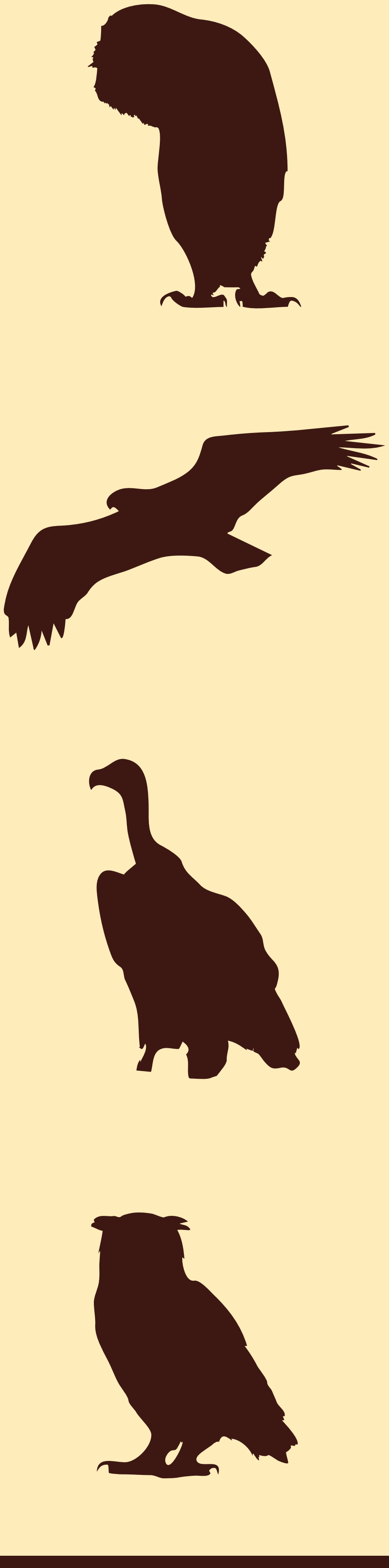

Morbilidad y mortalidad de rapaces ingresadas en el Centre de Recuperació de Fauna de Torreferrusa: análisis de los factores de riesgo durante el período 1995-2007

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Tesis doctoral 2013

Departament de Sanitat i d´Anatomia Animals

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Tesis Doctoral

28 de Febrero, 2013

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Laila Darwich Soliva y Jordi Casal Fàbrega, profesores del Departament de Sanitat i d´Anatomia Animals de la Facultat de Veterinària de la Universitat Autònoma de Barcelona,

HACEMOS CONSTAR,

Que el trabajo "Morbilidad y mortalidad de rapaces ingresadas en el Centre de Recuperació de Fauna de Torreferrussa: análisis de los factores de riesgo durante el período 1995-2007", presentado por Rafael A. Molina López para la obtención del grado de Doctor por la Universidad Autónoma de Barcelona, ha sido realizado bajo nuestra dirección.

Para que conste, firmamos la presente,

Laila Darwich Soliva   Jordi Casal Fàbrega

Bellaterra, 28 de Febrero de 2013

<u>Especialmente dedicada a</u>

A tu, Laila, esposa i "directora", perquè t'estimo; i a les nostres princesetes, Clara i Emília.

Ara no hi ha més excuses.

A mis padres y a mi hermana, que me han dejado vivir en mi planeta; y a mi titos: Mari, Juan y José Antonio, que "me recuperaron" hace casi…45 años.

"Dios quiso crear el vuelo,
Y por eso le dio alas a lo pájaros del cielo,
Dios quiso crear el vuelo.
Y es por eso que la gente
lucha contra las cadenas con espíritu valiente,
pues libre nació la gente"

"Diós quiso crear el vuelo"

Arturo Pareja Obregón

AGRADECIMIENTOS

Aquesta tesi doctoral o crisi doctoral, com diu la meva filla Clara, ha estat més llarga que “el parto de la burra”. Crec que he passat més temps parlant de la tesi, que realment escrivint-la, però això forma part de la meva idiosincràsia i a aquestes alçades de la pel·lícula… no hi ha solució. És clar, que tot el procés es va accelerar quan la meva directora va decidir posar fil a l’agulla. Moltes gràcies, sense tu, Laila, no ho hagués aconseguit. Perdona, això també ho haig de dir, el maldecap crònic que t’he causat.

Gràcies, també, a en Manel Pomarol i en Jordi Ruiz per autoritzar la realització de la tesi. I a en Jordi Porres pel seu ajut amb les dades. Ah! i agrair-li al Gaby d’infeccioses el disseny tan encertat de la portada de la tesi.

Gràcies, evidentment, a tots aquells companys amb qui he consumit tantes hores de feina i de vida al llarg de tots aquests anys…ara ja 20. La rehabilitació de fauna salvatge és una tasca d’equip i un servei a la societat en el qual em sento especialment orgullós de participar. Sense la persona que recull un ocell ferit i les autoritats competents que el porten al centre; sense el company que prepara l’aliment i el voluntari que l’ajuda; sense els responsables de la gestió al Servei de Fauna (Generalitat de Catalunya) i a Forestal Catalana, sense tots ells, res d’això hagués estat possible.

Gràcies a tots.

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RESUMEN

Los estudios epidemiológicos sobre las causas de mortalidad y morbilidad en fauna salvaje han permitido obtener datos sobre el estado de salud de los ecosistemas, proporcionando información sobre los factores naturales o antropogénicos que pueden representar una amenaza para las poblaciones animales. Por otro lado, la creciente concienciación de la sociedad sobre la conservación de la naturaleza y por el bienestar animal, y la necesidad de protección de las poblaciones de animales salvajes amenazados, ha conducido al desarrollo de la medicina y rehabilitación de la fauna silvestre.

El primer objetivo de esta tesis doctoral ha sido describir las causas de ingreso de aves rapaces en el Centro de Fauna de Torreferrussa (Barcelona), durante los años 1995-2007 y evaluarlas a lo largo del período de estudio, detectar variaciones estacionales y diferencias relacionadas con valores demográficos como la edad, el sexo o el orden zoológico. En este estudio retrospectivo unicéntrico se incluyen un total 7021 individuos homogéneamente distribuidos en los órdenes Strigiformes (con 3521 ejemplares pertenecientes a 7 especies) y Falconiformes (con 3500 ejemplares pertenecientes a 23 especies).

En el primer trabajo se presentan las frecuencias de las causas de ingreso de acuerdo con las variables especificadas y, además, se introduce el concepto de Incidencia Acumulada Estacional (SCI), referida a las poblaciones estimadas de las diferentes especies, tanto en el período de invernada como en la época de reproducción. En consecuencia, los resultados obtenidos mediante el valor de las prevalencias nos permiten una valoración cualitativa de las amenazas, y los calculados mediante la SCI, nos proporcionan una aproximación cuantitativa del impacto potencial de cada factor en las poblaciones de cada especie, permitiendo la comparación con los datos de otras zonas. En este primer estudio se pone de manifiesto que las causas antropogénicas, tanto directas como indirectas, son las más frecuentes. Cabe

destacar la importancia de los disparos, la segunda causa de traumatismo y que no ha experimentado un descenso a lo largo del período de estudio. En cuanto a las enfermedades naturales, la trichomoniasis presenta la mayor prevalencia tanto en rapaces diurnas como en nocturnas.

