

First data about movements and threats of Rüppell's Vultures (*Gyps rueppellii*) tagged in Morocco: an international and multi-institutional study.

Jose Rafael Garrido¹, Rachid El Khamlichi², Zouhair Amhaouch³, Justo Martín⁴, Juan Jose Iglesias-Lebrija⁵, Ernesto Álvarez⁵, Virginia Moraleda⁵, Miguel Ferrer⁶, Carlos Florencio⁶, Iñigo Fajardo⁷, Jose Ramón Benitez¹, Jesús Bautista⁸, Helena Clavero⁹ & Catherine Numa⁹.

¹ Environment and Water Agency, Regional Ministry of Agriculture, Livestock Production, Fisheries and Sustainable Development of the Autonomous Government of Andalusia (Junta de Andalucía; – CAGPDS-), Seville, Spain

² GREPOM/Birdlife Morocco and Jbel Moussa Vulture Recovery Centre (Centre de Réhabilitation des Vautours, CRV), M'diq-F'nideq, Morocco

³ National Water and Forestry Agency of Morocco, Head of the Parks and Natural Reserves Division, Rabat Agdal, Morocco

⁴ Environmental consultant, Seville, Spain

⁵ GREFA (Group for the Rehabilitation of Wildlife and their Habitat), Majadahonda, Madrid, Spain

⁶ Applied Ecology Group, Estacion Biológica de Doñana, CSIC, Seville, Spain

⁷ Head of the Vulture Conservation Programme of Andalusia, Regional Ministry of Agriculture, Livestock Production, Fisheries and Sustainable Development of the Autonomous Government of Andalusia (Junta de Andalucía), Seville, Spain

⁸ Wilder South (Sociedad para la Estudio, Observación y Conservación de la Biodiversidad Mediterránea), Loja, Granada, Spain

⁹ International Union for Conservation of Nature - Centre for Mediterranean Cooperation (IUCN-Med), Malaga, Spain

*Corresponding author: jrafael.garrido@juntadeandalucia.es

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Summary

The Rüppell's Vulture (*Gyps rueppellii*) is listed as 'Critically Endangered' at the global and regional levels in the IUCN Red List of Threatened Species. A multi-institutional collaboration to fit 13 vultures with GPS transmitters in northern Morocco was launched to get information on their movements and threats along the flyway, both to the north and the south of the Sahara. Preliminary results from individuals released in November 2021 indicate a low survival rate during the wintering period in Morocco and on the return journey to the Sahel, which is usually attempted by Rüppell's Vultures with large groups of migratory birds, especially Griffon Vultures (*Gyps fulvus*). Of the group of tagged individuals, only four birds travelled definitely in a southwards direction, apparently migrating. Two of those have died, with one presumed to have starved in the Algerian desert, and another one presumed to have been killed by human persecution in The Gambia. A third individual was captured by local people in Mauritania and it is unknown what happened thereafter. One bird remains alive in Senegal at the time of writing. For the birds that did not disperse far after being fitted with transmitters, a relatively high number of fatalities seems to confirm that threats to the species are prevalent in Morocco: one bird died after being struck by a wind turbine; one was electrocuted by a power line; and two suffered from starvation and weakness. Birds remaining close to the release area fed mainly at a vulture feeding station or at rubbish dumps, which may indicate that there is a lack of food available in the wider surroundings. Five vultures originally fitted with transmitters are still alive in North Africa at the time of writing.

Introduction

The historical range of the Rüppell's Vulture (*Gyps rueppelli*) extends throughout the Sahel region of Africa and south through the savannah regions of East Africa (BirdLife International 2021), but in the last 15 years, it seems to be colonising the Mediterranean basin in the area of North Africa and south of Spain. It has been recorded more frequently far away from its breeding colonies, reaching the Iberian Peninsula through Morocco and the Strait of Gibraltar, often travelling with migrating Griffon Vultures (*Gyps fulvus*) (Botha *et al.* 2017; El Khamlichi 2020), and there are signs that could indicate that it is breeding in Algeria (Garrido *et al.* 2021). In addition, recently some individuals have been observed as showing breeding behaviour in Griffon Vulture colonies in Andalusia, southern Spain (Elorriaga *et al.* 2022), where the species has recently been added to the list of resident species (CAGPDS 2019), now being considered the fifth vulture species occurring in Europe (VCF 2019). After significant population declines the species is classed as 'Critically Endangered' at global and regional levels in the IUCN Red List (Birdlife International 2021; Garrido *et al.* 2021; Westrip *et al.* 2022). Concerned by its status, a group of vulture experts and managers from different countries along the species distribution range exchanged available knowledge and information about the species during the First International Symposium on the Rüppell's Vulture in the Mediterranean Region (Garrido, Martin-Martin & Clavero-Sousa 2021) and recommended to increase monitoring by tagging individuals to learn more about the ecology, migratory movements or causes of mortality in the Mediterranean.

