

# Final outcome of raptors admitted to the Tafira Wildlife Rehabilitation Center, Gran Canaria Island, Spain (2003–2013)

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## Abstract

*Final outcome of raptors admitted to the Tafira Wildlife Rehabilitation Center, Gran Canaria Island, Spain (2003–2013).*— The outcomes of wild raptors admitted to the Tafira Wildlife Rehabilitation Center in Gran Canaria Island, Spain, from 2003 to 2013 were analyzed using a quality auditing system based on the crude and stratified (by causes of admission) rates of four final outcome categories, time until death and length of stay as quality indicators. The outcome categories were: euthanasia ( $E_r = 19.78\%$ ); unassisted mortality during hospitalization ( $M_r = 22.20\%$ ); release ( $R_r = 57.57\%$ ); and permanent captivity ( $C_r = 0.46\%$ ). Taking into account the particular vulnerability of insular raptor species and the high  $R_r$  achieved, findings from this study emphasize the importance of wildlife rehabilitation centers for the medical management of injured raptors and the subsequent release of rehabilitated individuals into the wild.

Key words: Wildlife rehabilitation center, Raptor, Birds of prey, Final outcome

## Resumen

*Disposición final de las rapaces admitidas en el Centro de Rehabilitación de Fauna Silvestre de Tafira, Gran Canaria, España (2003–2013).*— En este estudio se analizan los resultados de la rehabilitación de aves rapaces silvestres admitidas en el Centro de Rehabilitación de Fauna Silvestre de Tafira en la isla de Gran Canaria, España, desde 2003 hasta 2013, mediante un sistema de auditoría de la calidad basado en los índices generales y clasificados (por causa de admisión) de las cuatro categorías de disposición final, el tiempo hasta la muerte y el tiempo de permanencia como indicadores de calidad. Las categorías de disposición final fueron: eutanasia ( $E_r = 19,78\%$ ), mortalidad no asistida durante la hospitalización ( $M_r = 22,20\%$ ), liberación ( $R_r = 57,57\%$  y cautividad permanente ( $C_r = 0,46\%$ ). Teniendo en cuenta la especial vulnerabilidad de las especies de rapaces insulares y el alto índice de  $R_r$  conseguido, los resultados de este estudio ponen de relieve la importancia de los centros de rehabilitación de fauna silvestre en el tratamiento médico de las aves heridas y la consiguiente liberación de las aves rehabilitadas.

Palabras clave: Centro de rehabilitación de fauna silvestre, Rapaz, Ave de presa, Disposición final

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## Introduction

The most common threats to the survival of raptors are the effects of human activities on the natural environment (Komnenou et al., 2005). Raptors are especially sensitive to ecological changes, particularly those species living on islands with high human population density (Rodríguez et al., 2010). In this setting, wildlife rescue networks and wildlife rehabilitation centers play a critical role in conservation. Rehabilitation of wild raptors has several direct benefits: it can reinforce a population after release into the wild—especially in the case of endangered species, help identify causes of morbidity and mortality, and assess the regulatory changes implemented after determining human influences and causes of admission (Sleeman & Clark, 2003; Molina-López et al., 2013). Indirect benefits include public education and enhancement of veterinary skills (Redig & Duke, 1995; Komnenou et al., 2005; Molina-López et al., 2013).

Data on rehabilitation of raptors are usually focused on the causes of morbidity and mortality, but a stratified analysis by causes of the final outcome is rarely reported (Molina-López et al., 2013, 2014). In addition, the use of quality indicators of the rehabilitation process of wild raptors is not widespread, with the exception of by Molina-López et al. (2013).

The aim of this study was to analyze the outcomes of the rehabilitation of wild raptors admitted to the Tafira Wildlife Rehabilitation Center (TWRC) in Gran Canaria Island, Spain, from 2003 to 2013, assessing a quality auditing system based on the crude and stratified (by causes of admission) rates of the four final outcome categories (euthanasia, unassisted mortality, release, and permanent captivity), the time until death, and the length of stay as quality indicators.

## Material and methods

### Birds and study area

A retrospective study was performed using the original medical records of 2,458 raptors admitted to the TWRC, Gran Canaria Island, Spain, from 2003 to 2013. Gran Canaria (27° 73'–28° 18' N and 15° 35'–15° 83' W) is the third largest island (1,560.1 km<sup>2</sup>) of the Canary Island archipelago. It has a permanent population of 852,700 inhabitants and the highest mean density (547 inhabitants/km<sup>2</sup>) among islands in the archipelago. The raptor rehabilitation program at the TWRC was conducted with the authorization of the Wildlife Department of the Canary Islands Government and the Environment Department of the Cabildo de Gran Canaria. Animal work and all sampling procedures were specifically approved by the TWRC Animal Care Committee and the insular government Cabildo de Gran Canaria, and were consistent with standard vertebrate protocols and veterinary practices. Raptors that had to be euthanized for animal welfare reasons were administered barbiturates by intravenous injection.