Otro de los objetivos de la tesis ha sido expresar los resultados de la evolución clínica de la rehabilitación de aves rapaces y desde la perspectiva del control de calidad, aspecto novedoso en la medicina de animales salvajes. Para ello, en el segundo y tercer trabajos, se ha realizado un análisis de los resultados de la rehabilitación estratificados por causa, especie y signos clínicos. Esta aproximación pretende establecer unos parámetros básicos para poder valorar la calidad universal y adecuada para todos los CRF, que resulta de gran importancia para poder comparar los distintos estudios en un futuro. Es evidente, que tanto desde el punto de vista de la gestión como del control de calidad, es necesario presentar los datos sobre tasas de liberación, de mortalidad no asistida (muerte natural), de eutanasia y de no recuperados o mantenidos en cautividad de por vida. Basándose en los datos crudos del segundo y tercer estudios, es evidente que el balance global de la rehabilitación es negativo, con 52.8% de resultados de fracaso (que incluye la muerte natural, la eutanasia y las aves no recuperadas pero mantenidas en cautividad) y 47.2% de aves liberadas al medio natural.

Otros parámetros de gran utilidad son la duración de la estancia hospitalaria o “tiempo hasta la liberación” y el "tiempo hasta la muerte”. Ambos índices permiten una valoración de la optimización de recursos económicos, así como de mejora del bienestar animal. Se ha de destacar que el tiempo hasta la muerte en los casos de eutanasia ha sido de 1 día, hecho que confirma que la decisión se suele tomar en el momento del ingreso. Por otro lado, el tiempo de muerte natural es de 2 días, indicando la gravedad en que llegan muchos de estos animales al centro. Además, sugerimos estimar el P_{90} de estos índices, ya que los valores extremos están relacionados con complicaciones o sucesos inesperados del proceso de rehabilitación y que por tanto deben de ser detectados y corregidos a tiempo.

La información básica sobre los resultados de rehabilitación de aves rapaces salvajes ha de incluir tanto el análisis crudo de las tasas previamente descritas y los parámetros ligados al tiempo, como también los resultados estratificados por las causas primarias, la especie y los signos clínicos. De esta forma, es posible identificar los factores de riesgo relacionados con cada especie y proporcionar resultados comparables entres estudios, paso previo a la implementación de protocolos normalizados de rehabilitación.

Finalmente, con objetivo final de estimar los factores pronósticos del proceso de rehabilitación de rapaces salvajes, en el cuarto trabajo se analizaron las variables que podrían ser predictivas de la evolución clínica de las rapaces durante la primera semana de ingreso en el centro. La presencia de signos neurológicos y una concentración de sólidos totales inferior a 5mg/dl, en el grupo de aves adultas, resultaron ser los factores predictivos de mortalidad durante la primera semana de ingreso. Estos datos sugerirían la necesidad de realizar un examen neurológico completo en el momento del ingreso y aplicar pautas de rehidratación y nutrición clínica adecuadas.

SUMMARY

Epidemiological studies on the causes of death and disease in wildlife have provided data on the health of ecosystems, providing information on natural or anthropogenic factors that may represent a threat to animal populations. Moreover, the growing awareness of society on nature conservation and animal welfare, and the need for protection of threatened wildlife populations has led to the development of medicine and wildlife rehabilitation.

The first objective of this thesis was to describe the causes of admission of raptors in Torreferrussa Wildlife Centre (Barcelona), during the years 1995 to 2007 and to assess throughout the study period seasonal variations and differences related to demographics such as age, sex or zoological order. In this single-center retrospective study included a total 7021 individuals homogeneously distributed in the orders Strigiformes (with 3521 specimens belonging to 7 species) and Falconiformes (with 3500 specimens belonging to 23 species). In the first study, frequencies of the causes of income are presented in accordance with the specified variables, and in addition, for the first time the concept of cumulative incidence Seasonal (SCI) is introduced referring to the estimated populations of different species, both in the wintering and in the breeding seasons. Consequently, the results obtained using the value of the frequencies allow a qualitative assessment of the threats, and results calculated by SCI provide a quantitative approach of the potential impact of each factor on populations of each species, allowing comparison with data from other areas. In this study is showed that anthropogenic causes both direct and indirect, are the most common. Note the importance of the shots, the second leading cause of injury, which has not experienced a decrease throughout the study period. As for natural disease, trichomoniasis has the highest prevalence in both diurnal and nocturnal raptors.

Another aim of the thesis was to express the results of the clinical evolution and outcomes of the rehabilitation process of wild raptors from the perspective of quality control, an issue of novel application in wildlife medicine. Thus, in the second and third work, an analysis of the results of the rehabilitation practice was made stratifying by causes, species and clinical signs. This approach seeks to establish basic parameters to assess the quality universal and suitable for all CRF, which is of great importance in order to compare the different studies in the future. Clearly, from the point of view of both management and quality control, it is necessary to present data on rates such as the release, unattended death (natural death), euthanasia, and not recovered or kept in captivity for life. Based on the raw data of the second and third studies, it is clear that the overall balance of rehabilitation is negative, with 52.8% of results of failure (including natural death, euthanasia and unrecovered birds but kept in captivity) and 47.2% of birds released into the wild. Other useful parameters are the length of stay in the hospital or "time to release" and "time to death". Both indexes allow an assessment of the optimization of economic resources and improvement of animal welfare. Notably, the time to death for the euthanasia cases was 1 day, which confirms that the decision is usually taken at the time of admission. Moreover, time to natural death was 2 days, indicating the severity of lesions that these animals presented at the time to be admitted at the center. On the other hand, estimation of the percentile 90^{th} (P90) of these indexes should be given, for detecting extreme values related to complications or unexpected events in the rehabilitation process.

Finally, with the end goal of estimating the prognostic factors of the rehabilitation process in wild raptors, the fourth study analyzed the variables that might be predictive of the clinical course of raptors during the first week of admission at the center. The presence of neurological signs and suboptimal levels in the total solids <5mg/dL were directly related with a higher mortality in these animals. Thus, complete neurological examination and the application of fluid therapy and an equilibrate diet protocols at the moment of admission seem to be critical for the survival of these animals.

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Introducción

Cierto día una liebre se burlaba de las cortas patas y la lentitud al caminar de una tortuga. Pero ésta, riéndose, le replicó: «Puede que seas veloz como el viento, pero en una competición yo te ganaría». La liebre, totalmente segura de que aquello era imposible, aceptó el reto, y propusieron a la zorra que señalara el camino y la meta.

Llegado el día de la carrera, emprendieron ambas la marcha al mismo tiempo. La tortuga en ningún momento dejó de caminar y, a su paso lento pero constante, avanzaba tranquila hacia la meta. En cambio, la liebre, que a ratos se echaba a descansar en el camino, se quedó dormida. Cuando despertó, y moviéndose lo más veloz que pudo, vio como la tortuga había llegado tranquilamente al final y obtenido la victoria.

Con constancia y paciencia, aunque a veces parezcamos lentos, obtendremos siempre el éxito.

"La liebre y la tortuga", Esopo (Fábula)

1.1. CONSERVACIÓN Y MEDICINA DE LA CONSERVACIÓN: CONCEPTOS GENERALES

La conservación ambiental[1], también denominada conservación de las especies, conservación de la naturaleza o protección de la naturaleza, se centra en conocer las distintas formas de proteger y preservar para el futuro, la naturaleza, el medio ambiente, o específicamente alguna de sus partes como las distintas especies de flora y la fauna, los distintos ecosistemas, los valores paisajísticos, etc.

Las amenazas a la biodiversidad son numerosas y mayoritariamente son el resultado de los cambios causados por la especie humana en el medio ambiente. Estos cambios conllevan distintas consecuencias como la fragmentación del hábitat, el cambio climático, la invasión de especies halóctonas y la sobrexplotación del medio ambiente. Estas amenazas causadas por el hombre no sólo están empobreciendo su entorno y a sí mismo, sino que están comprometiendo su propia supervivencia como especie.

La conservación implica necesariamente un conocimiento de la ecología, que es la ciencia que estudia las relaciones entre la vida y el ambiente. Pero la ecología misma se basa en una amplia variedad de disciplinas, y la conservación abarca sentimientos, creencias y actitudes, a veces complementarias y otras divergentes, entre ciencia y tecnología. Así pues, la conservación de la naturaleza se da por razones científicas, económicas, culturales, éticas, sociales y legales[1]:

- **Razones científicas**: la conservación de áreas naturales, con su flora y su fauna, permite preservar importante material genético para el futuro.

