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# Causes of Raptor Mortality in Crete

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## ABSTRACT

Raptors found injured as well as a small sample of carcasses collected during the period 1992-2002 were used for the assessment of natural and man-induced mortality factors in Crete. Shooting, poisoning, starvation, collision with power lines, accidents and drowning at sea and in water reservoirs have been the main death causes. The Buzzard, Golden Eagle and the two vulture species that occur on the island have suffered most of the impact of human activities. Illegal shooting and poisoning accounted for more than 60% of the mortality cases (although the total number of birds affected by the latter is suspected to be higher). Poisoning is considered to be an increasing threat mainly due to modern farming methods and commercial standards for the export of agricultural products.

## INTRODUCTION

Crete has been a stronghold for several bird of prey species in Greece as it harbours substantial breeding populations of national and global importance (i.e. Bearded Vulture *Gypaetus barbatus*, Griffon Vulture *Gyps fulvus*, Eleonora's Falcon *Falco eleonora* et.c). Habitat conditions are principally favourable for large species such as vultures and eagles that select high inaccessible cliffs for nesting. Besides the rugged terrain in its high mountains and numerous gorges (more than one hundred) as well as the steep rocks in satellite islets offer primarily shelter and ample breeding opportunities to many other cliff-nesting raptors. In addition the mild winters and the island's agricultural landscape have allowed many species, which are summer visitors in Greece, to stay all year round (e.g. Scops Owl *Otus scops*). Furthermore Crete functions as a stopover for many raptor species that cross the Mediterranean on spring and autumn migrations. In the latter case, few food resources are available in late summer and autumn in North Africa, thus some birds appear to fly in one nonstop crossing over the southern Mediterranean and the Sahara (Moreau 1961; Walter 1979). Considering the distance from Crete to the coast of Libya such a journey ranges from 1.800 to 2.500km and reveals the significance of the island for refuelling migrants.

Out of a total of 37 diurnal and 9 nocturnal birds of prey that occur in Greece, 36 (97%) and 7 (78%) respectively are found in Crete (Table 1, Appendix). The number of nesting raptor species is estimated at 16, a figure that constitutes 14,7%-21,3% of the island's avifauna, depending on the number of species regarded as breeders (Stresemann 1956, 82 species; Vaglianos 1984, 109 species; Malakou 1994, 75 species) and represents 48% of the number of breeding raptors of Greece. Eight species have also been included in the Red Data Book of the threatened vertebrates of Greece (Karandinos 1992): the Bearded Vulture, classified as on the brink of extinction at national scale, the Griffon Vulture, the Golden Eagle *Aquila chrysaetos*, Bonelli's Eagle *Hieraaetus fasciatus* and the Lanner *Falco biarmicus*, classified as vulnerable as their populations are under constant pressure and can easily "drop" to the "endangered" category, the Long-legged Buzzard *Buteo rufinus*, classified as rare because of its small breeding population, and lastly the Peregrine *Falco peregrinus* and Eleonora's Falcons, classified as insufficiently known since the available data on their distribution and status are poor and their populations need better monitoring (Table 2, Appendix).

The unfavourable conservation status of the aforementioned species has been the by-product of agricultural intensification and tourist development during the last two decades. This was especially so after Greece joined the European Union in 1981 and received financial aid in the form of subsidies for many agricultural products (e.g. olive oil, raisins, sheep and goat meat et.c). At present monocultures of olive trees and vineyards have covered much of low and middle land while the coastline has been exploited by the tourist industry. Mountain areas probably bear the highest stock density in Europe and rangelands are being continuously degraded (Hill *et al.* 1998; Lyrintzis & Papanastasis 1995). Compared to the pre-war era much of the island's landscape has changed and it would be naïve to believe that the increasing human population and subsequent pressure on wildlife and its habitats will relax in the near future. On the contrary the demand for energy and space is intense and anticipated to increase mainly because of urban sprawl and agricultural intensification. As a result, new kinds of infrastructure that have already appeared in many parts of the island (e.g. reservoirs, greenhouses, windmills, irrigation et.c.) are expected to spread.

The present study addresses the majority of known mortality cases of birds of prey on Crete during 1992-2002. The ultimate aim has been the evaluation of all actual and potential causes of raptor deaths and an assessment of the significance of the different natural and man-induced mortality factors. The case of the declining Eleonora's Falcon (Thorstrom & Rene de Roland 2000; Ristow 2001) is discussed at greater length.

