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SPECIE-SPECIFIC OUTCOMES OF WILD RAPTORS ATTENDED AT A WILDLIFE REHABILITATION CENTRE IN CATALONIA (1997-2005)

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ABSTRACT

Outcome research of rehabilitation of wild birds of prey and owls are scarcely reported. The aim of this study is to investigate specie-specific outcomes of the rehabilitation practice in wild raptor attended in a wildlife center. A total of 6221 hospitalized wild raptors (3241 Strigiformes; 2980 Falconiformes) admitted at a Wildlife Rehabilitation Centre (WRC) of Catalonia from 1995 to 2007 were analysed. The outcomes indicators were based on ratios of Euthanasia (E_r), Mortality (M_r), Release (R_r) and Captivity (C_r). Stratified analyses by main causes of admission were performed for the different raptor species. Species from the Falconiformes order presented higher rates of euthanasia (33.9%) compared to the Strigiformes (18.6%). Species like *B. buteo* (45.7%) and *M. migrans* (47.6%) in the Falconiformes and *B. bubo* (33.6%) in the Strigiformes, presented the highest E_r. Despite no differences between orders could be observed in the row mortality rates, data analysed by the causes of admission showed that the M_r of owls was significant higher than the Falconiformes for the trauma (13.2%; $\chi^2 = 49.97$; $p<0.001$), non trauma (12.7%; $\chi^2 = 17.41$; $p<0.001$) and orphaned young categories (4.9%; $\chi^2 = 5.4$; $p = 0.02$). The release rate was similar between orders. Based on species, *G. fulvus* (69.2%), *C. aeruginosus* (56.3%) and *A. gentillis* (43.1%) in the Falconiformes and *O. scops* (48.5%) in the Strigiformes showed the highest R_r. In the orphaned young category owls had better R_r than the diurnal raptors, being *S. aluco* the specie with the best rates of release (84%), whereas *B. bubo* had the worst values (50%). Specie-specific differences were found in the rehabilitation outcomes according to the different causes of admission. The stratified analysis of outcomes can be useful in order to to identify specie-specific risk factors.

Keywords: Wild Raptor Species, Wildlife Rehabilitation, Specie-Specific Outcomes, Quality Indicators

1. INTRODUCTION

The rehabilitation of wild birds of prey and owls, nowadays extensively developed in many countries, has played a significant improvement in wildlife medicine and wildlife conservation of species, including positive input on the recovery of some endangered species (Negro *et al*., 2007), the identification and understanding of many menaces to the wild populations (Harris and Sleeman, 2007) and the improvement of animal welfare (Grogan and Kelly, 2013). The main goal of the rehabilitation of wild life species is to be able to release individuals to the wild after physical and behavioral recovery, taking into account, not only welfare concerns but also providing a critical evaluation of the chances of individual to survive in the wild after rehabilitation.

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The analysis of the outcomes or final disposition of wild species in the rehabilitation centers is of great important to assess the quality of the rehabilitation process since such analysis can detect critical points in the hospitalization and rehabilitation practice. In a previous paper (Molina-Lopez *et al*., 2013) we describe these issues for the whole population of wild raptors at a wildlife rehabilitation centre in Spain. The aim of this study is to analyze the outcomes in a specie-specific base, in order to detect risk factors associated at this level.

2. MATERIALS AND METHODS

2.1. Study Design and Animals

A retrospective study was performed using the original medical records of birds of prey admitted at the Wildlife Rehabilitation Centre of Torreferrussa, Catalonia (Spain) from 1995 to 2007. The centre is under the direction of the governmental Catalan Wildlife-Service. Samples were collected in compliance with the Ethical Principles in Animal Research in the wildlife rehabilitation centers. The rehabilitation centers directly depend on the governmental Autonomous Wildlife Services. Thus, protocols, amendments and other resources were done according to the guidelines approved by each Autonomous government following the published law R.D.1201/2005 (10th October 2005, BOE 21st October 2005) of the Ministry of Presidency of Spain. Animals that had to be euthanized for humanitarian reasons were sacrificed by endovenous injection of barbiturates.

2.2. Definition of Variables

The classification of primary causes of admission was described in a previous study (Molina-Lopez *et al*., 2011). Briefly, the most relevant causes of admission comprised the following categories: Trauma (unknown trauma, gunshot, collision with vehicles and electrocution), non-trauma (fortuity, metabolic/nutritional diseases, captivity and infectious/parasitic diseases) and orphaned young chicks.