Recent efforts to monitor Rüppell's Vultures are being carried out in Spain (Andalusian Vultures Action Plan, Regional Government of Andalusia). In Morocco, 60 individuals were wing-tagged and

13 of them equipped with GPS transmitters at the Jbel Moussa Vulture Recovery Centre (Centre de Réhabilitation des Vautours de Jbel Moussa –CRV-Jbel Moussa-), belonging to the National Water and Forestry Agency of Morocco and co-managed in collaboration with GREPOM/BirdLife) in 2020 (according to El Khamlichi and Rousselon, in Garrido, Martin-Martin & Clavero-Sousa 2021; El Khamlichi, pers. comm.). As part of coordinated monitoring efforts, a multi-institutional collaborative initiative was launched in November 2021 to tag a sample of Rüppell's Vultures with GPS transmitters in northern Morocco to collect information on their movements and threats through their migratory route. This initiative is the product of the collaboration of experts from GREPOM/Birdlife Morocco, the CRV-Jbel Moussa, the Regional Government of Andalusia (south of Spain), the Migres Foundation, the Doñana Biological Station-Spanish Council for Scientific Research (EBD-CSIC), and the NGOs GREFA and Wilder South, with the support of the IUCN Centre for Mediterranean. Here, we present the first results obtained from this multi-institutional initiative.

Methods

In November 2021, 12 Rüppell's Vultures were tagged at the CRV Jbel Moussa, where approximately 60 vultures were kept in captivity with dozens of other Griffon Vultures that had not been able to complete their migration due to weakness and fatigue. Vultures were tagged with patagial tags and GPS loggers by the staff of the CRV Jbel Moussa and a team of experts from GREFA and Andalusian Government (Table 1). Later (January 2022) another vulture was tagged with a logger recovered from one of the previously-tagged vultures. Ten birds were fitted with backpack-type harnesses and three with leg-loop harnesses, made of 55 and 66-inch Teflon tubular

tapes.

All the birds were aged and released in the same area where they were captured (CRV-Jbel Moussa in M'diq-Fnideq province, Figure 1) after a period of quarantine to ensure good health, and the first twelve were examined by a wildlife veterinarian from GREFA (Table 1). The CRV-Jbel Moussa has a feeding station where carrion is regularly supplied and where birds can be observed directly. Twelve birds were immatures (six in their first calendar year, three in the second and three in the third), and one was in the fourth calendar year (Table 1).

Six satellite and six GSM transmitter devices were fitted and scheduled to provide enough downloads to give the Moroccan Water and Forest Agency the possibility of rescuing the vultures if deemed necessary (e.g. due to suspected injury or fatigue). The devices were configured to always maintain battery charge above 20 % throughout the study period. The first 12 birds were released on 16 November 2021 to increase the likelihood that they would join migratory groups of Griffon Vultures from Spain through the Strait of Gibraltar to the Sahel. One more vulture was released later, on 8 January 2022. The whereabouts of vultures were tracked and shared with members of the partner institutions through the internet platform Movebank (<https://movebank.org>), under the title “Study of migratory movements of migratory Rüppell's Vultures in Morocco”.

Results

When examined prior to release, four of the 12 birds (33.3 %) showed some old bone fractures which had already recovered when captured, and one had a broken claw. Five individuals (41.7 %) showed low grade pododermatitis and one had a splinter through a foot, all of which were medically treated. Only one had slightly deteriorated wing feathers (Table 2).

A week before releasing the tagged individuals,

more than 3,000 vultures crossed the Strait of Gibraltar in a single day (R. El Khamlichi, pers. obs.). However, immediately after the release, bad weather prevented any vultures from crossing, meaning that there were no migrating groups for the released birds to join. One bird (coded M59) lost the transmitter several days after release, although it has since been seen periodically at the feeding station of CRV. One vulture (M49) was tagged with the transmitter of a vulture (M54) found grounded due to fatigue, and taken back to CRV for treatment.