[1] http://es.wikipedia.org/wiki/Conservaci%C3%B3n_ambiental

- **Razones económicas**: el desarrollo con un uso razonable de los recursos naturales es más rentable a largo plazo que aquél que destruye los recursos naturales. La degradación de los recursos conlleva pérdidas económicas para los países.

- **Razones culturales**: en diversas regiones del planeta, como por ejemplo en la Amazonía, se han desarrollado grupos humanos con técnicas y manifestaciones culturales de gran importancia, que no deberían desaparecer por significar una fuente de riqueza cultural y formar parte del patrimonio de la humanidad.

- **Razones éticas o morales**: la naturaleza, los recursos naturales, la cultura y, en general, todo el ambiente, son patrimonio de cada nación y de la humanidad entera; y el Estado es el encargado de conservar el bien común, con participación de los ciudadanos.

- **Razones sociales**: la sobreexplotación de los recursos naturales, la contaminación y el deterioro del medio ambiente repercuten en las sociedades humanas en forma de enfermedades, agitación social por el acceso a la tierra, al espacio y a los alimentos. En consecuencia son generadores de pobreza, desigualdades y crisis económica.

- **Razones legales**: justifican la conservación y están en la Constitución Política, en los tratados internacionales y en la legislación. Por estas razones, gobiernos, organismos públicos, organizaciones, instituciones y asociaciones interesados en estas materias, reunidos el 5 de octubre de 1948 en Fontainebleau, crearon una unión denominada ahora Unión Internacional para la Conservación de la Naturaleza y de los Recursos Naturales (UICN).

La definición de conservación más ampliamente aceptada fue presentada en 1980 por la UICN como: "La utilización humana de la biosfera para que rinda el máximo beneficio sostenible, a la vez que mantiene el potencial necesario para las aspiraciones de futuras generaciones”.

Los objetivos de dicha organización son influenciar, alentar y ayudar a las sociedades de todo el mundo a conservar la integridad y la diversidad de la naturaleza, y asegurar que cualquier utilización de los recursos naturales se haga de manera equitativa y ecológicamente sostenible (UICN, 2012)

La práctica de la conservación implica, entre otras actividades, el mantenimiento de los procesos ecológicos esenciales y sistemas de apoyo a la vida, la preservación de la diversidad genética, y la garantía de uso sostenible de especies (conservación de las especies en peligro de extinción) y de ecosistemas.

La continua modificación del ambiente por la acción humana ha incrementado la aparición de Enfermedades Infecciosas Emergentes o el resurgimiento de otras ya controladas, las Enfermedades Reemergentes, muchas de ellas zoonóticas. Esto conlleva a la integración de la medicina veterinaria, la medicina humana y la salud ambiental bajo un solo enfoque denominado Medicina de la Conservación (Pokras *et al*., 2000; Arrivillaga y Carballo, 2009).

La medicina de la conservación (MC) es una ciencia multidisciplinaria, pues busca entrelazar conceptos entre varias especialidades históricamente separadas, como la medicina humana, la medicina animal, la biología de la conservación, la ecología, la epidemiología, la parasitología, la toxicología, la microbiología, entre otras ramas de las ciencias biológicas y las ciencias sociales (Tabor, 2002; Allan *et al.*, 2003).

Esta integración de disciplinas históricamente desconectadas, tiene por finalidad un mejor entendimiento de la ecología de esas enfermedades, para su detección, prevención, control y manejo (Meffe, 1999; Daszak *et al.,* 2000). Además, su visión multidisciplinaria permite un abordaje integrado de las enfermedades infecciosas de origen zoonótico, estableciendo una conexión entre los sistemas de salud humana, animal y ambiental. De esta manera, se garantizaría la sustentabilidad del medio ambiente, tal como ha sido propuesto por la Organización Mundial de la Salud (OMS, 2004).

El enfoque de la MC puede representar, para muchos países con alta incidencia de zoonosis, una excelente oportunidad para la integración de individualidades y grupos multidisciplinarios de las distintas áreas del conocimiento. Adicionalmente, la gran diversidad de fauna salvaje que poseen algunos países introduce un factor de riesgo epidemiológico, dada la potencialidad de distintas especies silvestres y domésticas para desempeñar un papel como hospedadores y reservorios en la transmisión de patógenos de importancia en salud humana (Arrivillaga y Carballo, 2009).

1.1.1. CONSERVACIÓN DE LA FAUNA SALVAJE

La conservación de la fauna salvaje tiene como objetivo principal evitar la extinción de especies a nivel global y el mantenimiento de las poblaciones, su distribución y diversidad (Burfield, 2008). Por ello, dentro del término “conservación de la fauna salvaje” se incluyen aquellas medidas o intervenciones del hombre destinadas a proteger o ayudar las poblaciones de animales salvajes amenazados.

Se reconoce que sin medidas de conservación activa, muchas poblaciones de animales salvajes estarían al borde de la extinción debido a los cambios recientes que ha experimentado el medio ambiente.

En consecuencia, las intervenciones para la conservación mediante protección y gestión del hábitat, la cría en cautividad y las translocación de animales, entre otros, son actualmente los métodos de conservación activa más aceptados.

Por otro lado, en los últimos años se ha producido un incremento de la concienciación social por la medicina de la fauna salvaje. Este tipo de medicina aborda tanto el tratamiento y control de las enfermedades de la fauna en su medio natural, como el rescate, tratamiento y rehabilitación de los animales silvestres enfermos o accidentados. Todo este esfuerzo ha sido realizado, bajo un punto de vista conservacionista y, además, desde una mayor concienciación por el bienestar animal (Cooper y Cooper, 2006; Sleeman, 2008).

1.1.2. LAS AVES RAPACES: CARACTERÍSTICAS GENERALES Y TAXONOMÍA

Las aves de presa o aves rapaces, tanto diurnas como nocturnas, comprenden un grupo de especies depredadoras caracterizadas por tener un pico fuerte en forma de gancho y una garras afiladas. Las diferencias morfológicas, ecológicas y genéticas han permitido diferenciar ambos grupos de aves en dos órdenes (Wink, 2007).

Las aves de presa diurnas están incluidas en el Orden Falconiformes y las aves de presa nocturnas en el Orden Strigiformes.

Existe cierta controversia en cuanto a establecer el número real de especies que forman cada una de las familias, por ello se establecen unos rangos de aproximación (Tabla 1).

El orden Falconiformes comprende un máximo de 307 especies y 5 familias, caracterizadas por una gran diversidad de formas, tamaños, dietas y hábitats que se distribuyen por todo el planeta (Houston *et al*., 1994). El orden Strigiformes incluye unas 160-180 especies distribuidas por todos los continentes excepto la Antártida (Bruce *et al.*, 1999).

Tabla 1. Distribución taxonómica de las aves rapaces en el mundo.

Clase Aves Subclase - Neornithes		
Orden (N)	**Familias**	**Especies representantes (n)**
Falconiformes (292-307) [a]	Accipitridae	Águilas, milanos, gavilanes, azores (216-226) gallinazos del Viejo Mundo (15)
	Falconidae	Halcones (46-51) y caracaras (6)
	Pandionidae	Águila pescadora (1)
	Cathartidae	Buitres del Nuevo Mundo (7)
	Sagittariidae	Secretario (1)
Strigiformes (162-178) [b]	Tytonidae	Lechuza común (13-17)
	Strigidae	Búhos (149-161)

[a]Houston *et al*., 1994; [b]Bruce *et al*., 1999

En el Estado Español, están presentes 29 especies de Falconiformes y 8 especies de Strigiformes (De Juana y Varela, 2001), aunque esta cifra puede aumentar si se añaden las citas de especies accidentales.