The final outcomes were divided into four categories based on previous works (Molina-Lopez *et al*., 2013): Euthanized animals (based on humanitarian principle), dead animals (mortality with no human intervention), released animals to the wild (result of successful rehabilitation) and captive non-releasable animals (due to its poor prognosis of survivability in wilderness). The final dispositions were calculated by dividing the number of cases of each category by the total number of admissions in each species; in consequence all four categories were expressed as rates: Euthanasia rate (E_r), Mortality rate (M_r), Release rate (R_r) and Captivity rate (C_r).

2.3. Statistical Analysis

Descriptive statistics, normality test and inferential analyses were done at 95% of confidence with SPSS Advanced Models ™ 15.0 (SPSS Inc. 233 South Wacker Drive, 11th Floor Chicago, IL 60606-6412). Chi-square (χ^2) or Fisher exact tests were used for comparisons between the E_r, M_r, R_r and C_r and the covariate specie. For comparisons, only species with more than 25 animals were used.

3. RESULTS

3.1. Descriptive Analyses of the Total Population

A total of 7553 raptor admissions were reported at the WRC during a period of twelve years (from 1995 to 2007). After a critical review of all the admissions, 1332 cases were excluded for not fulfilling the inclusion criteria (739 cases were admitted death and 593 cases included captive birds, captive borne or falconry birds). Thus, the final population of this study was composed by 6221 individuals distributed in the following orders: 3241 Strigiformes (1511 adults and 1730 chicks) and 2980 Falconiformes (2557 adults and 423 chicks). Seven different species were included in the nocturnal raptors group and 23 species in the diurnal group **Table 1**.

3.2. Euthanasia Rates (E_r) of Different Raptor Species

Species from the Falconiformes order presented higher rates of euthanasia (33.9%) compared to the Strigiformes (18.6%) (**Table 2**). Species like *B. buteo* (45.7%), *M. migrans* (47.6%) and M. milvus (40% aprox) were the species with the highest E_r in the Falconiformes and *B. bubo* (33.6%) in the Strigiformes (**Fig. 1**).

Regarding causes of admission, 37% *B. bubo* were euthanized due to the severity of lesions caused by electrocution (**Table 3**), whereas other species of owls and *B. buteo* and *M. migrans* in Falconiformes were mainly sacrificed due to unknown trauma or collision with vehicles (**Table 3**). In the orphaned group euthanasia rates were very low compared to other categories of animals (**Fig. 1**).

Table 1. Description of the total number of species analysed in the study

Species category (n)	Total excluding orphaned category (n)	Only orphaned
Strigiformes		
Asio flameus	10	0
Asio otus	60	13
Athene noctua	481	578
Bubo bubo	137	13
Otus scops	268	577
Strix aluco	230	437
Tyto alba	325	112
Total	1511	1730
Falconiformes		
Accipiter gentillis	174	11
Accipiter nisus	386	12
Aquila chrysaetos	2	0
Buteo buteo	770	16
Circaetus gallicus	39	1
Circus aeruginosus	32	0
Circus cyaneus	12	1
Circus pygargus	9	0
Falco columbarius	6	0
Falco naumanni	48	13
Falco peregrinus	86	7
Falco subbuteo	32	0
Falco tinnunculus	802	355
Falco vespertinus	1	0
Gypaetus barbatus	2	0
Gyps fulvus	39	2
Hieraetus fasciatus	8	0
Hieraetus pennatus	26	2
Milvus migrans	21	1
Milvus milvus	5	1
Neophron percnocterus	1	0
Pandion halietus	2	0
Pernis apivorus	54	1
Total	2557	423

3.3. Mortality Rates (M_r) in Different Raptor Species

Although there are not statistical differences between total mortality for Strigiformes (31.5%) and Falconiformes (29.6%), when we analyze the mortality for the three general categories of causes, the M_r of owls was significant higher for trauma (13.2%; $\chi^2 = 49.97$; $p<0.001$), non trauma (12.7%; $\chi^2 = 17.41$; $p<0.001$) and orphaned young categories (4.9%; $\chi^2 = 5.4$; $p = 0.02$) compared to Falconiformes.