As for the causes of death (Table 2), three vultures died or were rescued due to starvation, one in the vicinity of the CRV a few weeks after its release (M54), having fallen into the sea and making it to shore. Another (M46) died of starvation and dehydration in the desert of western Algeria two months after its release (Figure 1). And the third, M58, had to be rescued with signs of weakness in the Moroccan High Atlas (Figure 1). In addition, M55 died from collision with a wind turbine a few kilometres from the CRV and M53 died from electrocution on a power line in central Morocco, 220 km from the CRV, both a little more than two months after release (Figure 2). One vulture was captured by nomads in north-west Mauritania (M48), confirmed by a local informer with photographic evidence, but its ultimate fate was unknown. The only vulture that returned to the Sahel (M52) died after being captured for consumption by local people in The Gambia (Figure 1), as confirmed by a local partner after recovering the transmitter. Finally, one of the vultures, M51, died for unknown reasons in central Morocco 330 km from the release site (Figure 1). Neither of these three vultures survived more than two months in the wild either.

Of the 13 birds, only three showed a clear direction of movement towards their probable areas of origin in West Africa: the one that died in The Gambia (M52), the one that was captured in Mauritania

(M48) and the one currently in Senegal (M49) (Figure 1). The routes of the three converged in Mauritania, albeit along different paths. M48 travelled through western Morocco, skirting the western flank of the High Atlas mountain range. The other two followed an eastern route, avoiding the great mountain massifs of central Morocco to the east, although one entered the Sahara Desert through Algeria (M54) and the other through southern Morocco (M49). In Mauritania, M52 and M48 settled for some time in the north-west of the country, in the region of Tris Zemmour, towards Guelb Richatt in the Sahara. The region is known

as a goat farming area, being very important as a feeding place for raptors (Nature Mauritanie, pers. comm.).

Four other dead or rescued vultures also showed a clear southwards direction of movement, three through western Morocco and another one through the east of the country to Algeria where it died (Figure 1). The six individuals that moved in long journeys did not show grouping behaviour, undertaking their journeys alone and, apparently, without contact with other conspecifics or Griffon Vultures, although this could not be confirmed.

Table 1: Details of tracking devices attached to thirteen Rüppell’s Vultures released from the Vulture Recovery Centre (CRV-Jbel Moussa) in Morocco. * indicates satellite technology transmitter devices, ** indicate six GSM technology transmitter devices.

Wing tag code	Transmitter type	Transmitter weight (g)	Transmitter identification no.	Transmitter owner/sponsor	Age of vulture (calendar year)	Vulture weight (kg)	Harness type	Release date
M46	MICROWAVE 70*	70	52161	Government of Andalusia	1	6.860	Backpack	16/11/2021
M47	MICROWAVE 70*	70	145175	Government of Andalusia	2	6.740	Backpack	16/11/2021
M48	MICROWAVE 45*	45	80288	GREFA	2	7.540	Backpack	16/11/2021
M49	ORNITELA OT-E-25**	25	201144	Migres Foundation-EBD-CSIC	4	6.500	Leg-loop	08/01/2022
M50	ORNITELA OT-50**	50	191460	Wilder South	1	6.900	Leg-loop	16/11/2021
M51	MICROWAVE 70*	70	96047	GREFA	3	6.980	Backpack	16/11/2021
M52	MICROWAVE 45*	45	137397	GREFA	1	6.580	Backpack	16/11/2021
M53	ORNITELA OT-50**	50	192659	GREFA	3	7.980	Backpack	16/11/2021
M54	ORNITELA OT-E-25**	25	201144	Migres Foundation-EBD-CSIC	1	7.080	Backpack	16/11/2021
M55	ORNITELA OT-E-25**	25	210995	Migres Foundation-EBD-CSIC	1	5.580	Backpack	16/11/2021
M57	MICROWAVE 70*	70	72544	Government of Andalusia	1	6.380	Backpack	16/11/2021
M58	ECOTONE L1 SAKER**	33	IMSP07 48505628566	Government of Andalusia	2	7.220	Backpack	16/11/2021
M59	ORNITELA OT-E-25++	25	210993	Migres Foundation-EBD-CSIC	3	6.800	Leg-loop	16/11/2021

Of the remaining six vultures, four remained (two still alive) in the area around the CRV, always returning to the centre's feeding station, while the other travelled to western Algeria (M50) and another one did not go further than 150 km from the centre (M57), surviving by feeding on human rubbish dumps (Figure 2).

