



# Cabo Verde Egyptian Vulture *Neophron percnopterus* on the brink: community perceptions, inferences and facts of an extreme population crash

RUI FREITAS,  CATELENE MONTEIRO, ISABEL RODRIGUES, ALEX TAVARES, GILDA MONTEIRO, PEDRO LÓPEZ, SAMIR MARTINS, JOÃO FERREIRA, LIZA LIMA, JOSÉ PEDRO TAVARES and LUÍS PALMA 

## Summary

The Egyptian Vulture *Neophron percnopterus* was once an abundant species in the Cabo Verde Islands. Since the 1960s though, and especially during the 1980–1990s, it consistently declined to near extinction. Evidence collected indicates a remnant population of about a dozen pairs or less, scattered through the desert rangelands of only three islands. Extensive enquiry work revealed that this likely resulted from the concomitant effects of the rise in unnatural mortality due to the formerly widespread and long-lasting use of dangerous pesticides and the (still on-going) poisoning of stray dogs and other nuisance animals, and a decrease in food resources associated with factors linked with development, such as urbanisation, rural abandonment and better sanitation. Avoiding imminent extinction calls for emergency action against current threats to the remaining vultures, such as poisoning and electrocution, but also potential causes of impaired fecundity such as hazardous pesticides and shortage of food resources.

## Introduction

Vultures have been declining at an alarming rate worldwide due to human-related factors, including intentional and secondary poisoning, electrocution and decrease in food supplies (Ogada *et al.* 2012, 2016). In consequence, vultures are now the avian functional guild at a higher risk of extinction in the world (Buechley and Şekercioğlu 2016).

The collapse of vulture populations due to the ingestion of dietary toxins, including the veterinary drug diclofenac and poisons used against mammalian predators, may heighten the likelihood of dangerous pathogenic agents spreading from carcasses, with serious consequences to human and livestock health, and the economy (Markandya *et al.* 2008, Buechley and Şekercioğlu 2016). Also, due to the lack of competition from vultures, opportunistic facultative scavengers may increase in numbers, a fact that, like mesopredator release resulting from the eradication of apex predators, may result in the undesirable increase in predation upon several species (Buechley and Şekercioğlu 2016).

Extensive livestock herding is a staple food source for healthy vulture populations (Olea and Mateo-Tomás 2009) and conversely, its abandonment is a major cause of food shortage, with a negative impact on their survival and productivity (Margalida and Colomer 2012, Margalida *et al.* 2018). In Europe, this situation worsened due to sanitary restrictions to control the spread of the bovine spongiform encephalopathy and the associated risk to public health in the late 1990s,

which forced the removal of most livestock carcasses from the open, with a serious decrease of food availability for vultures (Donázar *et al.* 2009, Margalida *et al.* 2010). More recently, new regulations aimed at reducing the prevalence of bovine tuberculosis in wild ungulates through complete removal of the leftovers from hunted animals came into force in parts of Spain, causing further limitation of the food supply for vultures (Margalida and Moleón 2016).

Besides the impacts of poisoning and food shortage, the risk of raptor mortality by collision with wind farms, although highly variable, may be high in some species, in sensitive locations and particular individual turbines; besides, wind farms may also cause the loss of bird habitats, either through the occupation of critical areas of the home range or by causing avoidance of the wind farm area (Sánchez-Zapata *et al.* 2016).

Vultures have sharply declined in Africa, including West Africa (Thiollay 2006, Botha *et al.* 2012, Ogada *et al.* 2016, Safford *et al.* 2019). Consequently, most African vulture species have been recently uplisted to 'Endangered' and 'Critically Endangered' status (IUCN 2018). Also, a Multi-species Action Plan to Conserve African-Eurasian Vultures (Vulture MsAP) was recently adopted by the CMS (Convention on the Conservation of Migratory Species of Wild Animals) (Botha *et al.* 2017).

The 'Endangered' Egyptian Vulture *Neophron percnopterus* currently suffers from the illegal use of poisons against carnivores, lead poisoning, habitat degradation, electrocution and collision with powerlines and wind farms, and decrease of food resources (Donázar *et al.* 2002b, Sarà and Di Vittorio 2003, Carrete *et al.* 2007, Mateo-Tomás and Olea 2010, Botha *et al.* 2017).

In Africa, the species ranges from the Mediterranean to sub-Saharan Africa, with some island populations in the Arabian Sea and the Eastern Atlantic, including the Cabo Verde archipelago (Ferguson-Lees and Christie 2001). There are two currently recognised subspecies in the region: the nominal *Neophron p. percnopterus* and *N. p. majorensis* from the Canary Islands (Ferguson-Lees and Christie 2001, Donázar *et al.* 2002a). Island populations around Africa have suffered particularly severe declines, and the species has disappeared from Cyprus, Crete and Malta (Levy 1996), while in the Canary Islands it currently survives only on the two easternmost islands (Donázar *et al.* 2002b).

The Egyptian Vulture is the only vulture species occurring in the archipelago of Cabo Verde. It was an abundant species in the past (e.g. Moseley 1879), and during the mid-20<sup>th</sup> century the species still occupied all islands and islets (Naurois 1969, 1985, Bruyn and Koedijk 1990), although already declining (Hazevoet 1995). Indeed, towards the end of the century, Hille and Thiollay (2000) could not find the species on Sal, Santiago and Brava, and Barone *et al.* (2000) presumed it had already disappeared from Sal, São Vicente and Fogo. At the turn of the 21<sup>st</sup> century, Santo Antão might have held 10–20 pairs (Palacios 2002), still often seen flying over the villages (L. Palma pers. obs.). Lately, the species was said to remain only in Santo Antão and Boa Vista, not exceeding 13 breeding pairs (Hille and Collar 2011). A few years before, it was already missing from the mountains of Santiago and São Nicolau (Boughtflower 2006). Correia (2007) and Fernandes (2008) also could not collect any records respectively in the islands of Santiago and Fogo.

Like in the Canary Islands (Palacios 2000, Donázar *et al.* 2002b), the Egyptian Vulture's marked decline in Cabo Verde was presumably due to various causes, among which secondary poisoning linked to retaliation against stray dogs attacks on livestock (Hazevoet 1997), the use of dangerous rodenticides and pesticides, the decrease of food resources due to periodic drought-induced losses of livestock, as well as the changes in animal husbandry (fewer available corpses and afterbirths), slaughterhouse practices (less waste) and refuse disposal (use of burning), and improved urban sanitation (cleaner streets) (Hille and Collar 2011).

The main objective of this study was to make an assessment, as comprehensive as possible, of the species' current situation and its conservation problems, in order to provide guidance for emergency actions and management decisions, and help in delineating a sound conservation strategy for the species in the archipelago.

In particular, due the paucity of information on the species in Cabo Verde, including field data, and in view of the limited funds and few qualified personnel for a direct field assessment, we opted to carry out extensive interviews with knowledgeable rural people that might enable us gain a broader view of the current situation and recent history. This was complemented by all other information available in publications and unpublished records of vulture sightings from various sources.

It has been shown that studies using local peoples' perceptions can provide important insights into the social impacts and ecological outcomes of conservation, and at the same time a better understanding of the conservation implications of human behaviours and allow sounder conservation action (Martín-López *et al.* 2012, Bennett 2016). Social perceptions have been used to address wildlife conservation issues, which in the case of vultures included the identification of threats (Pfeiffer *et al.* 2015, Henriques *et al.* 2018) and specifically the understanding of secondary poisoning prevalence (Santageli *et al.* 2016), or the perception of how vultures are valued for the ecosystem services they provide (Morales-Reyes *et al.* 2018) and of their conservation importance (Cortés-Avizanda *et al.* 2018). This is especially relevant in Africa where most vulture species are dwindling (Craig *et al.* 2018, Henriques *et al.* 2018).

Conversely, these studies can also highlight the perception of vultures as a nuisance (Gbogbo and Awotwe-Pratt 2008, Henriques *et al.* 2018), or enable the recognition of negative attitudes towards vultures and help informing on the need of education programmes to change attitudes (Arnulphi *et al.* 2017). Several recent studies specifically addressed the perception of communities towards the Egyptian Vulture, generally revealing positive but heterogeneous views depending on the stakeholder profile, which may furthermore suggest conservation actions (Cortés-Avizanda *et al.* 2018). On the island of Fuerteventura (Canary Islands), which shows environmental similarities with some of the Cabo Verde Islands, a similar study showed that the Egyptian Vulture is seen as a beneficial scavenging service provider, and that this view is intimately related to the persistence of traditional livestock farming (García-Alfonso *et al.* 2018).