Among the Falconiformes, *A. nisus* and *F. Subbuteo* and with a lower number individual also *C. cyaneus* and *H. fasciatus*, presented M_r above 50%. Among the Strigiformes, *Asio spp* and *S. aluco* and *T. alba* were the species with the highest rate of mortality, also around 50% (**Fig. 1**). The main cause of mortality in these owls and diurnal raptors was unknown trauma (**Table 4**). Interestingly, the highest M_r due to infectious diseases was observed in *F. peregrinus* (10.3%) and *F. subbuteo* (9.5%). In the orphaned category, *B. bubo* had the highest rates of mortality (33.3%) and, in the diurnal the highest Mr was observed in *F. naumanni* and *F. peregrinus* (>50%) (**Fig. 1**).

3.4. Release Rates (R_r) in the Different Raptor Species

The overall R_r was not statistically different between orders. Strigiformes (33.2%) showed slightly higher release rates than Falconiformes (29.8%). Based on species, *G. fulvus* (69.2%), *C. aeruginosus* (56.3%) and *A. gentillis* (43.1%) showed the highest R_r in the Falconiformes and *O. scops* (48.5%) in the Strigiformes (**Fig. 1**). Most of the released species were hospitalized due to unknown trauma (*C. aeruginosus*, *O. scops*), fortuity causes (*G. fulvus*) or gunshot (*A. gentillis*) (**Table 5**).

On the other hand, high values of R_r were observed for trauma caused by vehicles in *S. aluco* (25.7%) and from gunshot (around 40%) in *B. buteo*, *A. gentillis* and *F. peregrinus* (**Table 5**). By contrast, when the cause of injure was electrocution the lowest rates of release were observed for all the examined species.

In the orphaned young category owls showed, in general, better R_r than diurnal raptors (**Fig. 1**). Within the Strigiformes, *B. bubo* presented the worst release rates with only 50% R_r and *S. aluco* the best rates with up to 84% R_r. In the Falconiformes, the best R_r (>80%) was observed for *B. buteo*, *A. nisus* and *F. tinnunculus* but it was very low for *F. naumanni* (16.7%) (**Table 6**).

3.5. Captivity Rates (C_r) in Different Raptor Species

The overall C_r of Strigiformes and Falconiformes were low and similar between groups (2 and 4.1% respectively). The highest Cr values corresponded to *F. naumanni* (16.1%) and *F. tinnunculus* (13.7%) in Falconiformes and *A. noctua* (10.6%) and *T. alba* (8.7%) in Strigiformes. In the orphaned category, the highest C_r was observed in *A. noctua* (29.6%) and *F. naumanni* (25.9%).

Table 2. Resolution rates of the different species attended at the Wildlife Rehabilitation centre according to the animal order

Species	Total raptor admissions, N*	Euthanatized		Dead		Released		Captivity	
		n	Rate (E_r)	n	Rate (M_r)	n	Rate (R_r)	n	Rate (C_r)
Strigiformes									
Asio flameus	10	2	20.0	6	60.0	2	20.0	0	0.0
Asio otus	60	18	30.0	30	50.0	6	10.0	6	10.0
Athene noctua	481	104	21.6	202	42.0	158	32.8	17	3.5
Bubo bubo	137	46	33.6	53	38.7	30	21.9	8	5.8
Otus scops	268	26	9.7	109	40.7	130	48.5	3	1.1
Strix aluco	230	32	13.9	120	52.2	74	32.2	4	1.7
Tyto alba	325	53	16.3	157	48.3	101	31.1	14	4.3
Total	1511	281	18.6	677	44.8	501	33.2	52	3.4
Falconiformes									
Accipiter gentillis	174	47	27.0	46	26.4	75	43.1	6	3.4
Accipiter nisus	386	92	23.8	202	52.3	85	22.0	7	1.8
Aquila chrysaetos	2	0	0.0	1	50.0	0	0.0	1	50.0
Buteo buteo	770	352	45.7	166	21.6	241	31.3	11	1.4
Circaetus gallicus	39	14	35.9	11	28.2	11	28.2	3	7.7
Circus aeruginosus	32	7	21.9	3	9.4	18	56.3	4	12.5
Circus cyaneus	12	3	25.0	7	58.3	2	16.7	0	0.0
Circus pygargus	9	2	22.2	1	11.1	0	0.0	6	66.7
Falco columbarius	6	2	33.3	3	50.0	1	16.7	0	0.0
Falco naumanni	48	4	8.3	13	27.1	5	10.4	26	54.2
Falco peregrinus	86	11	12.8	39	45.3	24	27.9	12	14.0
Falco subbuteo	32	2	6.3	21	65.6	5	15.6	4	12.5
Falco tinnunculus	802	302	37.7	251	31.3	227	28.3	22	2.7
Falco vespertinus	1	0	0.0	1	100.0	0	0.0	0	0.0
Gypaetus barbatus	2	0	0.0	1	50.0	0	0.0	1	50.0
Gyps fulvus	39	0	0.0	10	25.6	27	69.2	2	5.1
Hieraetus fasciatus	8	1	12.5	6	75.0	0	0.0	1	12.5
Hieraetus pennatus	26	7	26.9	10	38.5	8	30.8	1	3.8
Milvus migrans	21	10	47.6	2	9.5	9	42.9	0	0.0
Milvus milvus	5	2	40.0	2	40.0	1	20.0	0	0.0
Neophron percnocterus	1	0	0.0	0	0.0	0	0.0	1	100.0
Pandion halietus	2	0	0.0	1	50.0	1	50.0	0	0.0
Pernis apivorus	54	9	16.7	23	42.6	21	38.9	1	1.9
Total	2557	867	33.9	820	32.1	761	29.8	109	4.3