The average furthest distance travelled was 761 km (n=12, because one bird lost its transmitter), varying from 8-10 km for some of those that settled

in the vicinity of the CRV, to 832 km for the one that died in the Algerian desert, 1,350 km for the one that died in Mauritania and more than 2,400 km for the two that crossed the desert and reached the Sahel region (Table 2, Figure 3).

All birds that dispersed were of all ages (Tables 1 and 2) and did so during the winter period except for two, M49 towards the Sahel and M50 eastwards, which dispersed during April.



Figure 1: Location and movements of Rüppell’s Vultures tagged and released from the Vulture Recovery Centre (CRV-Jbel Moussa, Morocco). Inset shows the location of the CRV Jbel Moussa.

Table 2: First five months of monitoring information for thirteen Rüppell's Vultures tagged and released from the Vulture Recovery Centre (CRV-Jbel Moussa) in Morocco. These data are current at the time of writing (May 2022).

Wing tag code	Release date	Health examination	Last posititon date	Days since release	Last location	Status of bird	Cause of death	Furthest distance travelled (km)
M46	16/11/2021	Broken claw	23/01/2022	68	Western Algeria	Dead	Fatigue	832
M47	16/11/2021	Old wound in mandible, light pododermatitis	21/04/2022	156	CRV vicinity	Alive	–	25
M48	16/11/2021	Old phalangeal fracture in pelvic digit, wing feathers deteriorated	28/01/2022	73	Nothwestern Mauritania	Probably dead	Trapped	1.4
M49	08/01/2022	Not checked	21/04/2022	103	Senegal	Alive	–	2.5
M50	16/11/2021	Splinter through foot	21/04/2022	156	Western Algeria	Alive	–	453
M51	16/11/2021	Old clavicle fracture, carpal wounds	07/02/2022	83	Central Morocco	Dead	Unknown	330
M52	16/11/2021	Light pododermatitis	25/02/2022	101	Gambia	Dead	Trapped	2.8
M53	16/11/2021	Light pododermatitis	02/02/2022	78	Central Morocco	Dead	Electrocution power line	220
M54	16/11/2021	Light pododermatitis	03/12/2021	17	CRV vicinity	Re-captured	Weakness	14
M55	16/11/2021	None	22/01/2022	67	CRV vicinity	Dead	Collison with wind turbine	10
M57	16/11/2021	Older breastbone fracture	21/04/2022	156	Northern Morocco	Alive	–	148
M58	16/11/2021	Light pododermatitis	31/12/2021	45	Hight Atlas fo Morocco	Re-captured	Fatigue	427 km
M59	16/11/2021	Old wound in mandible	21/04/2022	156	CRV vicinity	Alive (observed since)	–	Transmitter lost

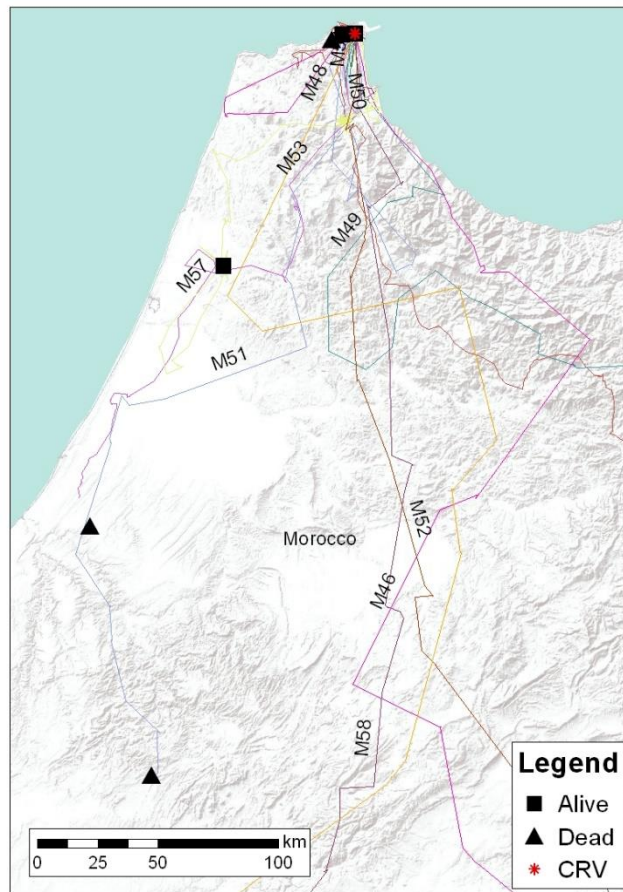


Figure 2: Location and movements of Rüppell's Vultures tagged and released from the Vulture Recovery Centre (CRV-Jbel Moussa, Morocco) in the North Morocco region.