### Variables analyzed

Species, gender, age, date and primary cause of admission, and final outcome of each bird, including date of death or release, were recorded. Primary causes of admission were classified into nine categories: trauma, infectious/parasitic disease, metabolic/nutritional disease, glue trapping, orphaned young birds, poisoning, entanglement in burr bristlegrass (*Setaria adhaerens*), other causes, and unknown/undetermined causes (Montesdeoca et al., 2016). The trauma category was subdivided into: gunshot, collision (with fences, power lines, motor vehicles, and buildings), predation, electrocution, and unknown trauma (for those cases with clinical signs of trauma but without clear evidence about the accident). The infectious/parasitic disease category was applied when a pathogenic microorganism and/or parasite was confirmed by microbiological, parasitological or histopathological diagnosis. The metabolic/nutritional disease category was subdivided into: weakness, cachexia, and other diagnoses grouped by organic systems. The 'glue trapping' category was applied for raptors admitted with plumage damage after attempting to capture rodents caught in these commonly used traps for domestic rodent control in the Canary Islands. Chicks and fledgling raptors were included in the orphaned young category. Poisoning was diagnosed by toxicological analyses. The 'entanglement in *Setaria adhaerens*' category included raptors with plumage damage caused by plant burr bristlegrass. The 'other causes' category was subdivided into: crude oil, transient captivity (raptors maintained illegally in captivity for several months), birds found in water ponds, birds found inside buildings, and miscellany.

Four categories were established to study the outcome of raptors admitted alive: euthanized birds (based on poor quality of life and/or prognosis for survival in the wild), birds that died during hospitalization, birds released into the wild, and birds moved to zoological collections for permanent captivity (due to poor prognosis for survival in the wild). Four percentage rates were thus calculated for the total group of raptors admitted alive: euthanasia rate ( $E_r$ ), unassisted mortality rate ( $M_r$ ), release rate ( $R_r$ ), and permanent captivity rate ( $C_r$ ). These percentage rates were also calculated for each cause of admission.

For each cause of admission we also evaluated the parameters 'time until death' ( $T_d$ , difference between the date of admission and the date of the death) for euthanized birds and for raptors that died during the hospitalization period, and 'length of stay' in the center for released raptors ( $T_r$ , difference between the date of admission and the release date).

### Statistical analysis

Statistical analyses were conducted using SPSS v.22.0 (SPSS Inc., Chicago IL) and R package v.3.1.0 (R Development Core Team 2014, Vienna, Austria). Percentiles 10 ( $P_{10}$ ), 25 ( $P_{25}$ ), 50 ( $P_{50}$ ) (median), 75 ( $P_{75}$ ) and 90 ( $P_{90}$ ) for the variables  $T_d$  and  $T_r$  were calculated. The Chi-square test ( $\chi^2$ ) or Fisher's exact

Table 1. Final outcome of raptors admitted to the Tafira Wildlife Rehabilitation Center (2003–2013) stratified by cause of admission: N, Number;  $E_r$ , Euthanasia rate;  $M_r$ , Unassisted mortality rate;  $R_r$ , Release rate;  $C_r$ , Permanent captivity rate. <sup>a</sup> Collision with a wall, glass or other structures; <sup>b</sup> Other systemic diseases; <sup>c</sup> Found within a building).

*Tabla 1. Disposición final de las rapaces admitidas en el Centro de Rehabilitación de Fauna Silvestre de Tafira (2003–2013) clasificadas por causas de admisión: N, Número;  $E_r$ , Índice de eutanasia;  $M_r$ , Índice de mortalidad no asistida;  $R_r$ , Índice de liberación;  $C_r$ , Índice de cautiverio permanente. <sup>a</sup> Colisión con un muro, cristal u otras estructuras; <sup>b</sup> Otras muertes sistémicas; <sup>c</sup> Encontrado dentro de un edificio).*