## Material and methods

### *Study area*

The archipelago of Cabo Verde lies in the Atlantic Ocean about 570 km off the coast of West Africa, between 14°45'–17°10' N and 25°20'–22°40' W (Figure 1). It comprises 10 islands and eight islets of volcanic origin with ages ranging from ~ 3 to 15.8 Mya (Ramalho 2011) and totalling an area of 4,033 km<sup>2</sup>. The younger western islands (Fogo, Brava, Santiago, Santo Antão and São Nicolau) exhibit steep relief and higher altitudes (reaching 2,828 m in Fogo) while the older eastern ones (Sal, Boa Vista and Maio) are lower (max. 406 m on Sal) and much flatter (Duarte and Romeiras 2009); Santa Luzia and São Vicente are of intermediate ruggedness. Cabo Verde is located within the Sahelian arid belt with a tropical arid to semi-desert climate and a wet period of one to three months (August to October). Annual precipitation barely reaches 260 mm and is unevenly distributed. Mean annual temperatures range from 23–27 °C at sea level to 18–20 °C at high altitude, but temperatures can reach 35–40 °C in the inner regions of the arid Eastern Islands. The archipelago is exposed to the north-easterly trade winds throughout most of the year, which especially affect the north-eastern slopes of the mountainous islands above 300–400 m (Duarte and Romeiras 2009). The archipelago of Cabo Verde is commonly divided into two island groups according to their exposure to trade winds: the Barlavento (windward) – Santo Antão, São Vicente, Santa Luzia, São Nicolau, Sal and Boa Vista; and the Sotavento (leeward) – Fogo, Santiago, Brava and Maio.

### *Compilation of published and unpublished data*

We made a broad review of Egyptian Vulture sighting records from 1998 up to 2018, retrieved from various sources: publications, unpublished reports and personal communications of

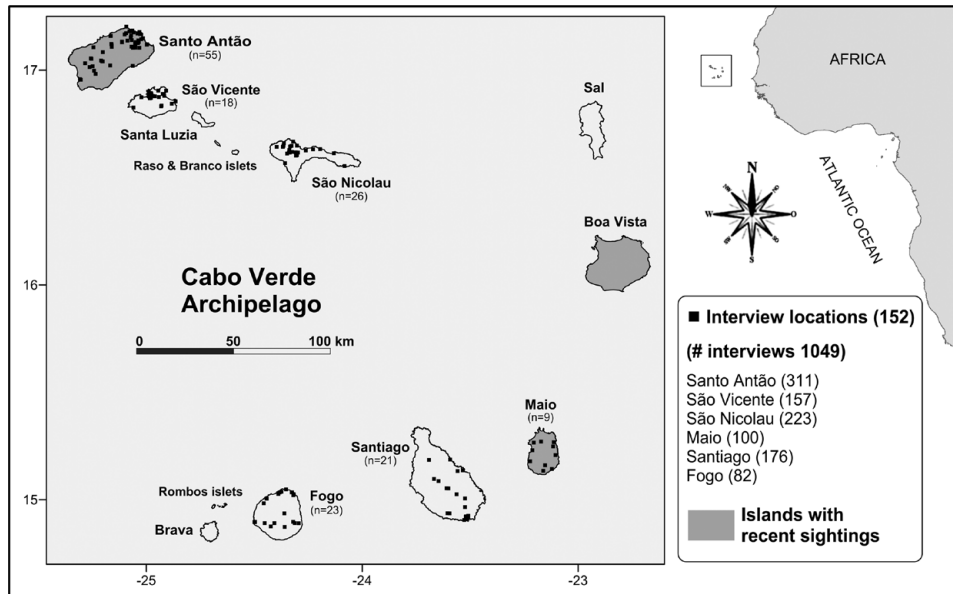


Figure 1. Cabo Verde archipelago with interviewing locations (black squares); number of interview locations per island are shown in brackets. Islands with Egyptian Vulture sightings after 2014 are shaded in grey.

ornithologists and amateur birdwatchers, plus our own observations (Table S1 in the online Supplementary Materials).

This information was used, jointly with the results of the enquiry work (see below), to estimate the current population status and recent trends, including detailed accounts for each island (Appendix S1), as well as an attempt to reconstruct the approximate chronology of the species' decline in the archipelago (Figure 7). For the latter, as we could not use a quantitative approach due to the almost complete lack of numerical data on the species prior to our study, we established relative abundance categories based on all available sources, namely mentions of the species abundance in the literature (e.g. Naurois 1985, Hazevoet 1995, Hille and Thiollay 2000, Barone *et al.* 2000, Palacios 2002, Hille and Collar 2011), the compilation of unpublished sighting records and our own observations (Table S1), as well as the statements of people interviewed. Because most of the available data are subjective assessments of abundance, this reconstruction attempt is inevitably approximate. Still, we believe this is a reasonable approach to the recent history of the species in the archipelago.

Additional sources of information concerning human population, livestock statistics, agrochemicals, and environmental politics were consulted, including official documents of the National Institute of Statistics, and of the current Ministry of Agriculture and the Environment.

### *Enquiry work: geographical and social scope and structure*

We carried out 1,049 interviews during 67 days in 152 localities of the archipelago: between December 2014 and July 2015 in Santo Antão, São Nicolau, São Vicente and Santiago, and in March-April 2016 in Maio and Fogo (Figure 1, Table 1). As we sought knowledgeable individuals in order to improve the likelihood of obtaining useful information on the species in the present and recent past, most interviews were carried out with residents in rural communities who were above 40 years old, while favouring people with occupations that likely enabled more frequent

Table 1. Enquiry effort in 2014–2016 and percentages of responses respectively concerning vultures, livestock, pesticides and poisons, garbage disposal and slaughterhouses.

ISLANDS	# days	# localities	# enquiries	% responses per item				
				Vulture	Livestock	Toxics	Garbage	Slaughter
Santo Antão	18	55	311	100	31	15	24	20
São Nicolau	8	26	223	100	31	13	12	10
São Vicente	11	18	157	100	32	8	24	28
Santiago	9	21	176	100	47	21	47	48
Maio	16	9	100	100	32	30	13	100
Fogo	5	23	82	100	26	22	21	26
Total/average	67	152	1049	100	33	18	23	39

contact with vultures and their habitat, or involved potential impact on the conservation of the species (Figure 2). These included farmers, forestry rangers and technicians, shepherds, garbage dump workers and slaughterhouse personnel, as well as technicians linked with agriculture, environment and sanitation issues (of the Ministry of Agriculture and the Environment, the INIDA, National Institute of Agrarian Research and Development, and Municipalities).

We did not carry out interviews in the islands of Boa Vista, Sal and Brava. In the first case the yearly bird monitoring work done by BIOS.CV ([www.bioscabo Verde.com](http://www.bioscabo Verde.com)) since 2013 was judged enough for a status assessment of the species on the island, while Brava and Sal were not investigated due to time constraints and the presumption that these islands were already devoid of vultures, as confirmed on Sal (Palma 2016).

The interviews were conducted individually and face-to-face in Cabo Verdean Creole, following prior consent of the respondent and keeping information anonymous. The interviews were semi-structured, following open-ended questions concerning: 1) sightings of vultures and their nests, and the presumed causes of decline and current threats, 2) livestock rearing systems, numbers and trends of free herding, mainly of goats, 3) pesticide use, and use of poisons like strychnine and rodenticides, 4) garbage dumps and landfills, and 5) slaughterhouses, slaughter practices and the fate of animal leftovers (Table 1). Printed photographs of Egyptian Vultures in different plumage patterns were shown to aid in identifying the species, whose vernacular name used in the interviews in each island was the one locally in use. Enquiry data were analysed in pivot tables in MS Excel from which percentage graphs were extracted and uploaded into a Geographic Information System.

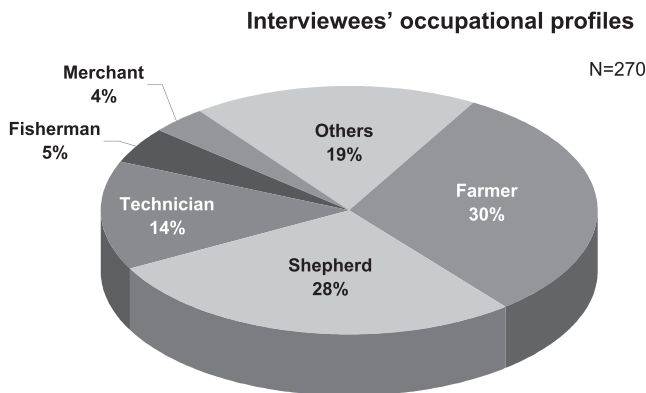


Figure 2. Occupational profiles of respondents. N is the number of respondents who declared occupation (26% of the interviewees).

In order to calculate the percentage of the rural population covered by the interviews we estimated the potential target population in each county of the sampled islands by consultation of the last (2010) official population census (INE.CV 2016a) regarding the resident rural population above 40 years old (~22%). Then we calculated the degree of enquiry coverage as the percentage of the potential target male and female segments of the rural communities that were interviewed. Although the demographic data are from 2010, this seemed to be a reasonable approach to evaluate the study coverage rate.