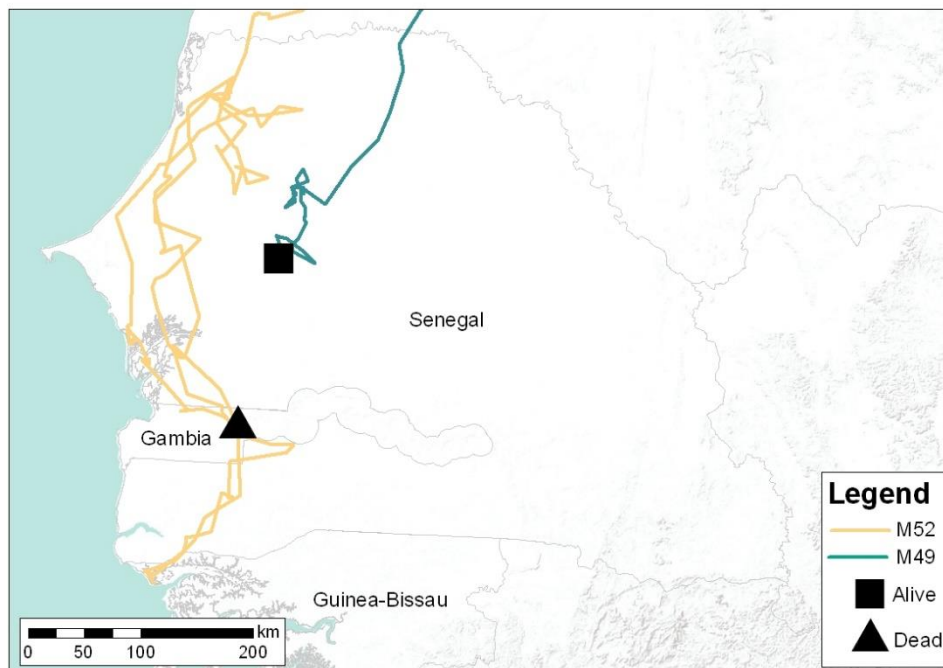


Figure 3: Location and movements of Rüppell's Vultures tagged and released from the Vulture Recovery Centre (CRV-Jbel Moussa, Morocco) in the Sahel region.

Discussion

Although we failed in the initial objective of enabling Rüppell's Vultures to join the migrating Griffon Vultures to return to their presumed origin in the Sahel due to weather conditions, the preliminary information provided by the tagged vultures is very interesting. Firstly, the vulture health check data indicate that there is a high incidence of vultures with old injuries, probably caused at their places of origin, despite the young age of most birds. Although these injuries do not seem to limit the vultures' ability to fly long distances, they may indicate a high level of social stress at the sites of origin due to feeding fights on carrion, which could be caused by poor trophic conditions there. This could support the idea that the increasing numbers of Rüppell's Vultures crossing the Sahara northwards with Griffon Vultures do so because of ecological deterioration in those places due to droughts, changes in agro-sylvo-pastoral systems, declining wild ungulate populations (and hence availability of carrion), and disturbance of breeding areas (Ogada *et al.* 2015; Onrubia *et al.* unpublished report). However, this hypothesis is not firmly supported and needs further investigation.

Almost all of the released birds exceeded the minimum period in the wild to be considered to be rehabilitated (six weeks, 42 days; Duke *et al.* 1981), which confirms the success of the CRV in rehabilitating vultures. However, our results seem to indicate very limited survival during the wintering period in Morocco and on the return journey to the Sahel under the conditions observed in 2021, with the tracked birds dispersing without joining large groups of migrant birds, especially Griffon Vultures. In these conditions, the harshness of the trans-Saharan migration that has already been highlighted (Strandberg *et al.* 2010) may have been a significant barrier, and should be considered in future releases to try to increase survival. In our

study, of the four birds that entered the desert, one died of starvation, even though they did so during the winter when the conditions in the Sahara are less harsh. Of the two birds that reached the Sahel, one did so only thanks to a prolonged temporary settlement in a suitable area in Mauritania where it recovered to reach the Sahel. But it is not only the harsh environmental conditions during migration that are a limiting factor for survival, but also human persecution, both on the flyway and in the Sahel, with two of the three birds that migrated being captured by local people for as yet unknown reasons. Similar results have been found by El Khamlichi and Rousselon (Garrido, Martin-Martin & Clavero-Sousa 2021).