Cause of admission	Number of raptors %		Final outcome							
			Euthanized		Dead		Released		Captive	
			N	$E_r$ (%)	N	$M_r$ (%)	N	$R_r$ (%)	N	$C_r$ (%)
<b>Trauma</b>	<b>758</b>	<b>34.55</b>	<b>283</b>	<b>37.33</b>	<b>180</b>	<b>23.74</b>	<b>291</b>	<b>38.39</b>	<b>4</b>	<b>0.53</b>
Gunshot	112	5.10	44	39.28	16	14.28	50	44.64	2	1.78
Collision with	67	3.05	14	20.89	17	25.37	36	53.73	0	0
Fences	3	0.13	0	0	1	33.33	2	66.67	0	0
Power lines	4	0.18	3	75	0	0	1	25	0	0
Motor vehicles	39	1.78	10	25.64	15	38.46	14	35.90	0	0
Buildings <sup>a</sup>	21	0.96	1	4.76	1	4.76	19	90.47	0	0
Predation	9	0.41	3	33.33	3	33.33	2	22.22	1	11.11
Electrocution	7	0.32	5	71.43	1	14.28	1	14.28	0	0
Unknown trauma	563	25.66	217	38.54	143	25.40	202	35.88	1	0.18
<b>Non-trauma</b>	<b>1,436</b>	<b>65.45</b>	<b>151</b>	<b>10.51</b>	<b>307</b>	<b>21.38</b>	<b>972</b>	<b>67.69</b>	<b>6</b>	<b>0.42</b>
Infectious/parasitic disease	15	0.68	4	26.66	9	60	2	13.33	0	0
Metabolic/nutricional disease	241	10.98	24	9.96	113	46.89	104	43.15	0	0
Weakness	94	4.28	5	5.32	29	30.85	60	63.83	0	0
Cachexia	83	3.78	9	10.84	55	66.26	19	22.89	0	0
Others <sup>b</sup>	64	2.92	10	15.62	29	45.31	25	39.06	0	0
Glue trap	121	5.51	3	2.48	12	9.92	104	85.95	2	1.65
Orphaned young	512	23.33	47	9.18	61	11.91	403	78.71	1	0.19
Nest chickens	50	2.28	3	6	6	12	41	82	0	0
Fledglings	462	21.05	44	9.52	55	11.90	362	78.35	1	0.21
Poisoning	30	1.37	1	3.33	12	40	17	56.66	0	0
Entanglement in										
<i>Setaria adhaerens</i>	40	1.82	0	0	6	15	34	85	0	0
Other causes:	126	5.74	38	30.16	24	19.05	61	48.41	3	2.38
Crude oil	2	0.09	0	0	0	0	2	100	0	0
Transient captivity	73	3.37	35	47.94	14	19.18	21	28.77	3	4.11
Water	9	0.41	0	0	2	22.22	7	77.78	0	0
Building <sup>c</sup>	22	1.00	0	0	3	13.64	19	86.36	0	0
Miscellany	20	0.91	3	15	5	25	12	60	0	0
Unknown/undetermined	351	16.00	34	9.69	70	19.94	247	70.37	0	0
<b>Total</b>	<b>2,194</b>	<b>100</b>	<b>434</b>	<b>19.78</b>	<b>487</b>	<b>22.20</b>	<b>1,263</b>	<b>57.57</b>	<b>10</b>	<b>0.46</b>

tests were used to determine whether there was a significant difference between proportions.

## Results

A total of 2,458 raptors were admitted to the TWRC during the eleven year study period (2003 to 2103). They were distributed in two orders: Falconiformes, with 1,652 animals (67.21%) of 13 species, and Strigiformes, with 806 animals (32.79%) of four species of owls (Montesdeoca et al., 2016). A total of 264 raptors were dead at admission. The most frequent causes of mortality in these birds were unknown/undetermined causes (38.26%,  $n = 101$ ), unknown trauma (14.39%,  $n = 38$ ), metabolic/nutritional disease (12.12%,  $n = 32$ ), and collision (9.85%,  $n = 26$ ).

The final outcome of the 2,194 raptors admitted alive showed the following rates:  $E_r = 19.78\%$  ( $n = 434$ ),  $M_r = 22.20\%$  ( $n = 487$ ),  $R_r = 57.57\%$  ( $n = 1,263$ ), and  $C_r = 0.46\%$  ( $n = 10$ ). Table 1 shows the final outcome according to cause of admission.

The euthanasia rate was notably higher in the trauma category (37.33%) than in the other causes of admission, and it was mainly due to electrocution or gunshot and unknown trauma. Raptors admitted due to infectious/parasitic diseases or metabolic/nutritional diseases had the highest unassisted mortality rates, 60% and 46.89%, respectively. The release rate was notably higher in the glue trap (85.95%), entanglement in *Setaria adherens* (85%), and orphaned young (78.71%) categories than in the other causes of admission. In the trauma category, raptors admitted due to collision had the highest release rate (53.73%) when compared to the other traumas. Only ten raptors were moved to zoological collections due to poor prognosis for survival in the wild during the study period.