### *Field surveys*

Targeted field surveys were organised on Santo Antão in 2014–2018 and on Maio in 2015–2017 to search for vultures and their nests or signs of presence. Searches were also made in 2016 on São Nicolau and Sal (Palma 2016). On Boa Vista, vultures were recorded circumstantially since 2012 during bird monitoring by BIOS.CV (Table S1). Brava and the small islands of Santa Luzia and nearby islets were left unsurveyed due to the lack of recent records (only one possible vagrant reported from Brava in 2017).

## **Results**

### *Enquiry effort, population coverage and response output*

The geographic distribution of the interviews is shown in Figure 1. The resident rural population in the whole set of counties of all islands sampled summed up to 84,924 men and 89,721 women; of these, 38,422 individuals (18,863 men and 19,739 women) were above 40 years old in 2010 (INE.CV 2016a), i.e., the potential target population, of which the 1,049 interviews represented 2.7%. With the exception of the 100 interviews carried out in Maio Is., the gender of the other 949 respondents was recorded. Among them, 837 (88.2%) were men and 112 (11.8%) women. Therefore, the enquiry work coverage in the sampled islands apart from Maio, represented 4.6% of the masculine and 0.6% of the feminine segments of the corresponding target population (i.e. without Maio, respectively 18,269 men and 19,303 women), and 2.5% of the total 37,572 individuals. Yet, the percentage of coverage varied extensively amongst these islands (men  $11.7 \pm 9.6$  SD, 1.4–24.4%; women  $1.7 \pm 1.4$  SD, 0.2–3.5%). Jointly considering both genders in the whole of the sampled islands, Santo Antão, São Vicente, São Nicolau and Maio had a much higher coverage ( $22.7 \pm 7.3$  SD, 10.8–29.9%) than Santiago and Fogo (1.4 and 3.0% respectively).

The number of interviews per island reflects its size, the number of inhabited places, and the extent of the current vulture range (based on the recent sighting data available, Table S1) thereby worthy of field work, as well as the logistic difficulties encountered. Thus, despite Santiago being the largest island, the number of interviews was lower there than on Santo Antão or São Nicolau, while the extent of work on the small island of Maio was comparable to that in the much larger Fogo. Particularly in Santiago, in addition to the logistical difficulties encountered, a larger sampling would be unfeasible considering the high number of rural residents above 40 yrs old (23,268). Still, as the 176 interviews were carried out in the area that we presumed to be of more suitable habitat for the species, we believe they were enough to provide a reasonable picture of the situation. Although we didn't sample Sal, Boa Vista and Brava, the total potential target population of the three islands, i.e. rural residents above 40 yrs old (2,296 individuals), accounts for only 5.6% of the corresponding country's total, so we assumed that this would not impact on the overall results.

Table 1 shows the distribution of the field work effort per island and the percentages of responses to each subject. The numbers of responses varied between items: while 100% of the people interviewed replied about current or past vulture occurrence, reply rates regarding other themes were in general much lower. Possible reasons for the lower response rates were the



interviewees' occupation being unrelated to the specific item in question; reluctance to answer to questions that the respondent judged sensitive; or not knowing what to respond.

### Popular perceptions on historical abundances and decline

Most of the 1,049 respondents (973; 93%) claimed to have seen Egyptian Vultures but only 205 (21%) of the sightings could be assigned to a specific year in the period 1974–2015; more than half of these (118; 58%) were since 2010, probably a result of fresher recalling. Most of these more recent sightings were from Santo Antão (62; 53%) and Maio (23; 19%). Only 5% stated having seen a vulture nest, with 41 former nest sites reported, most in Santo Antão (25; 61%) and São Vicente (9; 22%) (Figure 3).

Only 601 (57%) respondents had some perception of decline causes: food scarcity accounted for 45% (268) of responses, the use of poisons and pesticides 31% (188), and aerial spraying against locust swarms 16% (97). Urbanisation and development were indicated as underlying causes of decline due to improved sanitation, including in animal husbandry, hence fewer carcasses available for the vultures (Figure 4).

### Poisons

Only 29 (17%) of the 174 people who answered to the use of toxics admitted using poisons to kill animals such as rodents (15; 52%), dogs (10; 34%), the Helmeted Guineafowl *Numida meleagris* (3; 10%), and Brown-necked Ravens *Corvus ruficollis* (1; 3%). On Maio, *grogue* (the traditional sugarcane spirit) was reportedly used as a homemade “remedy” for the poisoning of guineafowl. One respondent on Santo Antão and two on São Vicente admitted using strychnine (allegedly imported illegally) against dogs in the form of the so-called *pastéis* (“cakes”), i.e. fish or meat poisoned baits.

### Pesticides

Aerial spraying against major swarms of the desert locust *Schistocerca gregaria* was often referred as a major cause of the vulture's demise. Two big operations using malathion ULV, fenitrothion ULV and DDT were deployed in 1989 and 1990. Yet, it remained uncertain whether the reported death of vultures and other wildlife was always witnessed or only inferred from the temporal coincidence between decreases in vultures and spraying operations. Indeed, later spraying like in 2004, when chlorpyrifos ULV was used (<https://tinyurl.com/y83vfhfa>, in Portuguese, accessed 06 March 2018) were not quoted as affecting vultures.

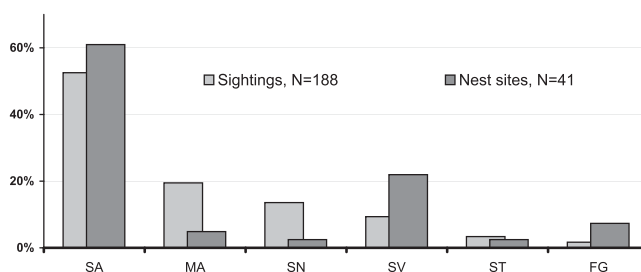


Figure 3. Geographical distribution of reports on vulture sightings (light bars) and vulture nest sites (dark bars) for the period 2010–2015 (in % of the total of sightings and nests reported). SA = Santo Antão, MA = Maio, SN = São Nicolau, SV = São Vicente, ST = Santiago, FG = Fogo.

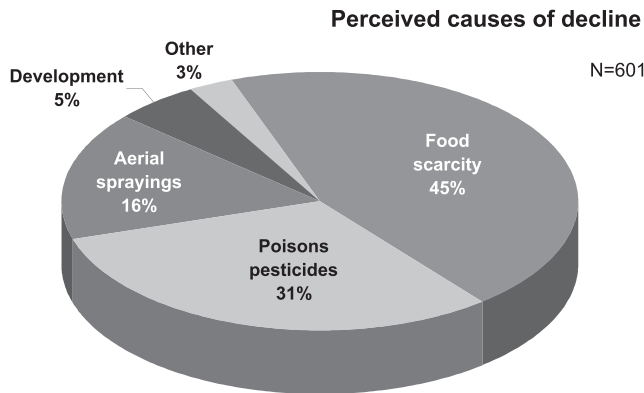


Figure 4. Percentages of responses concerning the various perceived causes of the Egyptian Vulture decline in Cabo Verde. N is the number of responses to the subject.

Eighty one percent of respondents who answered to the use of toxins ( $n = 174$ ) stated that they were routinely using phytosanitary pesticides in farms but only 1% reported impacts of these practices on vultures. Pesticides are used against e.g. the Senegalese grasshopper *Oedaleus senegalensis* and the green stink bug *Nezara viridula*. Products regularly used are propoxur, fenitrothion, carbaryl and the biological product *Metarhizium anisopliae* var. *acridum* (“Green Muscle”).

Table 2 lists the products most commonly used among those authorised by the Cabo Verde Ministry of Agriculture and the Environment (<https://tinyurl.com/y7jdar8f>, accessed 06 March 2018; in Portuguese).

Tudor’s Pest Control (<https://www.tudorpestcontrol.com.au/>) was also referred as an authorised product but it is not in the list. Information about its active ingredient could not be found, including in the USA Environmental Protection Agency (available at [www.epa.gov](http://www.epa.gov), accessed 10 March 2018). Among the unauthorised products referred were the “cockroach powder” allegedly bought in Chinese shops (possibly Kwik Cockroach Killer: deltamethrin 0.05% and fenvalerate 0.13%) and homemade water solutions of detergent, creolin, pepper, tobacco, bleach, sugarcane spirit, and manure.

### *Changes in carcass and fish processing, and refuse management*

According to the respondents who reported on the type of livestock rearing ( $n = 282$ ), in 57% of the cases livestock are reared in free-range, 26% in corrals and yards, and 17% indoors. Nearly half of replies about the fate of dead livestock ( $n = 329$ ) stated that dead livestock are buried (54%) and 11% that they are incinerated. Allegedly though, 35% still leave carcasses in the open (Figure 5), where they are eaten by dogs in 87% of responses ( $n=30$ ) or by vultures, ravens and other birds (13%).