*; Only adults were included (>1 year calendar)

Table 3. Euthanasia rates of the different species attended at the Wildlife Rehabilitation centre according to the main cause of admission

Species	Overall	Number and percentages of euthanized raptors Principal causes of admission*															
		Unknown trauma		Vehicles		Gunshot		Electrocution		Fortuity		Metabolic nutritional		Captivity		Infectious parasitic	
Strigiformes	N	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Asio flameus	2	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Asio otus	18	13	72.2	2	11.1	1	5.6	1	5.6	0	0.0	0	0.0	0	0.0	0	0.0
Athene noctua	104	68	65.4	26	25.0	3	2.9	0	0.0	0	0.0	0	0.0	1	1.0	0	0.0
Bubo bubo	46	16	34.8	4	8.7	1	2.2	17	37.0	0	0.0	2	4.3	0	0.0	0	0.0
Otus scops	26	16	61.5	7	26.9	0	0.0	0	0.0	0	0.0	2	7.7	0	0.0	0	0.0
Strix aluco	32	18	56.3	9	28.1	0	0.0	0	0.0	0	0.0	0	0.0	1	3.1	2	6.3
Tyto alba	53	27	50.9	20	37.7	0	0.0	3	5.7	1	1.9	0	0.0	0	0.0	0	0.0
Falconiformes																	
Accipiter gentillis	47	23	48.9	1	2.1	18	38.3	1	2.1	1	2.1	2	4.3	1	2.1	0	0.0
Accipiter nisus	92	53	57.6	4	4.3	29	31.5	1	1.1	0	0.0	0	0.0	0	0.0	1	1.1
Buteo buteo	352	144	40.9	40	11.4	97	27.6	53	15.1	3	0.9	0	0.0	2	0.6	3	0.9
Circaetus gallicus	14	4	28.6	0	0.0	0	0.0	6	42.9	0	0.0	0	0.0	0	0.0	1	7.1
Circus aeruginosus	7	7	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Circus cyaneus	3	1	33.3	0	0.0	2	66.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Circus pygargus	2	1	50.0	0	0.0	0	0.0	0	0.0	1	50.0	0	0.0	0	0.0	0	0.0
Falco columbarius	2	1	50.0	0	0.0	1	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Falco naumanni	4	3	75.0	0	0.0	0	0.0	0	0.0	1	25.0	0	0.0	0	0.0	0	0.0
Falco peregrinus	11	3	27.3	1	9.1	1	9.1	5	45.5	0	0.0	0	0.0	0	0.0	1	9.1
Falco subbuteo	2	0	0.0	0	0.0	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Falco tinnunculus	302	147	48.7	17	5.6	26	8.6	69	22.8	16	5.3	5	1.7	8	2.6	6	2.0
Hieraetus fasciatus	1	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Hieraetus pennatus	7	1	14.3	0	0.0	1	14.3	4	57.1	1	14.3	0	0.0	0	0.0	0	0.0
Milvus migrans	10	4	40.0	4	40.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	10.0
Milvus milvus	2	0	0.0	0	0.0	0	0.0	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0
Pernis apivorus	9	7	77.8	1	11.1	1	11.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

* Undetermined and other minority causes (fences, predation, power lines, toxicosis…) have been omitted to simplify data

Table 4. Mortality rates of the different species attended at the Wildlife Rehabilitation centre according to the main cause of admission