Species from the Falconiformes order showed no significantly different euthanasia rate (18.91%;  $\chi^2 = 1.96$ ,  $P = 0.0807$ ) but had a significantly lower unassisted mortality rate (20.34%;  $\chi^2 = 8.57$ ,  $P = 0.0017$ ) and significantly higher release rate (60.34%;  $\chi^2 = 13.69$ ,  $P = 0.0001$ ) than Strigiformes ( $E_r = 21.55\%$ ;  $M_r = 25.97\%$ ;  $R_r = 51.93\%$ ) (table 2).

Figure 1 shows the final outcomes of the raptor species with more than 100 admissions [Eurasian kestrel (*Falco tinnunculus*), Canary Islands common buzzard (*Buteo buteo insularum*), Eurasian long-eared owl (*Asio otus canariensis*), and Eurasian barn owl (*Tyto alba*)]. Within the Falconiformes order, a comparison of the Canary Islands common buzzard and the Eurasian kestrel showed the buzzard had a significantly higher rate of euthanasia (28.74%;  $\chi^2 = 11.2$ ,  $P = 0.0004$ ) and significantly lower rates of unassisted mortality (13.17%;  $\chi^2 = 2.94$ ,  $P = 0.0430$ ), but no significant difference was observed in release rate (56.89%;  $\chi^2 = 2.28$ ,  $P = 0.0655$ ) ( $E_r = 17.56\%$ ;  $M_r = 19\%$ ;  $R_r = 63.27\%$ ). Within the Strigiformes order, no significant differences in any of the rates were detected when we compared the Eurasian long-eared owl and the Eurasian barn owl.

Within the group of euthanized raptors, the longest

median  $T_d$  was observed for the metabolic/nutritional disease category ( $T_d = 20.5$  days), whereas most causes of admission had median  $T_d$  values  $< 3$  days (table 3). The median  $T_d$  in the raptors that died during hospitalization ranged from 0 days (predation) to 5.5 days (other causes). Within the group of released raptors, the median length of stay in the TWRC ranged from 1 day (orphaned young) to 153 days (infectious/parasitic disease).

## Discussion

Several wildlife practice guidelines dealing with welfare rehabilitation standards and pre-release health screening protocols have been published (Woodford, 2000; Miller, 2012), but quality indicators of the rehabilitation process of injured raptors have rarely been reported (Molina-López et al., 2013, 2014). We analyzed the outcomes of rehabilitation of wild raptors at the Tafira Wildlife Rehabilitation Center (TWRC) in a retrospective study over a period of 11 years.

All the raptor species admitted to the TWRC are currently included on the Spanish List of Wildlife Species with Special Protection (Real Decreto 139/2011). Three of these species are also included in the Spanish Catalogue of Menaced Species as 'In Danger of Extinction' [Barbary falcon (*Falco pelegrinoides*) and Egyptian vulture (*Neophron percnopterus*)], and 'Vulnerable' [osprey (*Pandion haliaetus*)] (Real Decreto 139/2011).

According to our data, 57.57% of raptors admitted alive to the TWRC were successfully released, while 41.98% of admissions resulted in euthanasia or unassisted mortality. A comparative analysis between studies regarding final outcome of raptors in wildlife rehabilitation centers is difficult due to the heterogeneity of surveys (Duke et al., 1981; Fix & Barrows, 1990; Deem et al., 1998; Rodríguez et al., 2010; Thompson et al., 2013; Molina-López et al., 2013, 2014). The stratified analysis by causes of admission of the four final outcome rates ( $E_r$ ,  $M_r$ ,  $R_r$ , and  $C_r$ ), and the parameters time until death ( $T_d$ ) and length of stay at the center ( $T_r$ ), should be included in the outcome research of the rehabilitation process of raptors in order to allow comparative studies between wildlife rehabilitation centers around the world (Molina-López et al., 2013).

Based on animal welfare, euthanasia is a final option in rehabilitation of all wildlife species (Sleeman, 2008). The overall rate of euthanasia in our study (19.78%) was lower than that reported in other surveys (Deem et al., 1998; Molina-López et al., 2013; Thompson et al., 2013), although in the trauma category (37.33%) it was similar to that reported by Molina-López et al. (2013) (37.4%). Within the admission categories, the euthanasia rate was notably higher in the trauma category than in other causes of admission, and it was mainly due to electrocution, gunshot and unknown trauma. The severity of lesions explains the generally poor prognosis for these raptors. Molina-López et al. (2013) also reported

Table 2. Final outcome of raptor species admitted to the Tafira Wildlife Rehabilitation Center (2003–2013) and estimated populations: N, Number; E<sub>r</sub>, Euthanasia rate; M<sub>r</sub>, Unassisted mortality rate; R<sub>r</sub>, Release rate; C<sub>r</sub>, Permanent captivity rate; GCI, Gran Canaria Island; CIA, Canary Islands Archipelago. <sup>a</sup> Lorenzo (2007); <sup>b</sup> García del Rey (2015); \* Insufficient data.