Table 2. Active ingredients and trade names of the authorised pesticides more commonly used by farmers, according to respondents.

Active ingredient	Trade name	Active ingredient	Trade name
acephate	Orthene SP 75%	imidacloprid	Confidor SL 17.7% or 200 g/l
carbaryl	Sevin DP 5%	propoxur	Unden DP 2%
			Unden WP 75%
chinomethionate	Apache	sulphur	e.g. Microlux Plantisoufre WP 80
deltamethrin	Decis EC 25	triadimefon	Bayleton
fenthion	Lebaycid EC 50	<i>Bacillus thuringiensis</i>	Thuricide (k) Turex
fenitrothion	Sumthion EC 50	<i>Metarhizium anisopliae</i> var. <i>acridum</i>	Green muscle



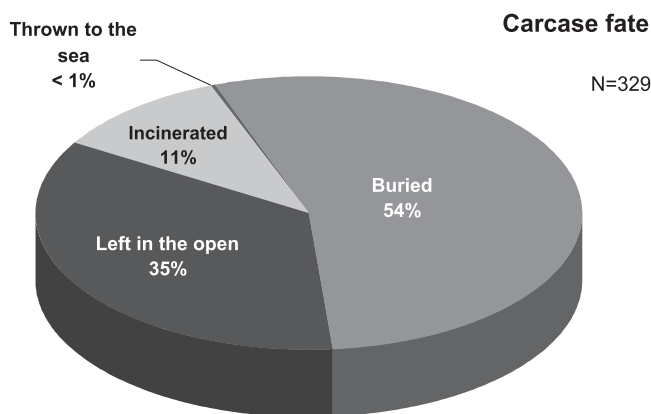


Figure 5. Fate of dead livestock carcasses according to shepherds. N is the number of responses to the subject.

Among the answers about the fate of poisoned carcasses ( $n = 192$ ), most (94%) claimed they are buried and 4% that they are incinerated or left in the open (2%).

Official municipal slaughterhouses exist on all inhabited islands, while in Santiago the existence of informal slaughterhouses was also reported. Livestock taken to municipal slaughterhouses consists predominantly of cattle, less often pigs and goats, but traditional homemade slaughter is still a common practice in many localities, being the most popular in the case of goats.

In coastal localities fish are no longer eviscerated, salted and dried on the beach as described by Naurois (1985), and are now directly sent for sale. Allegedly, 14 years ago when fish salting and drying was still done on beaches, many vultures gathered to feed.

Old informal garbage dumps have been gradually discontinued since the mid-1990s and replaced by modern official ones. Still, several old ones still operate in the Barlavento (Table 3), while trashing in stream beds is still reported, e.g. on Maio.

### Current population status and recent trends

On Santo Antão, there were nine sightings of vultures during the 2014–2018 target searches, plus eight circumstantial sightings. With two exceptions, in all 17 circumstances birds observed were adults and all were seen in or close to the desert areas of the south and west (Figure 6). In 2016, many old whitewashes were seen by Palma (2016) throughout Santo Antão, a clear indication of the species' former abundance, while rare fresh droppings were found only in the south and south-west, whereas on São Nicolau no vulture was seen and only one possible old roost was found. No vulture, sign or oral record of the species could be collected on Sal. On Boa Vista, monitoring by BIOS.CV yielded 89 sightings in 2013–2018 (Table S1). On Maio, field searches produced five sightings in 2015, in three of which two adults were seen together. One adult

Table 3. Number of garbage dumps on the islands surveyed.

Island		Sto. Antão	S. Vicente	S. Nicolau	Maio	Santiago	Fogo	Total	%
Official dumps	Active	4	1	2	1	10	3	21	95
	Deactivated	1						1	5
Informal dumps	Active	4	2	4				10	34
	Deactivated	8	3	6		2		19	66
Total		17	6	12	1	12	3	51	

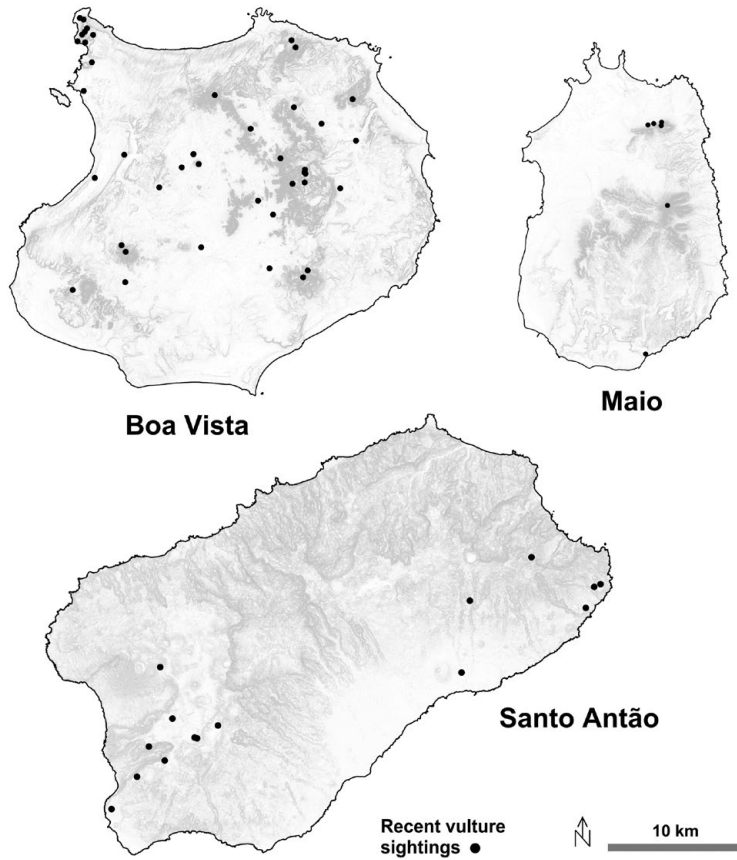


Figure 6. Distribution of Egyptian Vulture sightings in 2014–2018 (black dots) in Boa Vista, Maio and Santo Antão. Dots may refer to more than one sighting. Digital Terrain Model produced by the Cabo Verde National Institute of Land Management (INGT). Available at <http://ingt.maps.arcgis.com> [accessed on open-share, 20 April 2018].

was observed near a refurbished nest. Four additional adults were circumstantially sighted in 2017 (Figure 6).

The reconstruction attempt of the Egyptian Vulture's decline during the last c.50 years on the larger islands, based on bibliographic sources, unpublished sighting records (Table S1), interviews (present study) and authors' observations, is shown in Figure 7. Population decrease was more intense during the 1980s–1990s, when even abundant subpopulations quickly crashed to residual numbers and vanished. On Sal and Brava the species seems to have been always rare, but persisted at least in the late 1990s on Sal. In turn, on Santa Luzia and the islets of Branco, Raso and Rombos the species seemed to have been rare in the past but its history could not be tracked. Detailed accounts per island are presented in Appendix S1.

Based on the most recent information (Monteiro *et al.* 2015, 2017, Palma 2016; BIOS.CV's bird monitoring unpubl. reports) and the present study field data, a preliminary conservative estimate for the Egyptian vulture in Cabo Verde is of 7–11 pairs: 4–6 pairs on Santo Antão, 2–3 pairs on Boa Vista and 1–2 pairs on Maio. However, this estimate may be slightly optimistic as so far we could not confirm on Santo Antão that all presumed "pairs" are *de facto* pairs. It seems almost certain that the species no longer breeds on any of the remaining

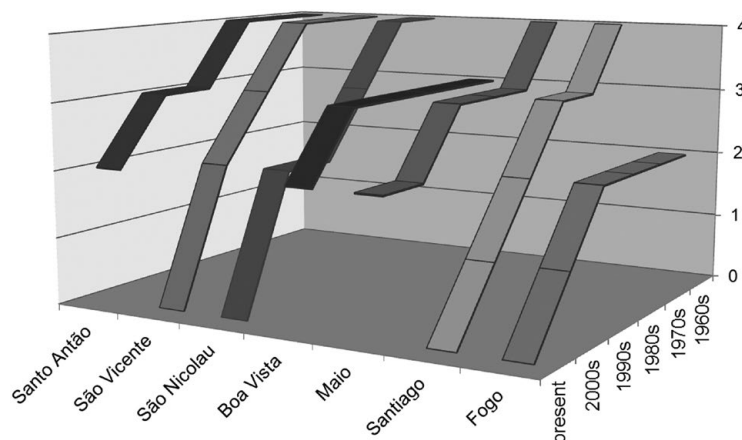


Figure 7. Reconstruction attempt of the Egyptian Vulture sequence of decline in Cabo Verde since the 1960s. Abundance categories: 4 = abundant, 3 = common, 2 = scarce, 1 = rare, 0 = extinct.

islands. Furthermore, the small number of non-adults seen is an indication that breeding may occur only irregularly.