## MATERIAL AND METHODS

Information was obtained from three main sources: a) communication with the Forestry Departments in the four prefectures of the island covering the period 1992-2002; b) the relevant database of the Hellenic Wildlife Hospital (HWH) based on the island of Aegina for the period 1996-2000, and c) the archives of the Natural History Museum of Crete (NHMC) that has been

functioning since 1998 as a first aid centre before transporting problematic birds to the HWH. The causes of death were registered according to the following categories and were considered as mortality factors regardless of the fact that many birds did not die but were rehabilitated and released back to the wild:

- 1) **Direct persecution:** Birds found dead or injured with broken limbs and apparent signs of gunshots (e.g. haemorrhage). For a number of individuals that bore no external injuries but with shooting suspected as the cause of death, or for rehabilitation, X-rays were taken in an effort to detect gunshots and bone fractures.
- 2) **Poisoning:** Birds with normal weight that had been collected on the ground and bore symptoms of poisoning (e.g. vomiting and diarrhoea, convulsions et.c.). For a limited number of carcasses (n= 25) post-mortem examinations were made, while toxicological analysis was undertaken for priority species (European Commission 2002) in order to verify the cause of death and find out the chemical substance responsible.
- 3) **Starvation:** Birds in bad physical condition (e.g. weak, dehydrated and underweight) and were unable to fly.
- 4) **Accident:** Birds bearing injuries and fractures caused by collisions with solid objects apart from power lines (e.g. rocks, roofs, glass windows, cars etc.).
- 5) **Captivity:** Birds that were kept in cages or aviaries for long periods. Most were collected by locals as fledglings or found injured on the ground but not released after recovery.
- 6) **Premature fledging:** Chicks fallen from their nest or found on the ground away from their nest sites with no clear problem or deficiencies.
- 7) **Drowning:** Birds found dead at sea and in water reservoirs or rescued by humans. Their weight and behaviour were normal and could be readily released after a few days.
- 8) **Collisions with power lines:** Birds found dead or injured under power lines or collected with signs of electrocution (mainly burns).
- 9) **Sickness:** Birds with no fractures, injuries or signs of poisoning but with symptoms of infectious disease, ectoparasites, virosis, diarrhoea etc. Birds kept in captivity and brought in by locals in bad condition (e.g. calcium deficiency, mycosis, bumble foot, avitaminosis etc.) were excluded.
- 10) **Unknown cause:** Any cause that cannot be classified in the above categories as well as cases where the carcasses were found too decomposed for collection.

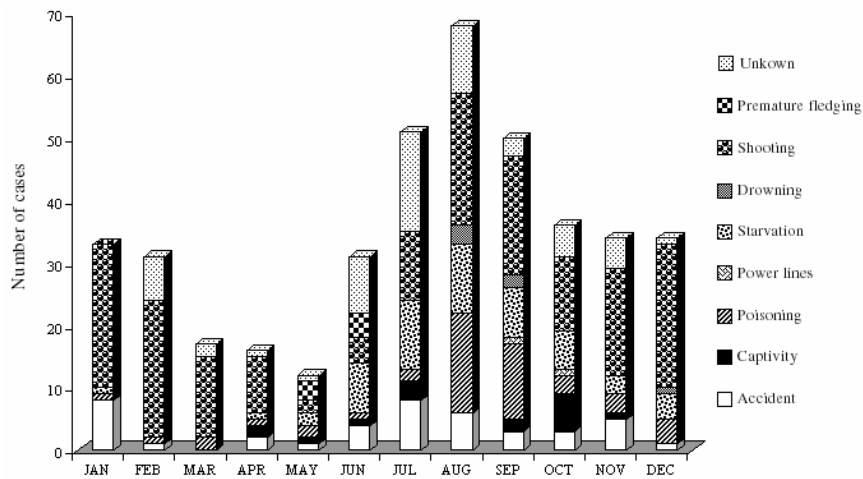
In one incidence Forest officers confiscated a juvenile Golden Eagle from civilians. The bird had serious bone abnormalities and undeveloped plumage. (This case was not included in the analysis, as there were not enough information to substantiate whether it was sick, mis-fledged or robbed from the eyrie).