	Number and percentages of dead raptors Principal causes of admission*																	
Species	Overall	Unknown trauma		Vehicles		Gunshot		Electrocution		Fortuity		Metabolic nutritional		Captivity		Infectious parasitic	
Strigiformes	N	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Asio flameus	6	2	33.3	0	0.0	4	66.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Asio otus	30	16	53.3	5	16.7	1	3.3	0	0.0	2	6.7	4	13.3	0	0.0	0	0.0
Athene noctua	202	104	51.5	47	23.3	6	3.0	0	0.0	18	8.9	10	5.0	2	1.0	1	0.5
Bubo bubo	53	15	28.3	5	9.4	2	3.8	3	5.7	7	13.2	8	15.1	0	0.0	3	5.7
Otus scops	109	58	53.2	17	15.6	0	0.0	0	0.0	16	14.7	6	5.5	3	2.8	1	0.9
Strix aluco	120	45	37.5	32	26.7	2	1.7	2	1.7	19	15.8	8	6.7	0	0.0	5	4.2
Tyto alba	157	52	33.1	41	26.1	6	3.8	2	1.3	15	9.6	12	7.6	0	0.0	10	6.4
Falconiformes																	
Accipiter gentillis	46	17	37.0	1	2.2	20	43.5	0	0.0	1	2.2	3	6.5	0	0.0	2	4.3
Accipiter nisus	202	107	53.0	12	5.9	56	27.7	0	0.0	4	2.0	6	3.0	2	1.0	2	1.0
Aquila chrysaetos	1	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Buteo buteo	166	51	30.7	34	20.5	49	29.5	7	4.2	12	7.2	1	0.6	1	0.6	3	1.8
Circaetus gallicus	11	6	54.5	0	0.0	0	0.0	2	18.2	1	9.1	0	0.0	0	0.0	0	0.0
Circus aeruginosus	3	1	33.3	0	0.0	1	33.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Circus cyaneus	7	5	71.4	0	0.0	2	28.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Circus pygargus	1	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Falco columbarius	3	3	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Falco naumanni	13	5	38.5	1	7.7	0	0.0	0	0.0	3	23.1	0	0.0	3	23.1	0	0.0
Falco peregrinus	39	14	35.9	1	2.6	11	28.2	3	7.7	2	5.1	0	0.0	1	2.6	4	10.3
Falco subbuteo	21	10	47.6	0	0.0	3	14.3	1	4.8	2	9.5	2	9.5	1	4.8	2	9.5
Falco tinnunculus	251	126	50.2	18	7.2	35	13.9	8	3.2	11	4.4	6	2.4	14	5.6	13	5.2
Falco vespertinus	1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Gypaetus barbatus	1	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Gyps fulvus	10	0	0.0	1	10.0	2	20.0	0	0.0	7	70.0	0	0.0	0	0.0	0	0.0
Hieraetus fasciatus	6	1	16.7	0	0.0	1	16.7	2	33.3	1	16.7	0	0.0	0	0.0	0	0.0
Hieraetus pennatus	10	5	50.0	1	10.0	4	40.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Milvus migrans	2	0	0.0	1	50.0	0	0.0	0	0.0	0	0.0	1	50.0	0	0.0	0	0.0
Milvus milvus	2	1	50.0	0	0.0	1	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Pandion halietus	1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0
Pernis apivorus	23	11	47.8	2	8.7	4	17.4	0	0.0	3	13.0	2	8.7	0	0.0	0	0.0

* Undetermined and other minority causes (fences, predation, power lines, toxicosis…) have been omitted to simplify data

Table 5. Number and percentage of species admitted at the rehabilitation centre and released to the wildlife according to main causes of admission