## Discussion

The demographic history of the Egyptian Vulture in Cabo Verde mirrors to some extent that of the Canary Islands where the establishment of the species matches the human colonisation of the archipelago about 2,500 years ago, profiting from the abundance of food resources brought in by humans (Agudo *et al.* 2010). In Cabo Verde, it is not known how long the species has inhabited the archipelago, but probably it also benefited from the human colonisation in the 15<sup>th</sup> century (Albuquerque 2001). Goats and unmanaged waste allowed vulture populations to increase to unprecedented levels, as described by Moseley (1879), Bannerman (1912) and other early authors (cited by Naurois 1985). This abundance could still be witnessed in Cabo Verde during the 1960s around growing towns with poor sanitation (Naurois 1985). Worldwide, this ancient relationship with humans has been disrupted by contemporary activities (Moleón *et al.* 2014) as happened in the Canary Islands (Palacios 2000, Donázar *et al.* 2002b, García-Alfonso *et al.* 2018) and later in Cabo Verde (Hazevoet 1995, Hille and Thiollay 2000, present study).

### *Population decline and causal factors*

This is the first approach to a comprehensive assessment of the Egyptian Vulture conservation status in Cabo Verde. All available sources indicated a precipitous decline in the last three decades, apparently more abrupt during the last two, and affecting all islands. Egyptian Vultures began to decrease shortly after the independence of Cabo Verde in 1975, in parallel with the country's economic growth and development, which translated into urban expansion, modernisation and better sanitation (UN Cape Verde 2010, WHO and UNICEF 2017, African Union 2018). Official statistics clearly show a marked urbanisation trend with the percentage of the urban population growing from 11% to 67% between 1970 and 2016; the population using improved sanitary facilities increased from 12.2% in 1980 to 80.3% in 2016 (INE.CV 2016b).

At the same time, the marked drop in the number of rural inhabitants between 1970 and 2016 (-27%: 241,226 > 175,167), whereas the country's population doubled (+49%: 270,999 > 530,931), highlights the extent of the rural exodus, also reported to us during the interviews as being related

to increased aridity. Livestock production (INE.CV 2016b) shows a fluctuating trend in goat numbers (presumably mostly free-ranging) between 1998 and 2015, with a steady increase from 95,338 (1998) to 148,094 head (2004), and then a -27% drop in 11 yrs (107,630 head in 2015). Free-ranging small livestock (sheep and goats) is a factor better explaining the persistence vs. abandonment of Egyptian Vulture territories in Europe (Sarà and Di Vittorio 2003, Mateo-Tomás and Olea 2010). Therefore, the decrease in free-ranging goat herding in Cabo Verde, together with reduced food supply from other sources, must have had a marked impact on food availability. The highly predictable food source represented by open-air landfill sites is an important factor shaping the distribution of Egyptian Vulture breeding territories, favouring productivity and the gathering of immatures at dump sites (Tauler-Ametller *et al.* 2017), even if feeding at dumps is not free of negative effects on body condition and health of the vultures (Tauler-Ametller *et al.* 2019).

This decrease in food resources co-occurred with the long-lasting and widespread use of dangerous substances to cause the observed vulture decline. In particular, the retaliatory poisoning of stray dogs may have had a central role in the near eradication of vultures. Strychnine was frequently used in the past, and despite being illegal, it seems that is still available. Stray dogs are still abundant throughout the archipelago and the cause of substantial mortality of free-ranging livestock, with a major impact on the small-scale rural economy. Therefore, poisoning will presumably not halt until dog predation upon livestock is effectively and efficiently tackled. This problem resembles the widespread conflict between wild predators and herders with the well-known serious consequences of illegal wildlife poisoning (Mateo-Tomás *et al.* 2012, Ogada 2014, Santangeli *et al.* 2016, 2017, Safford *et al.* 2019). Egyptian Vultures have been one of the victims in Europe (Hernández and Margalida 2009) where ongoing illegal poisoning is largely due to a lack of enforcement of existing legislation (Margalida and Mateo 2019).

Besides mortality, large-scale spraying against locusts may have also caused morbidity and impaired fecundity due to the high toxicity to birds of fenitrothion and chlorpyrifos (used in the 2004 spraying) and the moderate toxicity of malathion (PPDB 2018). Chlorpyrifos and other organophosphates have been shown to represent a potential risk to avian scavengers when used as topical anti-parasitics in livestock (Mateo *et al.* 2015). DDT in turn, which had been openly sold and extensively used in agriculture since the 1960s until its ban in the late 1980s, may have also considerably contributed to the vulture decline for its chronic deleterious effects in fecundity (Hickey and Anderson 1968).

Only vultures living in desert rangelands were presumably spared the effect of pesticides, but these areas offer scantier food resources. Indeed, on Boa Vista, despite the current livestock abundance, vultures remain few, supporting the idea that the former vulture abundance in the “green” areas of the mountainous islands was due to the higher food availability once provided by unmanaged refuse in urban and farmland areas.

### *Ongoing contamination*

Hazardous substances have in general been banned, but some of those authorised and most in use in Cabo Verde are not harmless, such as fenthion, fenitrothion, imidacloprid and propoxur, which are highly toxic to birds (PPDB 2018). Despite the moderate toxicity of malathion to raptors, it may nonetheless cause some mortality and sub-lethal effects (Ortego *et al.* 2007). In particular, malathion and chlorpyrifos have been shown to cause Egyptian Vulture mortality (Hernández and Margalida 2009).

Some unlisted and illegal products seem still easily bought and used. Although DDT is now banned, several responses suggested that it may still be in use and somehow available. Moreover, due to its persistence and that of its metabolites (Johnstone *et al.* 1996, Sørensen *et al.* 2004) it may probably still be circulating in the environment. Furthermore, to compensate for the difficulty in acquiring strychnine after the ban, other products (e.g. unidentified rodenticides and insecticides) purchased at Chinese shops have seemingly become increasingly popular against agricultural pests and dogs. However, neither the administration nor the general public knows what their chemical composition is.

### *Electrocution and collision risks*

Raptor electrocution is a worldwide conservation concern, and one of the drivers of risk is pole configuration (Lehman *et al.* 2007, Guil *et al.* 2011). Most of the medium-voltage powerline poles of Cabo Verde are three phase T-structures with flat or vaulted horizontal cross-arm configurations and all-exposed pin-type insulators and jumpers above the cross-arm. This most dangerous design (Kruger and van Rooyen 2000, Mañosa 2001, Janss and Ferrer 2001, Adamec 2004, Tintó *et al.* 2010), has been responsible for large numbers of electrocuted Egyptian Vultures in East Africa (Angelov *et al.* 2013). In Cabo Verde, two adult Egyptian Vultures were found electrocuted in 2018, respectively on Santo Antão and Boa Vista. During a first survey of the c.25-km long powerline network of Boa Vista by BIOS.CV in December 2018, the remains of 20 Ravens, one Osprey *Pandion haliaetus* and one guineafowl were found electrocuted under the pylons.

The adverse impacts of wind farms through the occupation of biologically sensitive areas and especially from collision with turbines are a well-known and universal threat to raptors, and among these, vultures in particular (Martínez-Abraín *et al.* 2012, Carrete *et al.* 2012, Sánchez-Zapata *et al.* 2016). As seen in Spain, where more than one-third of all Egyptian Vulture breeding territories lie within the risk buffers of wind farms, the risk to the species can be high (Carrete *et al.* 2009).

In Cabo Verde, there are four wind farms on four different islands, run by the national wind power company Cabeólica S.A ([www.cabeolica.com](http://www.cabeolica.com)). Currently, only the small Boa Vista wind farm (3 turbines in 18 ha) is potentially problematic to the Egyptian Vulture as the species is now absent from the other three islands. So far, the yearly monitoring of this wind farm since its construction in 2012 (BIOS.CV unpublished reports to Cabeólica) has not revealed mortality or displacement effect on local birds or transient vultures, which continue to use the vicinity of the farm.

### *Present situation, conservation needs and perspectives*

The critical situation of the Egyptian Vulture in Cabo Verde calls for urgent measures to save the relict nuclei, on which the species survival in the country depends, including: 1. The complete halt to illegal poison use, alongside an effective and sustainable tackling of stray dog predation on livestock; 2) revision of the legal status of dangerous pesticides still in use; and 3) the retrofitting of dangerous sections of powerlines, at least in what is left of the vulture distribution.

A supplementary feeding programme may also be important to maintain the remaining breeding pairs and improve their status. However, few leftovers remain from slaughterhouses as carcasses are almost fully processed, or in households where the remains of small livestock carcasses are used to feed pigs. Poultry farms, besides being few in the country, may not be the best alternative in case veterinary drugs are used, because of the related health risks to vultures (Blanco *et al.* 2017). Still, other sources of food can be investigated, such as the leftovers from fish markets, which may represent an easy source of supplementary food. Whatever the most feasible solutions, the feeding scheme should follow the recommended optimisation guidelines for supplementary feeding of Egyptian Vultures (e.g. Moreno-Opo *et al.* 2015).