## RESULTS AND DISCUSSION

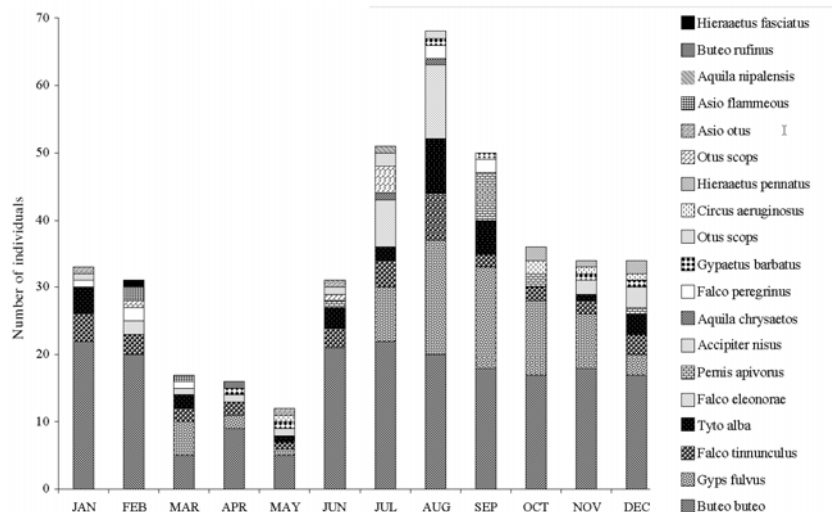
A total of 476 dead, poisoned or injured raptors have been received in the Hellenic Wildlife Hospital on Aegina and the first aid centre of the Natural History Museum of Crete during 1992-2002. On average 34 raptors were found dead or brought in disabled every month. The majority of the birds were

received in summer and early autumn with 40.9% collected in the three months of July-September. The monthly rate fluctuated about the average in early summer, mid-autumn and winter months, peaking in August (68 individuals) and decreasing in spring with the least number of recoveries during May (i.e. 12 individuals). On the other hand the number of different species that were collected was equally distributed throughout the year. Almost all of the mortality factors were recorded during September and October whereas incidences of poisoning and shooting were the only ones that occurred in all months (Figure 1). However, the recovery rate in time seems to depend on the species' abundance and conspicuousness, peaking during autumn migration and the grape and olive-harvest season (e.g. November- January and August-September respectively, Figure 2) when many people are active in the fields.

**Figure 1. Seasonal distribution of mortality factors of raptors in Crete during 1992-2002 (n= 413)**



**Figure 2. Seasonal distribution and species involved of raptor recoveries in Crete during 1992-2002 (n= 413)**



Buzzards and the Griffon Vultures accounted for 66.6% of the raptors received, followed by Kestrels *Falco tinnunculus* and Barn Owls *Tyto alba* representing 13.7% of the total recoveries. However, given the population size of the resident raptors, the most affected species have been the Golden Eagle and Bearded Vulture that comparatively suffered higher losses (Table 1). For the rest of the species the number of recoveries was relatively low even though some are quite common summer visitors such as Eleonora's Falcon and the Scops Owl *Otus scops* or spring and autumn migrants such as the Marsh Harrier *Circus aeruginosus* and the Honey Buzzard *Pernis apivorus*. The number of Sparrowhawk *Accipiter nisus* and Booted Eagle *Hieraaetus pennatus* recoveries was also limited compared to their numbers and distribution on the island although the population influx in wintertime depends greatly on the severity of weather conditions in mainland Greece. Peregrine Falcon and Bonelli's Eagle were few, probably due to their cryptic behaviour and inconspicuousness. The number of individuals received of the rest of the species was low because of their nocturnal activity and restricted range on the island (i.e. Long-eared *Asio otus* and Short-eared Owl *A. flammeus*) or their rarity such as the Steppe Eagle *Aquila nipalensis*, which is an accidental winter visitor, or the Long-legged Buzzard *Buteo rufinus* that breeds on the islet of Dia, north of Crete.