Cataluña, situada en el nordeste de la Península Ibérica, en la zona mediterránea de la región paleártica occidental (3 º 19'-0 º 9 'E y 42 º 51'-40 º 31 N), presenta una gran diversidad de poblaciones de aves, incluidas las aves rapaces, debido a su ubicación en las rutas migratorias, a la diversidad de su orografía y a la gran variedad de hábitats.

Más de 30 especies de aves rapaces diurnas y 8 especies de búhos se han observado en esta área, de las cuales, 21 especies de Falconiformes y 7 de Strigiformes se consideran especies reproductoras (Estrada *et al.,* 2004).

1.1.3. EL VALOR DE LAS AVES RAPACES: ECOLOGÍA Y CONSERVACIÓN.

Las aves de presa han suscitado un gran interés y fascinación por parte de las diferentes sociedades y culturas a lo largo de la historia. De hecho, debido a su carismática condición de depredadores, han sido a menudo usados como especie bandera en las campañas de conservación y como emblema para conseguir apoyo económico. No obstante, algunos autores han sido críticos con esta práctica (Andelman y Fagan, 2000), ya que requiere un inversión alta de recursos para muy pocas especies. Sin embargo, el desarrollo de planes de conservación basados en la protección de rapaces ha resultado beneficioso en el mantenimiento de la biodiversidad de ciertos ecosistemas (Sergio *et al.,* 2006). Además, si se tiene en cuenta que son aves de mediano o gran tamaño, con áreas de campeo en general amplias y que requieren una gran variedad de hábitats para desarrollar sus ciclos vitales, su conservación efectiva requiere la protección de extensos territorios.

Este hecho conlleva que muchas rapaces puedan utilizarse como especies paraguas, cuya protección beneficia a muchas otras especies (Martínez *et al.,* 2003; Simberloff, 1998).

Más allá del valor de la conservación de las especies de rapaces por su valor intrínseco, las aves de presa se han convertido en valiosos centinelas de los cambios que se producen en los ecosistemas en nuestro tiempo, aportando información relevante a nivel medioambiental, económico y social.

Efectivamente, por su posición en la cadena trófica, las rapaces diurnas y las nocturnas son los primeros organismos en exhibir respuestas medibles a determinados cambios ambientales. Por ejemplo, al ocupar el nivel superior de la cadena trófica han estado expuestas a concentraciones elevadas y persistentes de sustancias tóxicas que causaron un descenso importante en las poblaciones de especies como el halcón peregrino (*Falco peregrinus*), el águila calva (*Haliaeetus leucocephalus*) o el pigargo europeo (*Haliaeetus albicilla*) en el siglo XX (Henny y Elliot, 2007). Además, como muchas de las especies se distribuyen en áreas geográficas extensas, su estudio es relativamente más sencillo que el de otros grupos taxonómicos de aves.

En definitiva, los cambios en el tamaño de las poblaciones o en sus índices demográficos son indicadores de cambios en el medio ambiente de origen natural o antropogénico que necesitan ser identificados y comprendidos para poder actuar sobre ellos (Kovács *et al.,* 2008).

1.1.3.1. ESTADO DE CONSERVACIÓN DE LAS RAPACES

El descenso de las poblaciones salvajes de aves de presa diurnas y nocturnas en todo el planeta ha conducido a que ciertas especies estén amenazadas o en peligro de extinción (UICN 2012). La UICN ha elaborado una clasificación de las diferentes categorías o grados de vulnerabilidad de las especies que se presentan en la Lista Roja de la UICN (Figura 1).

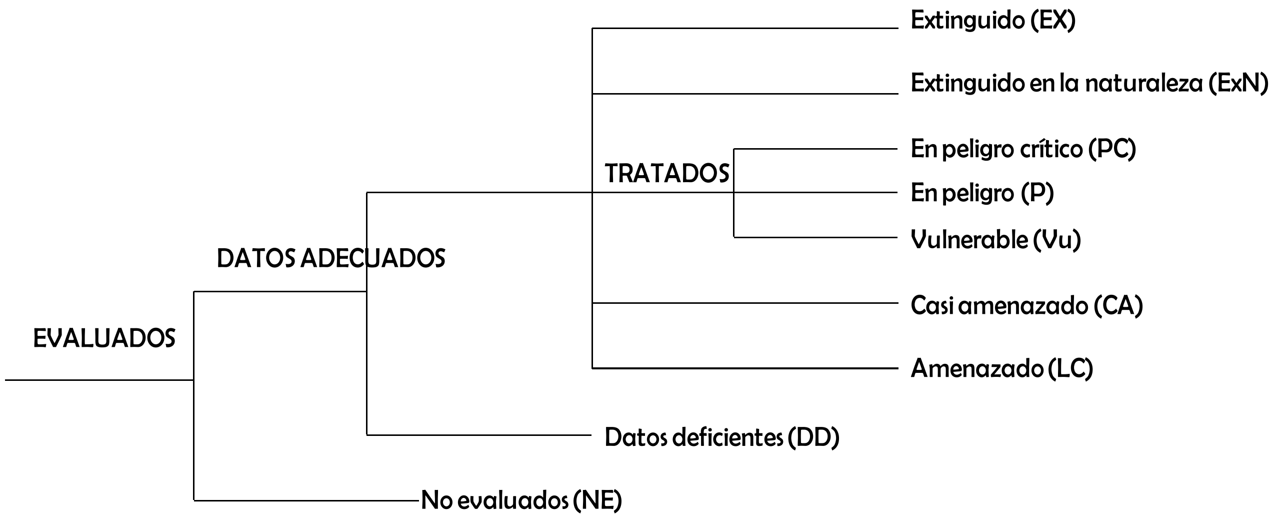

Figura 1. Grados de vulnerabilidad de las especies que se presentan en la Lista Roja de la UICN

La "BirdLife International" ha realizado dos evaluaciones de la poblaciones de aves en Europa (Tucker y Heat, 1994; BirdLife International, 2004), a partir de la cuales, la UICN ha podido actualizar el grado de amenaza de las diferentes especies. Los resultados de la primera evaluación de las poblaciones de aves de presa en Europa, revelaron que el 62% de dichas especies se encontraban en un estado desfavorable. En el momento de la segunda evaluación, la situación no había mejorado, y se evidenció que la proporción ascendió al 64%. Además, el número especies de aves rapaces europeas incluidas en la Lista Roja de la UICN aumentó de 7 a 10 entre 1994 y 2008, lo que refleja una reducción en las poblaciones (Burfield, 2008). En los 27 estados miembros de la UE viven 39 especies de aves rapaces diurnas, con una población total estimada de 1.2 - 1.7 $x10^6$ parejas, y 13 especies de rapaces nocturnas, con una población total estimada de 1.0 - 2.2 $x10^6$ parejas. De las 56 especies que se reproducen regularmente en Europa, 10 (18%) son de interés para la conservación mundial y 36 (64%) tienen un estado de conservación desfavorable a nivel de Europa (Tabla 2).

Tabla 2. Clasificación de las especies de rapaces amenazadas en la Unión Europea de acuerdo con la Lista Roja de la UICN, 2012.

Categoría	Código	Nombre científico	Nombre común
Peligro extinción	CR	*Neophron percnopterus*	Alimoche
		Falco cherrug	Halcón sacre
Vulnerables	VU	*Aquila clanga*	Águila moteada
		Aquila heliaca	Águila imperial oriental
		Aquila adalberti	Águila imperial ibérica
Casi amenazadas	NT	*Milvus milvus*	Milano real
		Aegypius monachus	Buitre negro
		Circus macrourus	Aguilucho papialbo
		Falco vespertinus	Cernícalo patirrojo

En España viven 42 especies reproductoras, lo que representa un 75% de las especies de Europa (BirdLife International, 2004). De dichas especies, 4 están incluidas en la Lista Roja de la UICN: 1 en Peligro (EN, Alimoche), 1 Vulnerable (VU, Águila imperial ibérica) y 2 Próximas al Peligro (NT, Milano real y Buitre negro).