Tabla 2. Disposición final de las especies de rapaces admitidas en el Centro de Rehabilitación de Fauna Silvestre de Tafira (2003–2013) y poblaciones estimadas: N, Número; E<sub>r</sub>, Índice de eutanasia; M<sub>r</sub>, Índice de mortalidad no asistida; R<sub>r</sub>, Índice de liberación; C<sub>r</sub>, Índice de cautiverio permanente; GCI, Isla Gran Canaria; CIA, Canarias. <sup>a</sup> Lorenzo (2007); <sup>b</sup> García del Rey (2015); \* Datos insuficientes.

Especies	Final disposition								Estimated opulation <sup>a,b</sup>	
	Euthanized		Dead		Released		Captive		GCI	CIA
	N	Er(%)	N	Mr(%)	N	Rr(%)	N	Cr(%)		
<b>Order Falconiformes</b>	<b>278</b>	<b>18.91</b>	<b>299</b>	<b>20.34</b>	<b>887</b>	<b>60.34</b>	<b>6</b>	<b>0.41</b>		
Family Accipitridae										
Eurasian sparrowhawk ( <i>Accipiter nisus granti</i> )	6	11.11	31	57.41	17	31.48	0	0	100–150	1,250–1,875
Eurasian griffon ( <i>Gyps fulvus</i> )	0	0	0	0	1	100	0	0	–	–
Black kite ( <i>Milvus migrans</i> )	0	0	1	33.33	2	66.67	0	0	–	–
Egyptian vulture ( <i>Neophron percnopterus majorensis</i> )	3	21.43	0	0	10	71.43	1	7.14	–	36–48
Canary Islands common buzzard ( <i>Buteo buteo insularum</i> )	48	28.74	22	13.17	95	56.89	2	1.20	175–263	1,250–1,875
Short-toed snake-eagle ( <i>Circaetus gallicus</i> )	1	100	0	0	0	0	0	0	–	–
Family Falconidae										
Barbary falcon ( <i>Falco pelegrinoides</i> )	12	29.27	19	46.34	9	21.95	1	2.44	48–84	203–357
Peregrine falcon ( <i>Falco peregrinus</i> )	1	100	0	0	0	0	0	0	–	–
Eurasian hobby ( <i>Falco subbuteo</i> )	0	0	0	0	2	100	0	0	–	–
Eurasian kestrel ( <i>Falco tinnunculus</i> )	207	17.56	224	19.00	746	63.27	2	0.17	2,970–5,940	12,500–50,000
Eleonora's falcon ( <i>Falco eleonora</i> )	0	0	1	20	4	80	0	0	–	400–500
Lesser kestrel ( <i>Falco naumanni</i> )	0	0	0	0	0	0	0	0	–	–
Family Pandionidae										
Osprey ( <i>Pandion haliaetus</i> )	0	0	1	50	1	50	0	0	–	35–44

Table 2. (Cont.)

Species	Final disposition								Estimated opulation <sup>a,b</sup>	
	Euthanized		Dead		Released		Captive		GCI	CIA
	N	Er(%)	N	Mr(%)	N	Rr(%)	N	Cr(%)		
<b>Order Strigiformes</b>	<b>156</b>	<b>21.55</b>	<b>188</b>	<b>25.97</b>	<b>376</b>	<b>51.93</b>	<b>4</b>	<b>0.55</b>		
Family Strigidae										
European scops-owl ( <i>Otus scops</i> )	1	20	1	20	3	60	0	0	–	–
Short-eared owl ( <i>Asio flammeus</i> )	0	0	0	0	1	100	0	0	–	–
Eurasian long-eared owl ( <i>Asio otus canariensis</i> )	141	22.56	160	25.6	320	51.2	4	0.64	*	6,070–12,140
Family Tytonidae										
Eurasian barn owl ( <i>Tyto alba</i> )	14	15.05	27	29.03	52	55.91	0	0	*	900–2,250
<b>Total</b>	<b>434</b>	<b>19.78</b>	<b>487</b>	<b>22.20</b>	<b>1,263</b>	<b>57.57</b>	<b>10</b>	<b>0.46</b>		

a notably higher  $E_r$  in the trauma category (34.2%) than in the non-trauma (9.2%) or orphaned young (2%) categories, and reported this was mainly due to electrocution and collisions with power lines.