	Number and percentages of released raptors principal causes of admission*																	
Species	Overall	Unknown trauma		Vehicles		Gunshot		Electrocution		Fortuity		Metabolic nutritional		Captivity		Infectious parasitic	
Strigiformes	N	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Asio flameus	2	1	50.0	0	0.0	1	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Asio otus	6	2	33.3	0	0.0	1	16.7	0	0.0	2	33.3	0	0.0	0	0.0	0	0.0
Athene noctua	158	62	39.2	23	14.6	5	3.2	1	0.6	33	20.9	4	2.5	11	7.0	1	0.6
Bubo bubo	30	7	23.3	0	0.0	4	13.3	0	0.0	11	36.7	4	13.3	3	10.0	0	0.0
Otus scops	130	46	35.4	11	8.5	0	0.0	0	0.0	37	28.5	3	2.3	14	10.8	5	3.8
Strix aluco	74	14	18.9	19	25.7	0	0.0	0	0.0	25	33.8	4	5.4	3	4.1	2	2.7
Tyto alba	101	33	32.7	10	9.9	3	3.0	0	0.0	29	28.7	7	6.9	5	5.0	0	0.0
Falconiformes																	
Accipiter gentillis	75	19	25.3	0	0.0	29	38.7	0	0.0	2	2.7	16	21.3	6	8.0	0	0.0
Accipiter nisus	85	36	42.4	8	9.4	17	20.0	0	0.0	2	2.4	4	4.7	3	3.5	0	0.0
Buteo buteo	241	63	26.1	23	9.5	96	39.8	0	0.0	15	6.2	21	8.7	10	4.1	4	1.7
Circaetus gallicus	11	4	36.4	2	18.2	2	18.2	0	0.0	1	9.1	1	9.1	0	0.0	0	0.0
Circus aeruginosus	18	5	27.8	0	0.0	4	22.2	0	0.0	4	22.2	3	16.7	0	0.0	1	5.6
Circus cyaneus	2	0	0.0	0	0.0	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Falco columbarius	1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0
Falco naumanni	5	0	0.0	0	0.0	0	0.0	0	0.0	3	60.0	0	0.0	1	20.0	0	0.0
Falco peregrinus	24	6	25.0	2	8.3	10	41.7	0	0.0	3	12.5	1	4.2	1	4.2	0	0.0
Falco subbuteo	5	4	80.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Falco tinnunculus	227	72	31.7	10	4.4	22	9.7	0	0.0	10	4.4	45	19.8	42	18.5	6	2.6
Gyps fulvus	27	1	3.7	0	0.0	1	3.7	0	0.0	24	88.9	0	0.0	0	0.0	1	3.7
Hieraetus pennatus	8	1	12.5	0	0.0	6	75.0	0	0.0	0	0.0	0	0.0	1	12.5	0	0.0
Milvus migrans	9	4	44.4	0	0.0	0	0.0	0	0.0	1	11.1	3	33.3	0	0.0	0	0.0
Milvus milvus	1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Pandion halietus	1	0	0.0	0	0.0	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	0	0.0
Pernis apivorus	21	5	23.8	0	0.0	4	19.0	1	4.8	6	28.6	3	14.3	0	0.0	0	0.0

* Undetermined and other minority causes (fences, predation, power lines, toxicosis…) have been omitted to simplify data

Table 6. Evolution of the orphaned raptors attended at the Wildlife Rehabilitation centre

	Orphaned young category number (rate, %)		
Species	Euthanized	Dead	Released
Strigiformes	N (E_r)	N (M_r)	N (R_r)
T. alba	1 (0.9)	22 (19.6)	89 (79.5)
O. scops	7 (1.2)	138 (24)	431 (74.8)
A. otus	0	3 (25)	9 (75)
B. bubo	2 (16.7)	4 (33.3)	6 (50)
S. aluco	4 (1)	64 (14.7)	366 (84.3)
A. noctua	8 (1.4)	112 (19.7)	450 (78.9)
Falconiformes	N (E_r)	N (M_r)	N (R_r)
G. fulvus	0	0	2 (100)
C. cyaneus	0	1 (100)	0
M. migrans	0	0	1 (100)
M. milvus	0	0	1 (100)
B. buteo	0	1 (6.7)	14 (93.3)
P. apivorus	0	1 (100)	0
A. nisus	1 (9.1)	1 (9.1)	9 (81.8)
A. gentillis	0	4 (36.4)	7 (63.6)
H. pennatus	0	0	1 (100)
C. gallicus	0	0	1 (100)
F. tinnunculus	20 (5.7)	46 (13)	286 (81.3)
F. naumanni	0	5 (83.3)	1 (16.7)
F. peregrinus	0	4 (57.1)	3 (42.9)