In the long run, assisting traditional goat and cheese production may be essential for maintaining and enhancing vulture food resources. The importance of traditional small livestock pastoralism for the conservation of the Egyptian vulture has been demonstrated elsewhere (Sarà and Di Vittorio 2003, Mateo-Tomás and Olea 2010, García-Alfonso *et al.* 2018) and is probably also key to improving the species' food supply in Cabo Verde on a sustainable basis. Intimately linking vulture conservation with improvements in goat production would be a step forward to reinventing mutualism *sensu* Gangoso *et al.* (2013).

However dramatic the situation may be, the recent recovery of the formerly highly endangered population of the Canary Islands shows that with the right level of conservation investment and effort, namely the alleviation of poisoning and electrocution casualties (<https://canarianegyptianvulture.com>, accessed 12 August 2018) it is possible to revert the fate of an island population of the 'Endangered' Egyptian Vulture.

## Supplementary Material

To view supplementary material for this article, please visit <https://doi.org/10.1017/S0959270919000376>

## Acknowledgements

We are indebted to: Wind power company Cabeólica S.A., Santo Antão Protected Areas and Fogo Natural Park, Delegations of the Ministry of Agriculture and the Environment of Santo Antão, São Nicolau, São Vicente and Fogo, the Town Halls of São Vicente, Paúl and Ponta do Sol in Santo Antão, the Praia Municipal Sanitation Services, and INIDA, for providing logistical support and/or information. We also thank: Nathalie Almeida and Rosiane Fortes for helping in interviews; Rogério Cangarato, the shepherds César Fortes, “Primo”, Romão and Manuel (“Manel”) for their help in field monitoring; and Cornelis Hazevoet for the compilation of unpublished observations. We also thank Marina Temudo for clarifying enquiry methods and an anonymous referee for the thorough review that allowed much improvement of the manuscript. Finally, we are grateful to all people who agreed to respond to the enquiry. This article is an output from the Portuguese - Cabo Verde TwinLab, established between CIBIO/InBIO and the University of Cabo Verde. L. Palma was supported by Portuguese national funds through FCT – Fundação para a Ciência e a Tecnologia, I.P. This work was supported by AFdPZ - Association Française des Parcs Zoologiques, VCF - Vulture Conservation Foundation, Fondation Ensemble, Cabeólica S.A. and DNA - Cabo Verde National Directory for the Environment. This study was conducted with the acknowledgement and support of the Cabo Verde national and regional authorities of the environment and agriculture. Enquiries were carried out under the supervision of the University of Cabo Verde and with prior consent from the people interviewed.

## References

- Adamec, M. (2004) Birds and power lines – status in the Slovak Republic. Pp. 417–421 in R. D. Chancellor and B.-U. Meyburg, eds. *Raptors worldwide*. Blaine, Washington, USA: WWGBP, Hancock House.
- African Union (2018) *2018 Africa Sustainable Development Report: Towards a Transformed and Resilient Continent*. Addis Ababa, Ethiopia: African Union, Economic Commission for Africa; African Development Bank and United Nations Development Programme.
- Agudo, R., Rico, C., Vilà, C., Hiraldo, F. and Donazar, J. A. (2010) The role of humans in the diversification of a threatened island raptor. *BMC Evol. Biol.* 10: 384.
- Albuquerque, L. de (2001) O descobrimento das ilhas de Cabo Verde. Pp. 23–39 in E. M. Santos and L. de Albuquerque, coords. *História Geral de Cabo Verde* (v. 1) (M). IICT. Lisboa, Portugal and Praia, Cabo Verde: Instituto de Investigação Cultural de Cabo Verde.
- Angelov, I., Hashim, I. and Oppel, S. (2013) Persistent electrocution mortality of Egyptian Vultures *Neophron percnopterus* over 28 years in East Africa. *Bird Conserv. Internatn.* 23: 1–6.
- Arnulphi, C. V. B., Lambertucci, S. A. and Borghi, C. E. (2017) Education can improve the negative perception of a threatened long-lived scavenging bird, the Andean condor. *PLoS ONE* 12 (9): e0185278.
- Bannerman, D. A. (1912) The birds of Gran Canaria. *Ibis* 9: 557–627.
- Barone, R., Delgado, G. and Castillo, M. F. (2000) La avifauna nidificante del Archipiélago de Cabo Verde. *Makanoresia* 2: 45–55.
- Bennett, N. J. (2016) Using perceptions as evidence to improve conservation and environmental management. *Conserv. Biol.* 30: 582–592.
- Blanco, G., Junza, A. and Barrón, D. (2017) Food safety in scavenger conservation: Diet-associated exposure to livestock pharmaceuticals and opportunist mycoses in threatened



- Cinereous and Egyptian vultures. *Ecotox. Environ. Safe.* 135: 292–301.
- Botha, A. J., Andevski, J., Bowden, C. G. R., Gudka, M., Safford, R. J., Tavares, J. and Williams, N. P. (2017) Multi-species Action Plan to conserve African-Eurasian vultures. Abu Dhabi, UAE: Coordinating Unit of the CMS Raptors MOU. (CMS Raptors MOU Technical Publication No. 4, CMS Technical Series 33).
- Botha, A. J., Ogada, D. L. and Virani, M. Z. eds. (2012) *Proceedings of the Pan-African Vulture Summit*. Masai Mara, Kenya: Endangered Wildlife Trust / The Peregrine Fund.
- Boughtflower, A. (2006) *Ornithological report: Serra Malagueta, Monte Gordo*. Integrated Participatory Ecosystem Management in and around Protected Areas (Phase 1). Unpublished Report to the Government of Cape Verde / GEF / UNDP.
- Bruyn, D. and Koedijk, O. (1990) Birdwatching during the great drought on the Cape Verde Islands. *Cour. Forsch. Senck.* 129: 191–196.
- Buechley, E. R. and Şekercioğlu, Ç. H. (2016) The avian scavenger crisis: Looming extinctions, trophic cascades, and loss of critical ecosystem functions. *Biol. Conserv.* 198: 220–228.
- Carrete, M., Grande, J. M., Tella, J. L., Sánchez-Zapata, J. A., Donazar, J. A., Diaz-Delgado, R. and Romo, A. (2007) Habitat, human pressure, and social behavior: partialling out factors affecting large-scale territory extinction in an endangered vulture. *Biol. Conserv.* 136: 143–154.
- Carrete, M., Sánchez-Zapata, J. A., Benítez, J. R., Lobón, M. and Donazar, J. A. (2009) Large scale risk-assessment of wind-farms on population viability of a globally endangered long-lived raptor. *Biol. Conserv.* 142: 2954–2961.
- Carrete, M., Sánchez-Zapata, J. A., Benítez, J. R., Lobón, M., Montoya, F. and Donazar, J. A. (2012) Mortality at wind-farms is positively related to large-scale distribution and aggregation in griffon vultures. *Biol. Conserv.* 145: 102–108.
- Correia, A. R. S. (2007) *Avifauna da ilha de Santiago*. BSc thesis. Instituto Superior de Educação, Departamento de Geociências, Praia, Cabo Verde.
- Cortés-Avizanda, A., Martín-López, B., Ceballos, O. and Pereira, H. M. (2018) Stakeholders perceptions of the endangered Egyptian vulture: Insights for conservation. *Biol. Conserv.* 218: 173–180.
- Craig, C. A., Thomson, R. L. and Santangeli, A. (2018) Communal farmers of Namibia appreciate vultures and the ecosystem services they provide. *Ostrich* 89 (3): 211–220.
- Donazar, J. A., Margalida, A., Carrete, M. and Sánchez-Zapata, J. A. (2009) Too sanitary for vultures. *Science* 326 (5953): 664–664.
- Donazar, J. A., Negro, J. J., Palacios, C.-J., Gangoso, L., Godoy, J. A., Ceballos, O., Hiraldo, F. and Capote, N. (2002a). Description of a new subspecies of the Egyptian Vulture (Accipitridae: *Neophron percnopterus*) from the Canary Islands. *J. Raptor Res.* 36: 17–23.
- Donazar, J. A., Palacios, C.-J., Gangoso, L., Ceballos, O., González, M. J. and Hiraldo, F. (2002b). Conservation status and limiting factors in the endangered population of Egyptian vulture (*Neophron percnopterus*) in the Canary Islands. *Biol. Conserv.* 107: 89–97.
- Duarte, M. C. and Romeiras, M. M. (2009) Cape Verde Islands. Pp. 143–150 in R. G Gillespie and D.A. Clague, eds. *Encyclopedia of islands*. Berkeley, USA: University of California Press.
- Ferguson-Lees, J. and Christie, D. A. (2001) *Raptors of the world*. New York-Boston: Houghton Mifflin Co.
- Fernandes, H. C. (2008) *Inventário e Análise das aves da ilha do Fogo. Impacto antrópico sobre as espécies ameaçadas*. BSc thesis, Instituto Superior de Educação, Departamento de Geociências, Praia, Cabo Verde.
- Gangoso, L., Agudo, R., Anadón, J. D., de la Riva, M., Suleyman, A. S., Porter, R., and Donazar, J. A. (2013) Reinventing mutualism between humans and wild fauna: insights from vultures as ecosystem services providers. *Conserv. Lett.* 6: 172–179.
- García-Alfonso, M., Morales-Reyes, Z., Gangoso, L., Bouten, W., Sánchez-Zapata, J. A., Serrano, D. and Donazar, J. A. (2018) Probing into farmers' perceptions of a globally endangered ecosystem service provider. *Ambio*: 1–13.
- Gbogbo, F. and Awotwe-Pratt, V. P. (2008) Waste management and Hooded Vultures