As for the flyway of the tagged vultures with long displacements, the results seem to indicate that the High Atlas and Anti-Atlas Mountain ranges may present a geographical barrier that channels the movement of the vultures, either to the west, towards the coast, or mostly in this study to the east, towards the Sahara Desert.

For those birds that did not disperse long distances, the high number of fatalities also indicates that threats to the species are very high across Morocco. Threats already reported for the species in the Mediterranean (Garrido *et al.* 2021) have been confirmed for two individuals, collision with wind turbines and electrocution on power lines. In addition, two birds suffered from starvation and weakness both in northern Morocco and in the foothills of the High Atlas Mountains. Data show that the individuals remaining around the CRV feed mainly at the CRV feeding station or on rubbish dumps. Carrion from roadkill has been reported as the main available food item consumed by the African White-backed Vulture (*Gyps africanus*) in Morocco, another African vulture species released in Morocco (El Khamlichi *et al.* 2022). This possible local food scarcity in some places could be the reason for feeding in rubbish dumps which could be functioning as the only

stable food source available (JMM and Associates 2015) and would explain the settling of some individuals in these human-dominated environments. The concentration of vultures in landfill sites poses a high risk of death by collision with or electrocution on power lines (Martin et al 2019; UICN and DEF 2020; Garrido *et al.* 2021; UICN 2022), as has already recorded for the Rüppell's Vulture in Morocco (Monchaux 2018). In response, to increase food availability, the National Water and Forestry Agency of Morocco has recently set up a network of supplementary feeding stations for vultures (at least five) in various hunting reserves throughout the country (R. El Khamlichi, pers. comm.).

Although these results are very preliminary, the data seem to support the idea highlighted by El Khamlichi (2020) that there is a very high mortality risk for the Rüppell's Vultures during the journey back to their areas of origin in the Sahel, especially if they do not travel with large groups of migrating Griffon Vultures. Sub-Saharan vulture species cross towards north of the Sahara joining migrant flocks of Griffon Vultures on their return migration from the Sahel region where they winter (Gutiérrez 2003). Therefore, action to temporarily keep birds who fail crossing the strait to the north at CRV until they can join to the migratory flows of Griffon Vultures could increase the survival of these birds. Most of the Rüppell's Vultures arriving the Strait of Gibraltar in spring fail to cross into Spain because large water bodies are perceived as an obstacle, probably forcing them to start a return journey to their natal areas, during periods that coincide with the increase in temperature in sub-Saharan Africa (El Khamlichi 2020). Crossing the Strait of Gibraltar by Rüppell's Vultures seems to be linked

to a combination of factors and very specific conditions: a light to medium wind, clear visibility and the presence of groups of Griffon Vultures ranging from 50 to 200 individuals to accompany them on the crossing. This could be the reason why during spring migration dozens of weak individuals are recovered by the CRV. So, the high mortality observed in this study along the African migratory route in the autumn suggests that releasing Rüppell's Vultures in the spring when Griffon Vultures are traveling back to the Iberian Peninsula, when crossing conditions are ideal, could be a potential management action to increase the number of Rüppell's Vultures arriving in Spain. Andalusia, in southern Spain, is currently a suitable area for vultures, with more than 4,000 breeding pairs of Griffon Vultures (Garrido & de las Heras 2018) and more than 18,000 wintering individuals (Junta de Andalucía, unpublished), so it could also be a suitable area for Rüppell's Vultures (Onrubia *et al.* unpublished report). Ongoing studies with GPS-tagged African vulture species in Andalusia indicate that both the Rüppell's (A. Roman, pers. comm.) and the African White-backed Vulture (Migres Foundation, pers. comm.) find good feeding areas, so the existence of Rüppell's Vultures as breeding individuals cannot be ruled out. However, the risk of hybridisation with the more abundant Griffon Vulture cannot be ignored. It is essential to continue long-term monitoring studies involving various institutions and countries to confirm this hypothesis and to know in more detail about threats, along the migratory route, in the Mediterranean region and in the destination areas in the Sahel to contribute to the conservation of the species.

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