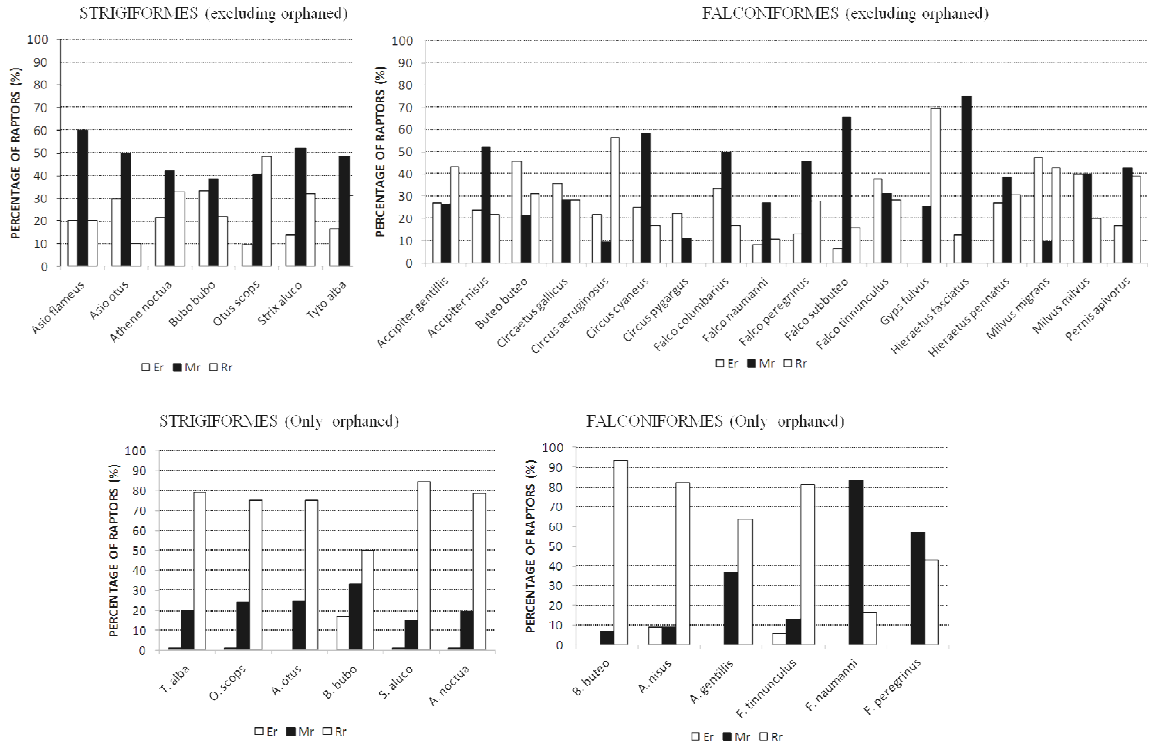

Fig. 1. Euthanized (Er), mortality (Mr) and released (Rr) rates of the different species of raptors admitted in the WRC in Catalonia

4. DISCUSSION

In the present study the outcomes of a long-term retrospective study of wild raptors admitted at a rehabilitation center were presented at specie-specific level. Wildlife rehabilitation outcomes have been focused in the proportion of releases taking into account the causes of admission (Richards *et al*., 2005) or the species (Harris and Sleeman, 2007), but rarely combining both variables (Ress and Guyer, 2004). Moreover, differences in the number of cases or in the methodological approaches make comparisons of the results difficult. For all these reasons, the presentation of the outcomes in rates can be an optimal approach to compare and extrapolate results of the rehabilitation process in different centers and species.

The criteria for euthanasia of wild birds have been clearly established (Miller, 2012), but the final decision is frequently based on the legal regulations and conservation plans for the different species in each particular region. As a general rule, the highest proportion of euthanasia is applied to animals with disabling complications after trauma. Thus, our results showed Falconiformes as the group with higher rates of euthanatized animals, basically because most of the animals of this group suffered traumatic casualties such as unknown trauma or collisions with vehicles. However, we also observed a high proportion of euthanized birds in *B. bubo* due to electrocutions. In fact, the worst R_r was observed in electrocuted birds of any species (Molina-Lopez *et al*., 2013). As previously described, electric burns are usually associated with poor prognosis and the majority of the birds are euthanized due to the severity of the soft tissue damage (Cooper, 2008; 2013).