En cuanto a su estado de conservación en el Estado Español, el Real Decreto 139/2011, de 4 de febrero, contiene la definición de las diferentes categorías de conservación e incluye el Listado de Especies Silvestres en Régimen de Protección Especial y el Catálogo Español de Especies Amenazadas.

De este modo, las especies de aves rapaces quedan clasificadas en el Estado Español como:

- **En Peligro de Extinción**: águila imperial ibérica (*Aquila adalberti*), quebrantahuesos (*Gypaetus barbatus*), milano real (*Milvus milvus*), alimoche canario (*Neophron percnopterus majorensis*) y halcón tagarote (*Falco pelegrinoides*).
- **Vulnerables**: águila pescadora *(Pandion haliaetus),* buitre negro *(Aegypius monachus),* alimoche (*Neophron percnopterus), aguilucho cenizo (Circus pygargus*), águila perdicera *(Aquila fasciata),* lechuza majorera *(Tyto alba gracilirostris)* y mochuelo boreal *(Aegolius funereus).*

1.1.3.2. MARCO LEGAL RELATIVO A LA CONSERVACIÓN DE RAPACES

En un intento de garantizar la conservación del medio natural, se han desarrollado diversas leyes y tratados internacionales limitando la captura, comercio y mantenimiento en cautividad de especies silvestres.

El Convenio de Berna sobre la "Conservación de la Vida Silvestre y el Medio Natural en Europa" incluye a las aves rapaces diurnas (Falconiformes) y nocturnas (Strigiformes), como especies estrictamente protegidas en su anexo II (Decisión

82/72/CEE). El Convenio de Bonn sobre la "Conservación de las Especies Migratorias de Animales Silvestres" incluye también a estas especies en sus anexos I y II, según el estado de conservación (Decisión 82/461/CEE). Además, la Directiva 2009/147/CE de 30 noviembre de 2009, relativa a la conservación de las aves silvestres, tiene como objetivo la protección, la regulación y la explotación de todas las especies de aves que viven normalmente en el territorio europeo, además de desarrollar medidas de conservación especiales en aquellas especies listadas en el Anexo I de dicha Directiva y que afecta a 42 especies de aves rapaces.

En España existe un amplio marco legislativo que tiene como objetivo principal la protección de la naturaleza, bien sea a través de la protección de determinadas especies amenazadas o bien a través de la protección de los espacios naturales donde estas especies viven. A nivel del Estado Español, tras la aprobación de la Ley 4/89 de "Conservación de los Espacios Naturales y de la Flora y Fauna Silvestres", se redacta el Real Decreto 439/90 que estableció el Catálogo Nacional de Especies Amenazadas. Dicho Real Decreto ha sido reemplazado por el Real Decreto 139/2011, de 4 de febrero de 2011, en el que se establece el "Listado de Especies Silvestres en Régimen de Protección Especial y del Catálogo Español de Especies Amenazadas". Las aves rapaces se incluyen en el Anexo, con diferentes categorías de protección según su estado de conservación.

Por otro lado, en Cataluña es de aplicación la "Llei de Protecció dels Animals", que considera protegidas a todas las especies de rapaces salvajes autóctonas (Decret Legislatiu 2/2008).

1.1.4. REHABILITACIÓN DE LAS RAPACES SALVAJES

Por rehabilitación de fauna salvaje se entiende el tratamiento y cuidado temporal de ejemplares de fauna silvestre heridos, enfermos o desplazados de su medio natural, su recuperación física y de conducta, y el consecuente retorno de animales sanos y viables a hábitats adecuados (Fa *et al.*, 2011).

El tratamiento y rehabilitación de la fauna salvaje ha sido justificado por razones de tipo legal, humanitario, científico y de conservación (Cooper, 1987):

- **Razones legales**: las aves rapaces silvestres están protegidas en la mayoría de países europeos y su tenencia en cautividad por particulares no está permitida. En consecuencia, los diferentes gobiernos, que son responsables de la protección de dichas especies, han desarrollado diferentes formas de atención a los animales de vida libre heridos, bien través de Centros de Recuperación de Fauna (CRF), públicos o privados u otros modelos de participación ciudadana.

- **Razones humanitarias**: En las sociedades avanzadas, el aumento de la preocupación por el bienestar de los animales ha motivado y justificado el desarrollo de programas de rehabilitación, que han sido bien gestionados y facilitados por la situación política, económica y cultural de los países implicados. En efecto, la enfermedad o traumatismos son, en muchos casos, causados de forma directa o indirecta por la actividad del hombre y esto conlleva una responsabilidad ética y una intervención a favor del bienestar animal, tal como ocurre en animales de granja, de compañía, de laboratorio o de zoo. En principio, nadie duda de la importancia de estas actividades para mejorar el bienestar de muchos animales salvajes, aunque este criterio no debe ser el único que prevalezca cuando se plantea la rehabilitación de un animal (Kirkwood y Sainsbury, 1996). Otro dilema surge cuando se plantea el destino de aquellos ejemplares no recuperables debido a la gravedad de las lesiones o las alteraciones de comportamiento. La eutanasia se postula frecuentemente como la mejor alternativa, aunque en algunos casos el destino de los animales no viables es la vida en cautividad y su inclusión en programas de cría en cautividad o su destino a actividades de educación ambiental.

- **Razones científicas**: Es evidente que el tratamiento de estos animales ha permitido un importante avance científico de la biología de la conservación y en la medicina veterinaria y su aplicación a los animales silvestres.

- **Razones de conservación**: La contribución de la rehabilitación de fauna a la conservación de las especies es un tema de controversia y algunos autores consideran que el esfuerzo realizado tiene poca relevancia en la conservación. Desde el punto de vista de las poblaciones donde se libera un animal recuperado, hay que tener en cuenta el posible desplazamiento de conespecíficos o la diseminación de enfermedades, comprometiendo el bienestar de las poblaciones salvajes. Por otro lado, la situación tras la liberación, especialmente si el animal se halla en condiciones subóptimas, puede implicar desplazamiento por otros ejemplares en sus territorios, depredación, debilidad y malnutrición, con lo cual la premisa del bienestar animal queda en entredicho (Sleeman, 2008). Además, es poco probable que la rehabilitación y posterior liberación de ejemplares de especies muy comunes o la liberación de pocos ejemplares, tenga un efecto significativo a nivel de la población (Sleeman y Clark, 2003). Sin embargo, se ha demostrado que el método de reforzamiento poblacional mediante la liberación de aves procedentes de CRF ha sido efectivo como medida de recuperación del búho real (*Bubo bubo)* en Bizkaia (Zuberogoitia *et al.,* 2003), del halcón peregrino (*Falco peregrinus*) y del águila calva (*Halietus leucocehalus*) en Estados Unidos (Sweneny *et al.,* 1997; Martell *et al.,* 1991) o del azor (*Accipiter gentilis*) en Gran Bretaña (Cooper, 1987).

1.1.4.1. OBJETIVOS Y UTILIDAD DE LOS CENTROS DE RECUPERACIÓN DE FAUNA SALVAJE

El hallazgo de animales salvajes heridos o enfermos, el expolio de nidos o madrigueras y la caza de especies protegidas, entre ellas las aves rapaces, hace que un gran número de ejemplares de dichas especies, lleguen a particulares. Este hecho, junto a los cuidados especiales que requiere su manejo y reintroducción en la naturaleza justifican la existencia de centros de recepción y recuperación (Ferrer *et al.,* 1989). Además, en el Estado Español, la protección legal de la fauna silvestre, debiera incluir la atención, por parte de las administraciones competentes, de los animales enfermos, heridos o huérfanos (Hernández, 1992).