**Table 1. Birds of prey collected dead, poisoned or injured in Crete during 1992-2002**

Species (Number of breeding pairs)	No. of cases	%
Common Buzzard	194	40,8
Griffon Vulture (100-140)	123	25,8
Kestrel	36	7,6
Barn Owl	29	6,1
Eleonora's Falcon (1500 *)	19	4,0
Honey Buzzard	11	2,3
Scops Owl	11	2,3
Sparrowhawk	9	1,9
Golden Eagle (16-22)	9	1,9
Peregrine Falcon (70-90)	8	1,7
Bearded Vulture (4)	7	1,5
Marsh Harrier	5	1,1
Booted Eagle	5	1,1
Long-eared Owl	4	0,8
Short-eared Owl	3	0,6
Long-legged Buzzard (3-5)	1	0,2
Steppe Eagle	1	0,2
Bonelli's Eagle (14-18)	1	0,2
<b>Total</b>	<b>476</b>	<b>100</b>

\* Source: Ristow 1999

The main causes of raptor mortality have been direct persecution and

poisoning which accounted for the majority of deaths (40.76% and 17.44% respectively). Additionally, in 13.87% of the cases the cause of death or disability was unknown. However, in this category more than half of the birds were suspected to have been shot as the carcasses were found with broken wings and no signs of predation or consumption by mammalian carnivores. So overall human induced mortality, in the form of shooting and poisoning, seems to be responsible for more than 60% of the causes of death (Table 2).

**Table 2. Causes of raptor mortality in Crete during 1992-2002**

Causes of mortality	Number of cases	%
Direct persecution	194	40,76
Poisoning	83	17,44
Unknown	66	13,87
Starvation	57	11,97
Accident	43	9,03
Captivity	16	3,36
Premature fledging	7	1,47
Drowning	6	1,26
Collisions with power lines	3	0,63
Sickness	1	0,21
<b>Total</b>	<b>476</b>	<b>100</b>

Starvation, accidents and captivity accounted for 24.36% of the cases, while premature fledging, drowning, electrocution and sickness were rather negligible (i.e. 3.57% of the cases). In addition the effect of two wind farms that function in Crete remains largely unknown. Although no bird was collected under or near them, the impact of windmills remains unknown since its evaluation would need systematic monitoring. More specifically:

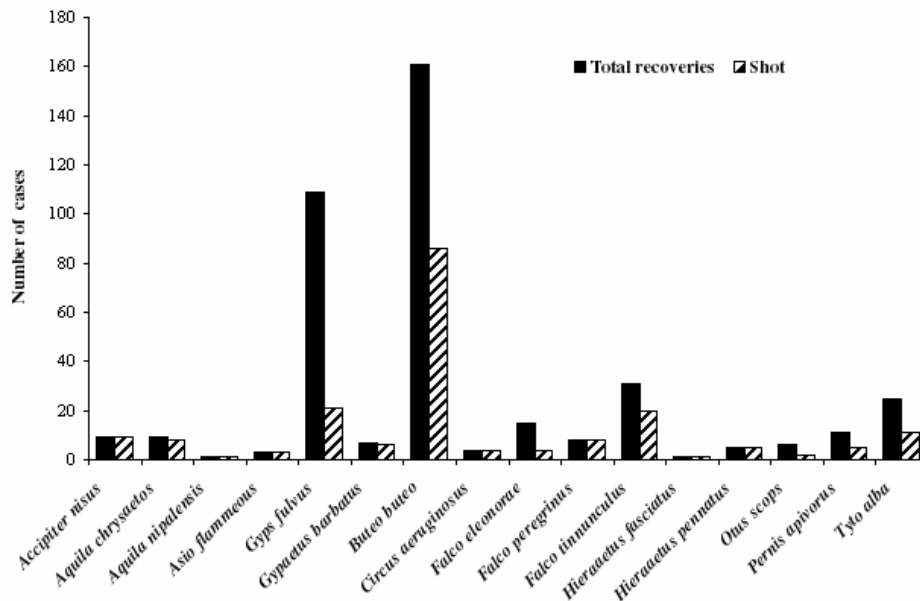
**Direct persecution.**

Shooting was responsible for more than 50% of the recoveries of the resident raptors apart from owls and Griffon Vultures (Figure 3). Shooting has been the prime cause of death for 88.8% of the species received and accounted on average for 15 raptor recoveries per month. Most of the birds shot were Buzzards (86 individuals), Griffon Vultures (21 individuals) and Kestrels (20 individuals). 13 birds (i.e. six Griffon Vultures, three Bearded Vultures and four Golden Eagles) were found stuffed, having been located as ornaments in hotels, houses and small restaurants. The activity has been more intense during the hunting season namely late August to late February peaking in winter months. Shooting has taken the greater toll from the populations of the Bearded Vulture and the Golden Eagle as well as many migratory Buzzards in autumn.