- on the Legon Campus of the University of Ghana in Accra, Ghana, West Africa. *Vulture News* 58: 16–22.
- Guil, F., Fernández-Olalla, M., Moreno-Opo, R., Mosqueda, I., Gómez, M. E., Aranda, A., Arredondo, Á., Guzmán, J., Oria, J., González, L. M. and Margalida, A. (2011) Minimising mortality in endangered raptors due to power lines: the importance of spatial aggregation to optimize the application of mitigation measures. *PLoS One* 6: e28212.
- Hazevoet, C. J. (1995) *The birds of the Cabo Verde Islands*. Tring: British Ornithologist' Union. (B.O.U. Check-list No. 13).
- Hazevoet, C. J. (1997) Notes on distribution, conservation, and taxonomy of birds from the Cape Verde islands, including records of six species new to the archipelago. *Bull. Zool. Mus. Univ. Amst.* 15: 89–100.
- Henriques, M., Granadeiro, J. P., Monteiro, H., Nuno, A., Lecoq, M., Cardoso, P., Regalla, A. and Catry, P. (2018) Not in wilderness: African vulture strongholds remain in areas with high human density. *PLoS ONE* 13: e0190594.
- Hernández, M. and Margalida, A. (2009) Poison-related mortality effects in the endangered Egyptian vulture (*Neophron percnopterus*) population in Spain. *Eur. J. Wildlife Res.* 55: 415–423.
- Hickey, J. J. and Anderson, D. W. (1968) Chlorinated hydrocarbons and eggshell changes in raptorial and fish-eating birds. *Science* 162: 271–273.
- Hille, S. M. and Collar, N. J. (2011) Status assessment of raptors in Cabo Verde confirms a major crisis for scavengers. *Oryx* 45: 217–224.
- Hille, S. M. and Thiollay, J.-M. (2000) The imminent extinction of the kites *Milvus milvus fasciicauda* and *Milvus m. migrans* on the Cape Verde Islands. *Bird Conserv. Internatn.* 10: 361–369.
- INE.CV (2016a) *Censo - IV Recenseamento Geral da População e Habitação (RGPH 2010), Volume 1*. Instituto Nacional de Estatística de Cabo Verde. Available at <http://ine.cv/quadros/rgph-2010-cabo-verde-em-numeros/> [accessed 19 April 2019].
- INE.CV (2016b) *Estatísticas do Ambiente 2016*. Instituto Nacional de Estatística de Cabo verde. Available at <http://ine.cv/publicacoes/estatisticas-do-ambiente-2016/> [accessed 19 April 2019].
- IUCN (2018) *The IUCN Red List of Threatened Species 2018*. Available at [www.iucnredlist.org](http://www.iucnredlist.org) [accessed 06 March 2018].
- Janss, G. F. E. and Ferrer, M. (2001) Avian electrocution mortality in relation to pole design and adjacent habitat in Spain. *Bird Conserv. Internatn.* 11: 3–12.
- Johnstone, R. M., Court, G. C., Fesser, A. C., Bradley, D. M., Oliphant, L. W and MacNeil, J. D. (1996) Long-term trends and sources of organochlorine contamination in Canadian tundra Peregrine Falcons, *Falco peregrinus tundrius*. *Environ. Pollut.* 93: 109–120.
- Kruger, R. and van Rooyen, C. S. (2000) Evaluating the risk existing power lines pose to large raptors by utilising risk assessment methodology: the Molopo Case Study. Pp. 757–764 in R. D. Chancellor and B.-U. Meyburg, eds. *Raptors at Risk*. Blaine, Washington, USA: WWBP, Hancock House.
- Lehman, R. N., Kennedy, P. L. and Savidge, J. A. (2007) The state of the art in raptor electrocution research: A global review. *Biol. Conserv.* 136: 159–174.
- Levy, N. (1996) Present status, distribution and conservation trends of the Egyptian vulture (*Neophron percnopterus*) in the Mediterranean countries and adjacent arid regions. Pp. 13–33 in J. Muntaner and J. Mayol, eds. *Biology and conservation of Mediterranean raptors (Monografía 4)*. Palma de Mallorca, Canary Islands, Spain: Sociedad Española de Ornitología.
- Mañosa, S. (2001) Strategies to identify dangerous electricity pylons for birds. *Biodivers. Conserv.* 10: 1997–2012.
- Margalida, A. and Colomer, M. À. (2012) Modelling the effects of sanitary policies on European vulture conservation. *Sci. Rep.* 2: 753.
- Margalida, A., Donázar, J. A., Carrete, M. and Sánchez-Zapata, J. A. (2010) Sanitary versus environmental policies: fitting together two pieces of the puzzle of European vulture conservation. *J. Appl. Ecol.* 47: 931–935.
- Margalida, A., and Mateo, R. (2019) Illegal killing of birds in Europe continues. *Science* 363 (6432): 1161–1161.

- Margalida, A. and Moleón, M. (2016) Toward carrion-free ecosystems? *Front. Ecol. Environ.* 14: 183–184.
- Margalida, A., Oliva-Vidal, P., Llamas, A. and Colomer, M. À. (2018) Bioinspired models for assessing the importance of transhumance and transboundary management in the conservation of European avian scavengers. *Biol. Conserv.* 228: 321–330.
- Markandya, A., Taylor, T., Longo, A., Murty, M. N., Murty, S. and Dhavala, K. (2008) Counting the cost of vulture decline – An appraisal of the human health and other benefits of vultures in India. *Ecol. Econ.* 67: 194–204.
- Martín-López, B., Iniesta-Arandia, I., García-Llorente, M., Palomo, I., Casado-Arzuaga, I., García del Amo, D., Gómez-Baggethun, E., Oteros-Rozas, E., Palacios-Agundez, I., Willaarts, B., González, J. A., Santos-Martín, F., Onaindia, M., López-Santiago, C. and Montes, C. (2012) Uncovering ecosystem service bundles through social preferences. *PLoS ONE* 7: e38970.
- Martínez-Abraín, A., Tavecchia, G., Regan, H. M., Jiménez, J., Surroca, M. and Oro, D. (2012) Effects of wind farms and food scarcity on a large scavenging bird species following an epidemic of bovine spongiform encephalopathy. *J. Appl. Ecol.* 49: 109–117.
- Mateo, R., Sánchez-Barbudo, I. S., Camarero, P. R. and Martínez, J. M. (2015) Risk assessment of bearded vulture (*Gypaetus barbatus*) exposure to topical antiparasitics used in livestock within an ecotoxicovigilance framework. *Sci. Total Environ.* 536: 704–712.
- Mateo-Tomás, P. and Olea, P. P. (2010) Diagnosing the causes of territory abandonment by the Endangered Egyptian vulture *Neophron percnopterus*: the importance of traditional pastoralism and regional conservation. *Oryx* 44: 424–433.
- Mateo-Tomás, P., Olea, P. P., Sánchez-Barbudo, I. S. and Mateo, R. (2012) Alleviating human-wildlife conflicts: identifying the causes and mapping the risk of illegal poisoning of wild fauna. *J. Appl. Ecol.* 49: 376–385.
- Moleón, M., Sánchez-Zapata, J. A., Margalida, A., Carrete, M., Owen-Smith, N. and Donazar, J. A. (2014) Humans and Scavengers: The Evolution of interactions and ecosystem services. *BioScience* 64: 394–403.
- Monteiro, C., Fortes, I., Freitas, R. and Palma, L. (2015) *Egyptian Vulture (Neophron percnopterus) survey and conservation in Cabo Verde*. Unpublished Report to AFdPZ, Association Française des Parcs Zoologiques and VCF, Vulture Conservation Foundation. COIA, Mindelo, Cabo Verde.
- Monteiro, C., Fortes, I., Freitas, R. and Palma, L. (2017) *Egyptian Vulture (Neophron percnopterus) survey and conservation in Cabo Verde*. Second phase. Unpublished Report to Fondation Ensemble. COIA, Mindelo, Cabo Verde.
- Morales-Reyes, Z., Martín-López, B., Moleón, M., Mateo-Tomás, P., Botella, F., Margalida, A., Donazar, J. A., Blanco, G., Pérez, I. and Sánchez-Zapata, J. A. (2018) Farmer perceptions of the ecosystem services provided by scavengers: What, who, and to whom. *Conserv. Lett.* 11: e12392.
- Moreno-Opo, R., Trujillano, A., Arredondo, Á., González, L. M., and Margalida, A. (2015). Manipulating size, amount and appearance of food inputs to optimize supplementary feeding programs for European vultures. *Biol. Conserv.* 181: 27–35.
- Moseley, H. N. (1879) *A Naturalist on the "Challenger". An account of various observations made during the voyage of H.M.S. "Challenger" round the world in the years 1872-1876*. London, UK: Macmillan and Co.
- Naurois, R. de (1969) Notes brèves sur l'avifaune de l'archipel du Cap-Vert. Faunistique, endémisme, écologie. *Bulletin de l'IFAN*, t. XXXI, série A: 143–218.
- Naurois, R. de (1985) La population de *Neophron percnopterus* Linné de l'archipel du Cap-Vert. Sa place parmi les peuplements de Vautours d'Afrique Occidentale. *Cyanopica* 3: 245–268.
- Ogada, D. L. (2014) The power of poison: pesticide poisoning of Africa's wildlife. *Ann. NY Acad. Sci.* 1322: 1–20.
- Ogada, D. L., Keesing, F. & Virani, M. Z. (2012) Dropping dead: causes and consequences of vulture population declines worldwide. *Ann. NY Acad. Sci.* 1249: 57–71.
- Ogada, D. L., Shaw, P., Beyers, R. L., Buij, R., Murn, C., Thiollay, J.-M., Beale, C. M.,