Es necesario señalar que desde el punto de vista exclusivamente conservacionista, los resultados de los centros de recuperación distan de compensar los requerimientos de medios humanos y materiales. Tales centros, no adquieren su total dimensión si no se utilizan también, para el desarrollo de investigaciones científicas sobre las especies a recuperar, aprovechando su mantenimiento en cautividad para obtener información sobre aspectos biológicos y clínicos imposibles de conseguir en el medio natural.

Por tanto, los objetivos de los centros de recuperación de fauna (CRF) son:

- El rescate, la recepción, el tratamiento y rehabilitación de los ejemplares que se ingresan enfermos o accidentados.
- La reinserción a la naturaleza de estos animales en perfecto estado.
- Evitar o mitigar el sufrimiento de los animales por causas humanas.
- Favorecer o promover la reproducción en cautividad de determinadas especies amenazadas.
- La reintroducción de especies desaparecidas en un área geográfica determinada.
- La sensibilización social.
- El desarrollo de investigaciones biológicas, veterinarias, fisiológicas y bioquímicas.
- La detección de problemas medioambientales.

La rehabilitación de la fauna tiene unos beneficios directos derivados de la recuperación del animal y también unos beneficios indirectos (Redig, 1995; Sleeman y Clark, 2003). Como directos podemos nombrar los siguientes:

- La mejora del bienestar individual del animal.
- El refuerzo de la población natural, sobre todo en especies en peligro de extinción o en especies de larga longevidad.
- La identificación de las causas de morbilidad (enfermedad) y mortalidad.

Los beneficios indirectos son los que se derivan de:

- La instauración de cambios en la legislación y su aplicación como consecuencia del análisis de todos estos factores.

- La educación pública y profesional sobre diversas facetas de la vida silvestre que salen a la luz a través del proceso de realización de rehabilitación de la fauna.
- Las vías que se desarrollan para la participación de las personas en las tareas de rehabilitación de animales salvajes.

1.1.4.2. CENTROS DE RECUPERACIÓN DE FAUNA EN ESPAÑA

Desde la apertura del Centro de Recuperación de Rapaces de la Estación Biológica de Doñana, en 1965, en España se han creado más de 60 CRF, tanto por iniciativa privada como financiados por las distintas administraciones públicas, y repartidos por las distintas Comunidades Autónomas (Figura 2).

Figura 2. Centros de Recuperación de Fauna en el Estado Español (Mayné, comunicación personal, 2012).

En la actualidad, el "Departament d'Agricultura, Pesca, Alimentació i Medi Natural" (DAAM), de la "Generalitat de Catalunya" dispone de cuatro CRF generalistas, es decir, no especializados en la recuperación de especies determinadas, y dos centros exclusivos de cría en cautividad de especies amenazadas, que forman la base de la red de CRF de Cataluña. Además de estos centros propios, el DAAM mantiene externalizada parte de sus competencias en centros especializados y otros núcleos zoológicos que participan en programas específicos de cría en cautividad.

El CRF de Torreferrusa se fundó en el año 1980 y está localizado en Santa Perpetua de la Mogoda, en la comarca del Vallès Oriental (Barcelona). Consta de dos áreas funcionalmente independientes: el Área de Cría en Cautividad y el Área de Rehabilitación. El número de ingresos de ejemplares de fauna silvestre ha aumentado progresivamente y en la actualidad, el CRF de Torreferrussa es el que más casos atiende en toda Cataluña (Figura 3).

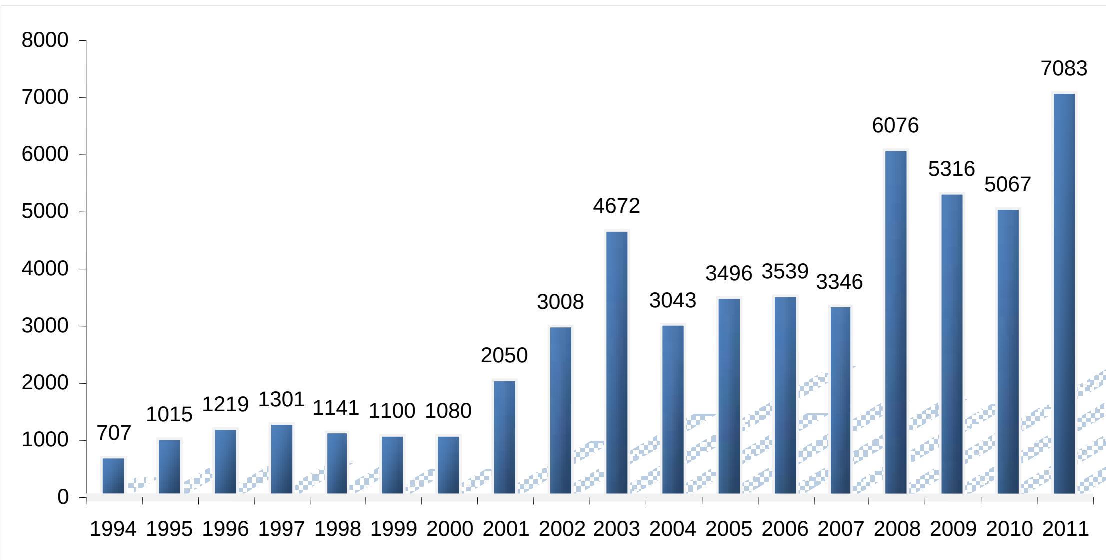

Figura 3. Número de ingresos totales en el CRF de Torreferrusa durante un periodo de tiempo de 18 años (1997-2011).

La proporción de aves rapaces autóctonas recibidas en el decenio 2000-2010 es del 18% de los ingresos (7189/40986), de los cuales un 13 % corresponde a animales muertos.

1.2. EPIDEMIOLOGÍA CLÍNICA EN LOS CRF

La identificación y la comprensión de las causas que intervienen en la variación de la población de fauna silvestre es esencial para la aplicación de medidas de conservación (Salafsky *et al.,* 2008). Los estudios de mortalidad se han utilizado para determinar las causas de muerte en la población silvestre, aunque es difícil determinar la importancia relativa de cada causa. Además, el análisis directo de estos factores en las poblaciones salvajes es difícil de realizar porque la mayoría de las muertes pasan desapercibidas y las que se observan están sesgadas hacia una asociación con la actividad humana (factores antropogénicos), bien de forma directa o indirecta (Newton, 1979).

Últimamente, los estudios de morbilidad han complementado la comprensión de amenazas en las rapaces, identificando los factores naturales y antropogénicos más relevantes. A tal efecto, el examen de los estudios sobre morbilidad y mortalidad de las rapaces de vida libre atendidas en los centros de rehabilitación han proporcionado información sobre las causas primarias o secundarias y la evaluación del estado de salud de las poblaciones silvestres (Morishita *et al.*, 1998; Wendell *et al.*, 2002).

1.2.1. CAUSAS DE INGRESO DE RAPACES SALVAJES EN CRF

Un aspecto esencial de la comunicación científica es el empleo de una nomenclatura estándar que permita el registro sistemático, el análisis, la interpretación y la comparación de los datos que resultan de las investigaciones realizadas por diferentes equipos. En medicina humana, existen sistemas de clasificación de enfermedades que consisten en un sistema de categorías a las cuales se les asignan entidades morbosas de acuerdo con criterios establecidos.

En general, tanto la nomenclatura de la enfermedad como su clasificación están íntimamente relacionadas y se basan en alguno de los siguientes elementos: el agente causal, las lesiones o funciones alteradas y la presentación clínica. En la práctica, estos sistemas se han convertido en una clasificación diagnóstica estándar internacional para todos los propósitos epidemiológicos generales y muchos otros de administración de salud. El "International Classification of Diseases" (ICD) fue desarrollado por expertos de la Organización Mundial de la Salud (OMS) y revisado de forma sucesiva hasta la versión ICD10 (WHO, 2004**).** El ICD define la afección o código principal cómo la causante primaria de la necesidad de tratamiento o investigación que tuvo el paciente.