The unassisted mortality rate has been used previously as a quality indicator parameter in rehabilitation of birds of prey (Molina-López et al., 2013) and also recently in rehabilitation of sea turtles (Orós et al., 2016). Comparing our results with those reported by Molina-López et al. (2013), we found that the overall rate of unassisted mortality in our study (22.20%) was slightly higher, whereas the rate of mortality due to trauma (23.74%) was lower. In addition, the high rates of mortality due to infectious/parasitic diseases (60%) and metabolic/nutritional diseases (46.89%) in our study were similar to those reported by Molina-López et al. (2013) (54.8 % and 42.6%, respectively). These results could perhaps be explained by the poor prognosis of the cases with severe trichomoniasis (Samour & Naldo, 2003; Molina-López et al., 2013) and possibly by the inaccurate diagnosis of conditions in the metabolic/nutritional diseases category due to financial limitations. The mortality rate due to gunshot (14.28%) was similar to that reported by Richards et al. (2005) (14%) and Ress & Guyer (2004) (< 20%), but lower than that reported by Molina-López et al. (2013) (33.5%). The mortality rate for orphaned young birds (11.91%) was lower than that reported in other surveys (Komnenou et al., 2005; Molina-López et al., 2013). The mortality rate due to glue trapping was not negligible (9.92%), emphasizing the need to regulate these products that are commonly used in the Canary Islands for domestic rodent control (Montesdeoca et al., 2016). In addition, our study provided data for the first time regarding the mortality rate due to entanglement in the plant *Setaria adhaerens* (15%).

Entanglement of raptors in this plant could also be a consequence of anthropogenic perturbations in the Canary Islands, because the densities of burr bristlegrass are highest in human-transformed areas (Rodríguez et al. 2010).

The overall rate of release in our study (57.57%) was higher than that reported by Rodríguez et al. (2010) in Tenerife (44.4%), by Thompson et al. (2013) in South Africa (38%), and by Molina-López et al. (2013) in Catalonia (47.2%). The overall release rate of trauma cases (38.39%) was also higher than that reported by Molina-López et al. (2013) (24.3%). In our survey, glue trap (85.95%), entanglement in *Setaria adhaerens* (85%), orphaned young (78.71%), and unknown/undetermined (70.37%) categories had higher release rates than the overall release rate. Molina-López et al. (2013) also reported a high release rate for orphaned young birds (77.9%). People with good intentions often confuse fledglings (with limited ability to fly) with orphaned birds that are unable to care for themselves (Komnenou et al., 2005), explaining why many of the orphaned birds were healthy at the time of admission (Montesdeoca et al., 2016).

Although the proportion of injured birds that are subsequently released is used as a measure of success by rehabilitators and conservationists, for rehabilitation to be classed as successful, the bird must be re-established into the wild population and have a similar chance of entering the breeding pool survival as wild birds (Joys et al., 2003). Monadjem et al. (2014) demonstrated that, despite the treatment received, the survival rate of rehabilitated birds did not recover to the level of non-injured, wild birds. When studying the life expectancy and mortality of rehabilitated barn owls in Spain, Fajardo et al. (2000) found that released individuals showed greater mortality due to starvation