- Holdo, R. M., Pomeroy, D., Baker, N., Krüger, S. C., Botha, A., Virani, M. Z., Monadjem, A. and Sinclair, A. R. E. (2016) Another continental vulture crisis: Africa's vultures collapsing toward extinction. *Conserv. Lett.* 9: 89–97.
- Olea, P. P. and Mateo-Tomás, P. (2009) The role of traditional farming practices in ecosystem conservation: the case of transhumance and vultures. *Biol. Conserv.* 142: 1844–1853.
- Ortego, J., Aparicio, J. M., Muñoz, A. and Bonal, R. (2007) Malathion applied at standard rates reduces fledgling condition and adult male survival in a wild lesser kestrel population. *Anim. Conserv.* 10: 312–319.
- Palacios, C.-J. (2000) Decline of the Egyptian Vulture (*Neophron percnopterus*) in the Canary Islands. *J. Raptor Res.* 34: 61.
- Palacios, C.-J. (2002) Situación actual de las rapaces en la isla de Santo Antão, Archipiélago de Cabo Verde. *Rev. Acad. Canar. Cienc.* XIII: 223–231.
- Palma, L. (2016) *Rapid assessment of the population and conservation status of the Egyptian vulture Neophron percnopterus in the islands of Sal, São Nicolau and Santo Antão, Cabo Verde*. Unpublished Report to the National Directorate for the Environment of Cabo Verde, Praia, Cabo Verde.
- Pfeiffer, M. B., Venter, J. A. and Downs, C. T. (2015) Identifying anthropogenic threats to Cape Vultures *Gyps coprotheres* using community perceptions in communal farmland, Eastern Cape Province, South Africa. *Bird Conserv. Internatn.* 25: 353–365.
- PPDB (2018) *Pesticide Properties DataBase*. University of Hertfordshire, UK. Available at <http://sitem.herts.ac.uk/aeru/ppdb/en/index.htm> [accessed 10 March 2018].
- Ramalho, R. A. S. (2011) *Building the Cape Verde Islands* (1st ed.). Berlin, Germany: Springer-Verlag.
- Safford, R., Andevski, J., Botha, A., Bowden, C. G. R., Crockford, N., Garbett, R., Margalida, A., Ramírez, I., Shobrak, M., Tavares, J. and Williams, N. P. (2019) Vulture conservation: the case for urgent action. *Bird Conserv. Internatn.* 29: 1–9.
- Sánchez-Zapata, J. A., Clavero, M., Carrete, M., DeVault, T. L., Hermoso, V., Losada, M. A.; Polo, M. J., Sánchez-Navarro, S., Pérez-García, J. M., Botella, F., Ibáñez, C., and Donazar, J. A. (2016) Effects of renewable energy production and infrastructure on wildlife. *USDA National Wildlife Research Center – Staff Publications* 1845: 97–123.
- Santangeli, A., Arkumarev, V., Komen, L., Bridgeford, P. and Kolberg, H. (2017) Unearthing poison use and consequent anecdotal vulture mortalities in Namibia's commercial farmland – implications for conservation. *Ostrich* 88: 147–154.
- Santangeli, A., Arkumarev, V., Rust, N. and Girardello, M. (2016) Understanding, quantifying and mapping the use of poison by commercial farmers in Namibia – Implications for scavengers' conservation and ecosystem health. *Biol. Conserv.* 204: 205–211.
- Sarà, M. and Di Vittorio, M. (2003) Factors influencing the distribution, abundance and nest-site selection of an endangered Egyptian vulture (*Neophron percnopterus*) population in Sicily. *Anim. Conserv.* 6: 317–328.
- Sørensen, P. B., Vorkamp, K., Thomsen, M., Falk, K. and Møller, S. (2004) *Persistent organic pollutants (POPs) in the Greenland environment – long-term temporal changes and effects on eggs of a bird of prey*. Denmark: National Environmental Research Institute. (NERI Technical report No. 509).
- Tauler-Ametller, H., Hernández-Matías, A., Pretus, J. L. L. and Real, J. (2017) Landfills determine the distribution of an expanding breeding population of the endangered Egyptian Vulture *Neophron percnopterus*. *Ibis* 159: 757–768.
- Tauler-Ametller, H., Pretus, J. L. L., Hernández-Matías, A., Ortiz-Santaliestra, M. E., Mateo, R. and Real, J. (2019) Domestic waste disposal sites secure food availability but diminish plasma antioxidants in Egyptian vulture. *Sci. Total Environ.* 650: 1382–1391.
- Thiollay, J.-M. (2006) The decline of raptors in West Africa: long-term assessment and the role of protected areas. *Ibis* 148: 240–254.

Tintó, A., Real, J. and Mañosa, S. (2010) Predicting and correcting Electrocutation of birds in Mediterranean areas. *J. Wildlife Manage.* 74: 1852–1862.

UN Cape Verde (2010) *Cape Verde An emerging nation*. Praia, Cape Verde: United Nations Cape Verde.

WHO and UNICEF (2017) *Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines*. Geneva: World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), 2017. Licence: CC BY-NC-SA 3.0 IGO.

RUI FREITAS

*FECM – Faculty of Engineering and Marine Science, University of Cabo Verde, COIA – Centre for Environmental Monitoring and Research, Mindelo, São Vicente, Cabo Verde; and CIBIO – Research Centre in Biodiversity and Genetic Resources / InBIO Associate Laboratory, Campus de Vairão, R. Padre Armando Quintas 7, 4485-661 Vairão, Portugal.*

CATELENE MONTEIRO

*FECM – Faculty of Engineering and Marine Science, University of Cabo Verde; and COIA – Centre for Environmental Monitoring and Research, Mindelo, São Vicente, Cabo Verde.*

ISABEL RODRIGUES

*Biosfera I, Mindelo, São Vicente, Cabo Verde.*

ALEX TAVARES

*FMB – Maio Biodiversity Foundation, Porto Inglês, Maio, Cabo Verde.*

GILDA MONTEIRO<sup>1</sup>, LIZA LIMA

*DNA – National Environment Directorate of Cabo Verde, Praia, Santiago, Cabo Verde. <sup>1</sup>and Protected Areas of Santo Antão, Água das Caldeiras, Santo Antão, Cabo Verde.*

PEDRO LÓPEZ, SAMIR MARTINS

*BIOS.CV – Association for Environmental Conservation and Sustainable Development, Sal Rei, Boa Vista, Cabo Verde.*

JOÃO FERREIRA

*Cerro Manuel Viegas, CP 759-Z, 8005-437 Estoi, Portugal.*

JOSÉ PEDRO TAVARES

*Vulture Conservation Foundation, Zurich, Switzerland.*

LUÍS PALMA\*

*CIBIO – Research Centre in Biodiversity and Genetic Resources / InBIO Associate Laboratory, Campus de Vairão, R. Padre Armando Quintas 7, 4485-661 Vairão, Portugal and University of Cabo Verde, Cabo Verde.*

*\* Author for correspondence; e-mail: luis.palma@cibio.up.pt*