Large raptors such as vultures and eagles are more prone to be shot because of their size and flight behaviour (i.e. soaring) and are collected for trophies or taxidermy. Moreover the Golden Eagle is blamed for preying on lambs and has been systematically persecuted by stock- breeders. Juvenile Bearded Vultures are also misidentified by their dark plumage and killed as eagles. Buzzards,

Kestrels and Barn Owls have been quite common among persecuted birds because of their relative abundance and wider distribution. Additionally these species become easy targets as they perch on utility poles near olive grooves and vineyards as well as close to houses when foraging for rodents. Buzzards have also proved quite tenacious and may survive with serious wounds for days, thus producing a high recovery rate.

**Figure 3. Birds of prey that were found shot in Crete during 1992-2002**



### Poisoning.

Deliberate or secondary poisoning has been the second significant mortality factor that accounted for 20.4% of the known cases of raptors' death. Most of the poisoning incidences have taken place in summer and early autumn. The Griffon Vulture suffered by far the greatest impact (68.7% of the cases). Many of them were received with no clinical symptoms and died after two or three days. Their abnormal behaviour such as spinning and final collapse of their nervous system suggested the effect of an acetylcholinesterase inhibitor. Post mortem examination showed extensive internal bleeding. Eleonora's Falcon accounted for 10.8% of the poisoning cases and 57.8% of the birds were collected from the Heraklion area during 1-12 July and 2-8 August 1999 (Ristow & Xirouchakis 2000).

Toxicological analysis of a Bearded Vulture revealed that the organophosphate Fenthion (trade name: Lebaycid) was the cause of death. A more thorough investigation showed that a stockbreeder deliberately spilled the chemical (normally used against ticks) over a lamb carcass. Bearded Vultures often use the same flight route every day and fly low in search of food, often passing a few metres over free-grazing flocks. Unfortunately the perpetrator attributed this kind of behaviour to a foraging predator. However, overstocking and rangeland deterioration has resulted in breeding the animals in pens or

large enclosures and supporting them with fodders. Small carnivores such as Martens are attracted to these places in search of food (mainly rubbish and offal etc.) and consequently provoke the excessive use of baits.

The carbamate Methomyl (sold in Crete under the commercial names of Lannate 90SP Lannate 20SP, Lannate 25WP and Methomyl-Makhteshim 20SL) was traced in the guts of two Eleonora's Falcons. LD<sub>50</sub> of Methomyl in birds ranges from 10-42mg/Kg (Tucker & Crabtree 1970; Kaplan & Sherman 1977; US Environmental Protection Agency 1987; Du Pont 1989) and 5000mg/Kg if absorbed through the skin (Tomlin 1994). Given the estimated lethal dose to a 330-390 grams raptor and the fact that Eleonora's Falcon is an aerial feeder, poisoning by consumption of poisoned food, bathing in poisoned water or inhalation was considered most unlikely (Ristow 2001; Grivas & Chilitides 2002). Aerial spraying is prohibited in Greece so the only way that the falcons acquired the chemical should be by drinking poisoned water (Tsatsakis *et al.* 2001). The most valuable crop in Crete in July is the table-grape variety of sultana. This variety is mainly cultivated in the Heraklion area where 77% of the vineyards of Crete are found and 93.5% of the grapes are produced, of which 64% are exported (Heraklion Dept. of Agricultural Development/ Division of Viniculture/ pers. com.). In addition a new cultivating method for the production of late table grapes has become quite popular since 1995. Farmers cover the vineyards with plastic in an effort to increase the temperature and slow down photosynthesis. By this means the harvest may delay for 2.5 months and grape production may extend through October. In the hot dry summer of Crete covered vineyards constitute the only plentiful source of food for many species of wildlife. Viticulturists admit they put out baits to protect their harvest from mice and mainly sparrows. Lannate has been the most popular substance in baits because of its high toxicity and effectiveness against birds and mammals. The usual form is a poisoned meatball or water in clay bowls where it can last longer, normally about a week (Howard 1991). Moreover the export standards of a single damaged grape in a 10kg cluster (Roditakis 1987) make the laying out of poisoned baits for pests more frequent.