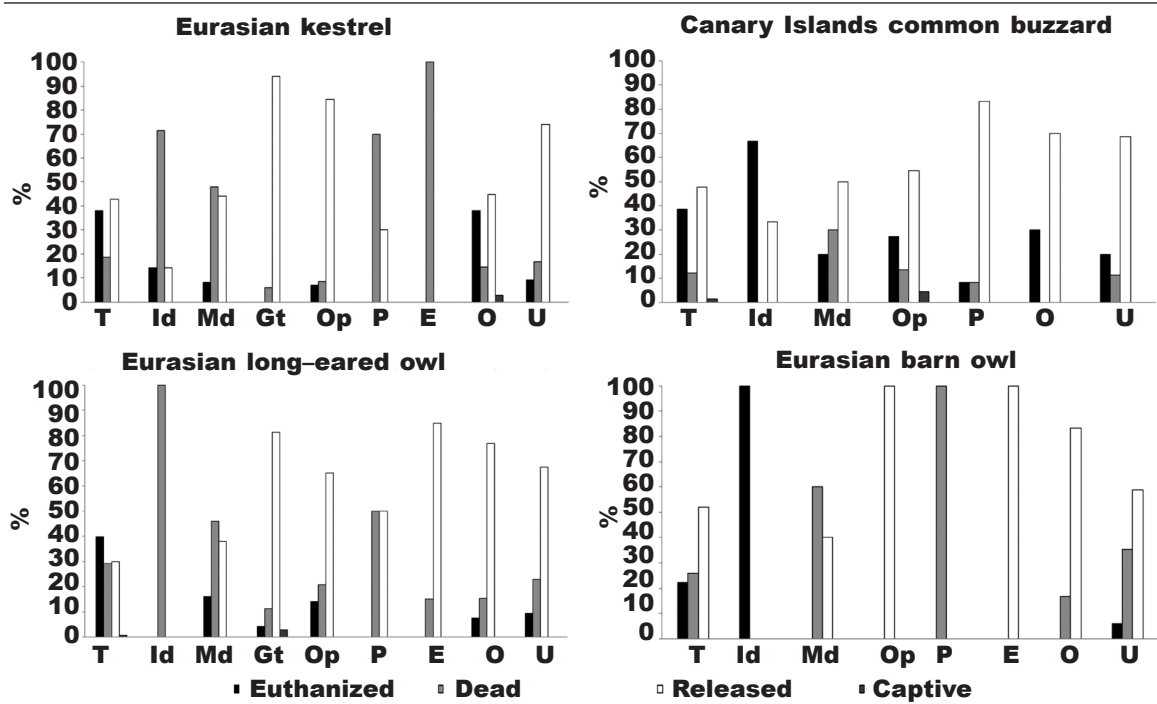


Fig. 1. Final outcome of the raptor species with more than 100 admissions at the Tafira Wildlife Rehabilitation Center (2003–2013) stratified by causes of admission: T. Trauma; Id. Infected/parasitic disease; Md. Metabolic or Nutritional disease; Gt. Glue trap; Op. Orphaned; P. Poisoning; E. Entanglement in *S. adhaerens*; O. Other causes; and U. Unknown.

Fig. 1. Disposición final de las especies de rapaces con más de 100 admisiones en el Centro de Rehabilitación de Fauna Silvestre de Tafira (2003–2013) estratificadas por causas de admisión: T. Trauma; Id. Infección/enfermedad parasitaria; Md. Enfermedad metabólica o nutricional; Gt. Trampas adhesivas; Op. Huérfano; P. Envenenamiento; E. Enmarañamiento en *S. adhaerens*; O. Otras causas; U. Causa desconocida.

in the first four weeks than local wild birds, but after this period surviving owls resembled wild populations in mortality patterns. The use of rings (Fajardo et al., 2000), a combined 'live encounter–dead recovery' approach in the program MARK (White, 2008; Monadjem et al., 2014), and radiotelemetry (Fischer et al., 2014) have shown to be suitable tools to monitor free-ranging bird survival.

When the number of released raptors belonging to the different raptor species is compared with their estimated populations in Gran Canaria (table 2), the highest numerical impact was observed for the Canary Islands common buzzard. However, the potential release impact of the two species 'in danger of extinction' (Barbary falcon and Egyptian vulture) on their populations is not negligible. Unfortunately, data on the populations of raptor species in Gran Canaria either have a wide range or are insufficient for more precise considerations (Lorenzo, 2007; García del Rey, 2015).

In our study, the euthanasia rates of the two taxonomic orders did not differ significantly. However, Molina-López et al. (2014) reported Falconiformes as the group with higher rates of euthanized birds, because most of these raptors were admitted due to

unknown trauma or collisions with vehicles. As reported by Molina-López et al. (2014), we also found that unassisted mortality in owls was significantly higher than that in diurnal raptors. Apart from differences in the causes of admission (Montesdeoca et al., 2016), other factors such as the severity of the lesions and the management in captivity could increase the mortality risk (Molina-López et al., 2014). Contrary to what reported by Ress & Guyer (2004), and Molina-López et al. (2014), we found diurnal raptors had a higher release rates than owls. When we studied the two most important causes of admission (trauma and orphaned young) for raptors admitted alive, 44.79% of admissions of Strigiformes were due to trauma (a cause with low release rates), compared to 27.39% of admissions of Falconiformes. Conversely, the 'orphaned young' category (with a high release rate for the above-mentioned reasons) accounted for 25.86% of admissions of Falconiformes but only for 13.89% of admissions of Strigiformes (Montesdeoca et al., 2016). Therefore, taking into account the frequency distribution according to causes of admission and raptor species (Montesdeoca et al., 2016), and also the fact that the veterinary protocols were basically

Table 3. Descriptive statistics of hospitalization time of raptors at the Tafira Wildlife Rehabilitation Center until final outcome:  $P_{10}$ ,  $P_{25}$ ,  $P_{50}$ ,  $P_{75}$ ,  $P_{90}$ . Percentiles 10, 25, 50 (median), 75 and 90; N/A. Not applicable (only one case).