En medicina veterinaria se han adoptado diferentes sistemas de clasificación de las enfermedades, teniendo en cuenta el objetivo de la investigación y normalmente se han basado en las manifestaciones de enfermedad o en las causas (Thrusfield, 2007).

En general, los estudios sobre causas de ingreso de aves rapaces en los CRF se han fundado en el diagnóstico primario definitivo y agrupando las enfermedades por causas (Morishita *et al.,* 1998; Naldo y Samour, 2004). Desde un punto de vista clínico, las causas se han clasificado en traumatismos y en enfermedades no relacionadas con traumatismos. Los traumatismos han representado la principal causa de ingreso en la mayoría de estudios publicados (Morishita *et al.,* 1998; Wendell *et al.,* 2002; Martínez *et al.,* 2001; Deem *et al.,* 1998; Kommenou *et al.,* 2005; Kelly, 2006).

Por otro lado, en el ámbito de la conservación de la biodiversidad se está realizando un esfuerzo por definir un léxico estándar y un sistema de clasificación que permita identificar amenazas de forma precisa y posibilite el desarrollo de una ciencia de la conservación sistemática (Salafsky *et al.,* 2008). De este modo, la "World Conservation Union–Conservation Measures Partnership" (IUCN-CMP) exponen una clasificación unificada de las amenazas directas para la vida silvestre que contempla 11 categorías, entre las cuales destacamos, por su aplicación al ámbito de los centros de recuperación de fauna salvaje, los grupos 4, 5 y 9 (Tabla 3).

Tabla 3: Clasificación de las amenazas directas a la biodiversidad según la "World Conservation Union–Conservation Measures Partnership" (IUCN-CMP) (Salafsky *et al.*, 2008).

Clasificación de las amenazas	Definición
1. Residencial y desarrollo comercial	Poblaciones urbanas y otras tierras no agrícolas alteradas por el hombre (campos de golf…)
2. Agricultura y acuacultura	Granjas y explotaciones ganaderas como resultado de una expansión e intensificación de la agricultura.
3. Producción energética y minera (energías renovables)	Explotación de los recursos no biológicos
4. Corredores de servicios y transporte	Redes de carreteras incluyendo los vehículos que circulan por ellas (influye en mortalidad de fauna), vías de ferrocarril, tendidos eléctricos, canales para conducción de agua y embarcaciones y rutas aéreas.
5. Uso de recursos biológicos	Consumo de recursos biológicos (la caza deliberada o no intencionada de fauna salvaje o también la persecución o control de especies específicas)
6. Intrusiones y alteraciones humanas	Actividades humanas que alteran, destruyen y distorsionan los habitantes y especies de una zona sin finalidad consumista de los recursos biológicos
7. Modificación del sistema natural	Acciones que convierten o degradan el hábitat para lograr un ambiente más natural o seminatural para mejorar el bienestar humano
8. Invasivas y otras especies problemáticas y genes	Plantas nativas o no nativas, animales, patógenos/microbios, o material genético que puede tener efectos nocivos para la biodiversidad una vez se introduzca disemine o crezca en abundancia
9. Polución	Introducción de materiales exóticos y / o exceso de energía o de fuentes puntuales y no puntuales. Incluye el efecto de pesticidas y residuos industriales
10. Eventos Geológicos	Eventos geológicos catastróficos
11. Cambio climático y climas extremos	Cambio climático a largo plazo puede estar relacionado al calentamiento global y otros cambios climáticos extremos que podrían hacer peligrar especies vulnerables o hábitats.

Desde el punto de vista de la biología de la conservación y en aras de la simplificación, las causas de ingreso pueden agruparse en dos categorías: causas naturales y causas antropogénicas o debidas a la acción del hombre (Martínez *et al.,* 2001). Sin embargo, ninguno de los sistemas expuestos permite establecer una clasificación de las causas de ingreso en los CRF inequívoca, hecho que dificulta la elaboración de resultados y la comparación entre centros.

1.2.1.1. CAUSAS NATURALES DE INGRESO

En este grupo se engloba toda causa no relacionada con la acción o actividad humana. Entre estas causas encontramos: las enfermedades metabólicas, las enfermedades infecciosas y parasitarias, las neoplasias y otras causas como la depredación o los accidentes debidos a fenómenos meteorológicos.

- **El trastorno metabólico** más frecuente es la inanición, con una frecuencia alrededor del 5% (Fix y Barrows, 1990; Deem *et al.,* 1998); otras enfermedades o alteraciones metabólicas citadas son la gota o las obstrucciones gastro-intestinales, entre otras (Morishita *et al.,* 1998).

- **Las enfermedades infecciosas y parasitarias** han sido extensamente estudiadas en las aves de presa y la información que se obtiene a partir de los datos procedentes de los CRF permite evaluar el estado de salud de las poblaciones salvajes y su importancia en la epidemiología de enfermedades compartidas con animales domésticos o con el hombre (Majó *et al.,* 1995; Saggesse, 2007). La ordenación más frecuentemente adoptada ha sido la taxonómica (Thomas *et al.,* 2007; Atkinson *et al.,* 2008).

Desde el punto de vista clínico, es importante diferenciar entre las infecciones primarias y aquellos agentes infecciosos o parasitarios que son detectados en animales atendidos en los centros por otras causas. De hecho, existe un alto número de estudios que calculan la prevalencia de agentes infecciosos (Schettler *et al.,* 2001; Schettler *et al.,* 2003; Joyner *et al.,* 2006; Loria *et al.,* 2008; Millán *et al.,* 2010; Molina *et al.,* 2011), y parasitarios (Lavoie *et al.,* 1999; Muñoz *et al.,* 1999; Ferrer *et al.,* 2004, Ferrer *et al.,* 2004, Sansano-Maestre *et al.,* 2009) e intentan establecer su potencial poder patógeno en estas especies. Algunos autores han demostrado que en muchos de los animales ingresados como consecuencia de un traumatismo, coexistía una enfermedad infecciosa sub-clínica que restaba vitalidad y actuaba como causa predisponente de dicho traumatismo (Lierz, 1999). En cuanto a las enfermedades primarias de tipo infeccioso o parasitario, presentan una baja prevalencia y existe gran heterogeneidad según los estudios revisados. Así, en el trabajo de Wendell *et al.,* (2002), la tricomoniasis es la enfermedad con mayor prevalencia, mientras que en Morishita *et al.,* (1998), las más frecuentes son la aspergilosis, la viruela aviar y la colibacilosis.

- **Las neoplasias** han sido citadas de forma anecdótica en rapaces de vida libre (Forbes *et al.,* 2000).

- Finalmente, tanto la **depredación** como **los accidentes** debidos a inclemencias meteorológicas aparecen citados por Newton (1979) como causa de mortalidad en aves rapaces, pero los casos que llegan a los CRF son muy escasos.

1.2.1.2. CAUSAS ANTROPOGENICAS DE INGRESO

1.2.1.2.1. Causas antropogénicas intencionadas

Desde una perspectiva histórica, las aves rapaces han despertado la admiración y el respeto del hombre en las más diversas civilizaciones y culturas. Sin embargo, esta situación sufrió un cambio drástico a partir del siglo XIX, coincidiendo con el desarrollo de la caza deportiva y el inicio de la persecución directa por parte del hombre (Newton, 1979). El principio básico de dicho conflicto ha sido la competencia por los recursos, en tanto en cuanto las aves rapaces podrían causar una reducción de la densidad de presas que quedarían disponibles para la caza. Este tema ha sido objeto de diferentes estudios y los resultados han sido diversos (Park *et al.*, 2008). Actualmente se acepta que el impacto real sobre las poblaciones de especies cinegéticas solamente se ha demostrado en algunas especies de rapaces, como el azor (*Accipiter gentilis*), el aguilucho pálido (*Circus cyaneus*) y el aguilucho cenizo (*Circus pygargus*) (Mañosa, 2002), pero en circunstancias específicas que requieren ser identificadas y evaluadas.