The case of the poisoned Eleonora's Falcons was quite alarming because the use of baits has been related to the decline of a large colony located 12km north of Crete. The decrease was estimated at a rate of 15% per year for the period 1997-2000 (Ristow 2001). Meanwhile it is known that aerial spraying by Fipronil (trade name: Adonis 4UL/ 7,5 UL) and Deltamethrin (trade name: Decis 17,5 UL) has been carried out in 1997-2000 in 5.6% of Madagascar's territory (that constitute its wintering grounds) for control of the migratory Locust *Locusta migratoria capito* (Habbard 1999; Tingle & McWilliam 1999; Peveling 2000). However, things became more complicated when chemical testing for insecticides in three falcon carcasses collected from the island of Milos and mainland Greece in July 2002 confirmed the presence of the organophosphates Phosphamidon and Mephosfolan (commercial names: Dymecron 50SCW and Cytrolane respectively). For one thing, these results should lead our research to additional areas outside Greece, to Cytrolane has not been imported to the country since 1994 and its license expired in 1996.

#### *Starvation.*

57 raptors were collected weak and unable to become airborne. Most of them were Buzzards and Griffon Vultures (85.9% of the cases) and were found during mid-June to late October (94.7% of the cases), namely during the autumn migration and Griffon Vulture dispersal period. All of the Griffons were juvenile birds in their first calendar year. Many times newly-fledged Griffons fail to follow the rest of the vultures on their daily foraging trips or, if they do, may fail to return to their natal colony. If a young bird overnights away from the breeding cliff the possibility that its parents feed it is nil (pers. obs.).

#### *Accident.*

In 43 cases Buzzards and Kestrels that had collided with walls or cars and owl species that had struck roofs or become trapped inside barns and old houses were received. Accidents manifested two peaks, one in January and one in August. Many of the Buzzards were probably birds on migration. However there is a quite high possibility that some of them had been poisoned and were suffering from lack of orientation and reflexes.

#### *Captivity.*

15 Common and one Long-legged Buzzard were received after having been kept in captivity. Most of the birds had been found exhausted in agricultural areas and were sent to the HWH or the NHMC only when their condition deteriorated. The period that most of the captive individuals were brought in was from July up to late October (73.3% of the cases). Generally the custom of keeping raptors in cages has been quite common in Crete. Many peasants take wounded raptors or chicks fallen from the nest and raise them as pets. Numerous times Kestrels, Buzzards and Eleonora's Falcons or even Griffons have been located in village hen-houses as well as in aviaries of luxurious hotels that maintain small "zoos" as a tourist attraction.

#### *Premature fledging.*

Five Buzzard chicks fledged prematurely in May-June as well as one Barn Owl and one Long-eared Owl, both in mid-June. The reason for leaving the nest could be the result of extremely high temperatures as well as human interference. Buzzards in Crete nest on trees or bushes overhanging rock ledges and vertical cliffs. The availability of tall trees in most of the species' range is low and some pairs are forced to nest close to humans in agricultural areas. In at least two cases it was proved that farmers working near the nest trees caused the flushing of the chicks.

#### *Drowning*

Three young Griffon Vultures were collected from the Libyan Sea a few kilometres from the south coast of the island. The incidences took place in August, September and December respectively. Another individual was rescued in mid-August from a water reservoir constructed less than 2km from the breeding cliff of a colony. Griffon Vultures drowned at sea have also been found on the north coast (Vaglianos pers. comm.; Marincovic & Orladic 1994).

Young birds are more susceptible to drowning as they are weak fliers and the fledging period from mid-July to late August coincides with the strong north winds (“*meltemia*”) that prevail in the Aegean that time. On three occasions I have recorded young Griffons struggling to return on Crete as they were swept over the sea by the wind. Considering that many colonies are located on coastal cliffs while most of them face southwards (Xirouchakis 2003), the impact of drowning might be more serious than expected. Moreover one individual collected from a small farm dam reflects another potential threat to the species. Water reservoirs of about 0.1ha have become quite popular in Crete and expanded rapidly the last few years. The impact of these is expected to increase as the places where birds have free access to water for drinking and bathing become scarce. This should also be the case of two Buzzards that had fallen into pools of olive- oil waste in August.