As regards the M_r, when this rate was estimated based on the different causes of admission, the mortality in owls was significant higher in the three categories of admission (trauma, non trauma and orphaned young). Unfortunately, data about M_r is anecdotal in the literature, making difficult to establish comparisons among studies. Thus, further investigation will be required to find the main risk factors associated to owl mortality during the rehabilitation practice. Some authors have described an inverse correlation between having a low body mass and the success of releases (Ress and Guyer, 2004). By contrast, in our study, three diurnal species of small size (*A. nisus*, *F. subbuteo* and *F. columbarius*) and highly specialized species such as *P. apivorus* presented a high M_r (>40%). Apart from the severity of the lesions, other factors like the management in captivity of high metabolic species, or the difficulty for feeding some specialized species, could increase the mortality risk (Naissbit and Holz, 2004). The M_r on birds related to traumatic casualties was higher than 50% in the majority of species and specially associated to the unknown trauma and gunshot. In most of the cases, the trauma was associated with severe musculoeskeletal, neurological and multiorganic damage with very poor prognoses. The low value of the M_r in the electrocuted birds was explained by the fact that almost all the affected birds were euthanized as commented before. Conversely, the mortality of animals classified as fortuity in our study, especially in owls, were normally observed in birds which presenting poor body condition, dehydration and weakness as a consequence of lack of food and water deprivation when they were inside buildings or other human structures.

The prevalence of primary infectious and parasitic diseases in wild birds of prey admitted at the rehabilitation centers are low compared to traumatic conditions. Nevertheless, the role of infectious diseases as predisposing factor to traumatisms and their severity have been prior suggested (Morishita *et al*., 1998). In our study, the highest M_r was related to severe trichomoniasis affecting mainly *F. peregrinus*, *T. alba* and *S. aluco*. In both owl species, the clinical form of the disease was characterized by extensive necrotic lesions in the upper part of the oral cavity, in agreement with previous reports in *T. alba* in the United States (Pokras *et al*., 1993) and more recently in *S. aluco* in the United Kingdom (Couper and Bexton, 2012). Regarding the low proportion of fatalities in the orphaned young category, our results showed that most of the cases were apparently healthy birds with a high chance of survival (Couper and Bexton, 2012). The most part of orphaned chicks were owls and *B. bubo* was the most susceptible specie to die. In our experience, most *B. bubo* are only captured as chicks when they are severely injured or ill, while the smallest species of owls are more easily found in the wild when branching and easily captured by humans, in comparison to *B. bubo*.

Interestingly, the rate of releases seemed to be slightly higher in owls than in diurnal raptors. This result agrees with those reported in the Southeastern United States by Ress and Guyer (2004). Nevertheless the highest overall R_r was observed in the *G. fulvus* population, because it was mainly composed by weak, otherwise healthy, young birds admitted during the end of the summer. Most of those animals were apparently healthy young animals that got disoriented and

accidentally moved out of their colonies. The population of this specie in Catalonia has increased in the last years (Garcia and Margalida, 2009) and the number of these incidents has also increased, as has been observed in other centers in Spain (Valenciana, 2010). Comparing our R_r results with other studies, we found similarities in some rates. For example, R_r of *A. gentillis* (43.1%) was similar to that reported by Duke *et al*. (1981) in United States (46.7%) and R_r of *A. nisus* (22%) was similar to that reported by Riojas-Rodríguez *et al*. (2010) (24.7%) in Tenerife (Canary Islands). In the orphaned group, the highest R_r were observed in the Strigiformes order, with rates over 75% in all the species with exception of *B. bubo*. In general, most of these cases are branching young birds, apparently healthy. In the area of study, the breeding sites of most of owl species and also of *F. tinnunculus* are closely related to human buildings or constructions (Durany *et al*., 2004) and a high number of chicks or fledging are brought to the rehabilitation centers (Molina-Lopez *et al*., 2011). By contrast, the lowest R_r of *F. naumanni* could be explained by the fact that this small falcon is endangered in Catalonia and a high proportion of the birds admitted at the center are kept in captivity and included in the breeding program developed for the recovery of their wild populations.

The proportion of non releasable birds of prey and owls kept in captivity for education or for captive breeding and reintroduction programs differs extremely between rehabilitation centers depending on legal policies and conservation strategies of the local governments, as stated above. In our center, both *F. naumanni* and *C. pygargus* species are subjected to breeding in captivity and reintroduction programs, thus the maximum number of non releasable birds are derived to captivity. On the other hand, within the owls, *A. noctua* and *T. alba* are the two species mostly intended to educational programs in the area of the study (Molina-Lopez and Darwich, 2011).

5. CONCLUSION

In conclusion, the stratified analysis of rehabilitation outcomes by species of wild raptors and owls, can be useful to identify specie-specific related risk factors that are essential to make studies comparable and to implement rehabilitation protocols worldwide.

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