population seems significant and their implications in population dynamics could be important. In species with extreme K-selected life history strategies adult mortality may have significant consequences because population stability demands high adult survival rates (see Meretsky et al. 2000). This means that management actions, as well as prioritizing in habitat conservation and minimizing anthropic disturbance in nesting areas, should focus on urgently reducing or eliminating the cases of poisoning due to the serious consequences it may have in the population dynamic of the Cinereous vulture and other threatened species (see González et al. 2007; Margalida et al. 2008). In this sense, regulatory changes in pesticide approvals should be contemplated as one of the most effective actions that could reduce the cases of malicious poisoning of Cinereous vultures.


References


DOCE 2003/199/CE (2003) Directiva del Consejo del 18 de marzo relativa a la no inclusión del Aldicarb en el Anexo I de la Directiva 91/414/CEE y a la retirada de las autorizaciones de los productos fitosanitarios que contengan esta sustancia activa. DOUE 76:21–24


Hintze J (2001) NCSS and PASS Number cruncher statistical system. Kaysville, Utah