#### *Collisions with power lines.*

In three documented cases juvenile Griffon Vultures were found under electricity pylons with symptoms of electrocution and minor burns. Griffon Vultures do not roost on electricity poles in Crete, since there are numerous cliffs in their foraging areas. However, young birds in their post-fledging wanderings have not yet mastered their flight abilities and can be easily drifted by the air currents. All incidences took place in autumn (i.e. September and October) in days with strong north winds, in areas with electricity poles situated near rocky outcrops.

#### *Sickness.*

A juvenile Griffon Vulture that suffered from diarrhoea has been classified as sick although secondary poisoning was the suspected cause of its grounding. The bird recovered quickly after three days of medical treatment and full access to food and water.

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## APPENDIX

**Table 1. Status of Birds of Prey in Crete (R: Resident/ Breeding, S: Summer visitor/ Breeding, W: Winter visitor, M: Spring/ Autumn migrant, A: Accidental in winter (W) or during migration (M), I-B: Irregular breeder, I-W: Irregular winter visitor, F: Formerly breeding, E: Extinct, U: Status unknown)**

Species	Species	Status
Honey Buzzard	<i>Pernis apivorus</i>	M
Black-winged Kite	<i>Elanus caeruleus</i>	A (W)
Black Kite	<i>Milvus migrans</i>	W, M
Red Kite	<i>Milvus milvus</i>	M
White-tailed Eagle	<i>Haliaeetus albicilla</i>	I-W
Bearded Vulture	<i>Gypaetus barbatus</i>	R
Egyptian Vulture	<i>Neophron percnopterus</i>	M
Griffon Vulture	<i>Gyps fulvus</i>	R
Black Vulture	<i>Aegypius monachus</i>	E
Short-toed Eagle	<i>Circaetus gallicus</i>	I-B, M
Marsh Harrier	<i>Circus aeruginosus</i>	M
Hen Harrier	<i>Circus cyaneus</i>	W, M
Pallid Harrier	<i>Circus macrourus</i>	M
Montagu's Harrier	<i>Circus pygargus</i>	M
Goshawk	<i>Accipiter gentilis</i>	I-W
Sparrowhawk	<i>Accipiter nisus</i>	I-B, W
Levant Sparrowhawk	<i>Accipiter brevipes</i>	M
Buzzard	<i>Buteo buteo</i>	R, W
Long-legged Buzzard	<i>Buteo rufinus</i>	R, W
Rough-legged Buzzard	<i>Buteo lagopus</i>	I-W
Lesser-spotted Eagle	<i>Aquila pomarina</i>	M
Spotted Eagle	<i>Aquila clanga</i>	A (W)
Steppe Eagle	<i>Aquila nipalensis</i>	I-W, A (M)
Imperial Eagle	<i>Aquila heliaca</i>	W, M
Golden Eagle	<i>Aquila chrysaetos</i>	R
Booted Eagle	<i>Hieraetus pennatus</i>	W, M
Bonelli's Eagle	<i>Hieraetus fasciatus</i>	R
Osprey	<i>Pandion haliaetus</i>	M
Lesser Kestrel	<i>Falco naumanni</i>	F, M
Kestrel	<i>Falco tinnunculus</i>	R
Red-footed Falcon	<i>Falco vespertinus</i>	M
Merlin	<i>Falco columbarius</i>	A (M)
Hobby	<i>Falco subbuteo</i>	M
Eleonora's Falcon	<i>Falco eleonora</i>	S
Lanner	<i>Falco biarmicus</i>	R
Saker	<i>Falco cherrug</i>	I-W
Peregrine Falcon	<i>Falco peregrinus</i>	R
Barn Owl	<i>Tyto alba</i>	R
Scops Owl	<i>Otus scops</i>	R, S
Eagle Owl	<i>Bubo bubo</i>	U
Little Owl	<i>Athene noctua</i>	R

Tawny Owl	<i>Strix aluco</i>	W, M
Long-eared Owl	<i>Asio otus</i>	R
Short-eared Owl	<i>Asio flammeus</i>	I-W, A (M)

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