Tabla 3. Datos estadísticos descriptivos del tiempo de hospitalización en el Centro de Rehabilitación de Fauna Silvestre de Tafira hasta la disposición final:  $P_{10}$ ,  $P_{25}$ ,  $P_{50}$ ,  $P_{75}$ ,  $P_{90}$ . Percentiles 10, 25, 50 (mediana), 75 y 90; N/A. No aplicable (solo en un caso).

Cause of admission	Time (days) from admission to final disposition														
	Euthanasia					Unassisted mortality					Release				
	$P_{10}$	$P_{25}$	$P_{50}$	$P_{75}$	$P_{90}$	$P_{10}$	$P_{25}$	$P_{50}$	$P_{75}$	$P_{90}$	$P_{10}$	$P_{25}$	$P_{50}$	$P_{75}$	$P_{90}$
Trauma	0	0	2	33	97.8	0	1	2	7	39.9	3	17	46	78.5	127
Gunshot	0	0	2.5	40.2	119.5	0	1	1.5	30.5	131.8	12.4	42	70.5	126.5	190.9
Collision	0	0	1	66	1,274.8	0.8	1	3	7	14.2	0	1.2	11.5	49	97.3
Predation	0	0	1	3	3	0	0	0	1	1	3	3	13.5	24	24
Electrocution	0	0	0	6.5	12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Unknown origin	0	0	2	35	94.2	0	0	2	7	39.6	5	18.2	46	76	116
Infectious/parasitic disease	0	0.25	2.5	26.5	34	1	2	4	8	10	10	10	153	296	296
Metabolic/nutritional disease	1	3	20.5	55	186.5	0	0	1	2	7.4	6	13	20	35.5	67.5
Glue trap	0	0	0	410	410	0.3	1.2	3	91.2	174.6	4	8.25	18.5	61.25	104
Orphaned young	0	0	2	18.7	45.6	0	1	1.5	5.7	58.6	0	0	1	20	56.8
Poisoning	N/A	N/A	N/A	N/A	N/A	0	0	0.5	2.7	7.5	7	15	19	25	62.4
Entanglement in <i>Setaria adhaerens</i>	–	–	–	–	–	0	0.7	1	2.2	3	0	1	4	8.5	17.8
Other causes	0	0	1	37.5	161.4	0.3	1	5.5	35.2	245.1	0.7	2.2	15.5	91.7	213
Unknown/undetermined	0	1.25	9	26.2	144.4	0	0	1.5	6	39.9	0	2.5	10	27	59

the same regardless of the species treated, all the statistically significant differences between species in the outcome rates were clearly related to the cause of admission; the different causes of admission with their different prognosis according to the severity of lesions determines the differences in the final outcome rates.

The parameter 'time to death' provides direct insight into the initial assessment and prognosis, the overall rehabilitation process, and the validity of veterinary protocols (Molina-López et al., 2013). In our study, most causes of admission had median  $T_d$  values < 3 days, meaning that the decision is made early based on the poor prognosis of these cases. The analysis of the median  $T_d$  values within the group of raptors that died during the rehabilitation process suggests that the first week of stay at the rehabilitation center is critical and, as recommended by

Molina-López et al. (2013), all raptors should receive intensive care during the first week even when their appearance seems less severe.

The parameter 'length of stay' must be as short as possible to reduce the risk of captive-related complications, infectious diseases, and behavioral disorders (Cooper & Cooper, 2006). In our study, the median length of stay in the center ranged from 1 day (orphaned) to 153 days (infectious/parasitic disease). The longest  $P_{90} T_r$  was also recorded in this category, 296 days, suggesting that raptors admitted due to infectious/parasitic diseases consume considerable time and effort.

In conclusion, our findings support the usefulness of the quality auditing system of the rehabilitation process in wild raptors proposed by Molina-López et al. (2013) for comparative studies between wildlife



rehabilitation centers. Taking into account the special vulnerability of the insular raptor species, the high release rate for wild raptors (57.57%) achieved at the TWRC during this long-term survey emphasizes the importance of wildlife rehabilitation centers for the medical management of injured raptors and subsequent release of rehabilitated individuals into the wild. However, to understand the effects of rehabilitation on the conservation of raptor populations in Gran Canaria, further studies are needed to determine the final survival rate of rehabilitated raptors and to obtain more accurate estimations of the wild raptor populations on this island.

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