La persecución directa por parte del hombre se ha perpetrado mediante cuatro sistemas que han sido el disparo, el uso de venenos, el trampeo y la destrucción de nidos.

El efecto que ha tenido la persecución directa de aves de presa en ciertas regiones de Europa hasta la década de 1980, ha afectado sus poblaciones a diferentes niveles y ha provocado una reducción en el éxito reproductor por la destrucción de nidos o la matanza de adultos, y cambios en la estructura de edad de las poblaciones silvestres (Mañosa, 2002).

En España, las rapaces han sido objeto de la persecución del hombre mediante la caza furtiva o el empleo de cebos envenenados, fundamentalmente. Este conflicto ha sido extensamente discutido y diferentes estudios han constatado una elevada mortalidad de distintas especies, algunas de las cuales se hallan gravemente amenazadas como el águila imperial ibérica (*Aquila adalberti*) o el quebrantahuesos (*Gypaetus barbatus*) (Hiraldo *et al.,* 1979; Lucio y Purroy, 1992). De hecho, en España hasta finales de la década de 1960 la administración pública incentivó la persecución y el aniquilamiento de muchas de las especies consideradas peligrosas por aquellos sectores sociales y económicos que tenían intereses cinegéticos y ganaderos, a través de las "Juntas de Extinción de Animales dañinos".

A partir de los años 70, y como consecuencia de la asunción de los diversos convenios internacionales que comenzaban a regular la protección de la fauna, la administración comenzó a modificar de manera paulatina su política en este ámbito, comenzando por eliminar las instituciones que habían encabezado la "lucha contra las alimañas" y derogando una legislación que había sustentado el mayor ataque contra la fauna silvestre y la biodiversidad. Sin embargo, a pesar de las medidas de protección que se empezaron aplicar a finales de la década de 1980, la matanza deliberada se ha seguido ejecutando y ha sido ampliamente comunicada (Real *et al.*, 2001; Martínez *et al.,* 2006; González *et al.,* 2007; Berdugo *et al.*, 2011). En el estudio de Mañosa (2002) se evaluó la información cedida por los CRF en el Estado Español y se computaron 2807 casos de matanza intencionada mediante disparo o trampa.

Desde el punto de vista de los CRF, las causas antropogénicas intencionadas se pueden clasificar en:

- **Traumatismos causados por disparos**: Se citan en la mayoría de estudios retrospectivos de todo el mundo y siguen suponiendo un indicador de persecución directa, a pesar de la estricta protección de las especies de aves rapaces en muchos países (Richards *et al.*, 2005; Desmarchelier *et al.*, 2010). En Europa se ha constatado una reducción en la proporción de muertes debidas a disparo (Saurola, 1985), como consecuencia de la aplicación de leyes de protección. Sin embargo, sigue representado la principal causa de muerte intencionada en Europa y en España (Mañosa, 2002). En ese trabajo se puso en evidencia que en España no solamente se daba muerte a especies consideradas competidoras con el hombre, en relación a las especies cinegéticas de caza menor, sino también a rapaces nocturnas y aves carroñeras.

- **Las capturas mediante trampas**, también se citan en la mayoría de estudios retrospectivos, aunque el número de casos comunicados es muy inferior (Kommenou *et al.*, 2005; Harris y Sleeman, 2007). Además, se ha observado una diferencia considerable en la frecuencia de captura de aves con trampas según los países (Mañosa, 2002). Es interesante destacar la captura de rapaces de tamaño pequeño con sustancias adhesivas, recientemente comunicada en las Islas Canarias (Rodríguez *et al.*, 2010).

- **Envenenamiento intencionado**: El empleo de cebos envenenados como método de control de las poblaciones de aves rapaces ha sido citados en todo el mundo (Newton, 1979; Sánchez-Barbudo *et al.*, 2012) y, de forma similar al tiro o al trampeo, ha experimentado un descenso.

  Sin embargo, a pesar de su prohibición, el envenenamiento se ha seguido practicando en España, afectando a especies gravemente amenazadas como el quebrantahuesos *(Gypaetus barbatus)*, el alimoche (*Neophron percnopterus*) o el águila imperial ibérica (*Aquila adalberti*) (Mateo, 2008; Cano *et al.,* 2008).

- **Aves cautivas**: Las aves de presa diurnas y, en menor cuantía las aves de presa nocturnas, han sido objeto de captura furtiva o expolio para su empleo en cetrería o como mascotas. Esto animales son ingresados en los CRF principalmente, como consecuencia de decomisos realizados por las autoridades competentes.

1.2.1.2.2. Causas antropogénicas no intencionadas

En cuanto a las causas relacionadas indirectamente con la actividad humana, destacamos las siguientes:

- **Traumatismos debidos a colisiones** con medios de transporte o con estructuras construidas por el hombre. Los traumatismos debidos a colisión con automóviles u otros vehículos, han sido ampliamente enumerados y analizados (Hernández, 1988; Frías, 1999). Desde el punto de vista metodológico hay que tener en cuenta que muchos de los estudios sobre atropellamientos se basan en rastreo de vías de comunicación y no en los datos sobre causas de ingreso en los CRF. Básicamente, la mayor incidencia de choque se ha observado en las rapaces nocturnas (Santamarina, 1990; Fajardo *et al.,* 1994) y rapaces diurnas como el busardo ratonero (*Buteo buteo*), que cazan en la proximidad de carreteras. Otras causas menos frecuentes son los impactos con edificios o con estructuras de construcción humana como vallados, torres o soportes eléctricos. El impacto con edificios ha sido especialmente descrito en el gavilán (*Accipiter nisus*) (Kelly, 2006).

Por el contrario los traumatismos con vallas y torres eléctricas afectan especies de mayor tamaño como el búho real (*Bubo bubo*) (Muñoz-Cobo, 1996) y rapaces planeadoras (Harness, 2007). El impacto de los choques con torres y tendidos eléctricos puede llegar a ser importante en especies amenazadas y los factores de riesgo asociados con este tipo de accidentes ha sido estudiado en el águila azor-perdicera (*Achila fasciata*) en Catalunya (Mañosa y Real, 2001; Rollan *et al.*, 2010). Recientemente, tras el desarrollo y expansión de los parques eólicos han aparecido descripciones de accidentes de aves rapaces, especialmente, en especies de de gran envergadura y planeadoras (Madders y Whitfield, 2006).

- **Electrocuciones**: Esta categoría constituye una entidad bien diferenciada debido a los mecanismos fisiopatológicos específicos de las quemaduras eléctricas, la gravedad de las lesiones y la frecuencia con que se presentan. Los factores de riesgo relacionados con la electrocución, las especies más afectadas y las medidas necesarias para reducir el riesgo han sido extensamente revisadas (Guzmán y Castaño, 1998; Janss, 2000; Lehman *et al.*, 2007; Mañosa, 2001). Así mismo, el efecto a nivel de población ha sido estudiada en el águila imperial ibérica (*Aquila adalberti*) en España (Ferrer y Negro, 1992) y en el búho real (*Bubo bubo*) en Italia (Sergio *et al.*, 2004).
- **Aves que quedan atrapadas** en construcciones humanas, especialmente búhos y otras aves de presa que anidan en edificios o que cazan en las proximidades de emplazamientos humanos, como los mochuelos (Van Nieuwenhuyse *et al.*, 2008). Aunque el número de casos es muy bajo, también se han comunicado casos de caídas o ahogamientos en albercas o similares o depósitos de aguas residuales o purines.

- **Intoxicaciones**: De forma general se debe diferenciar las intoxicaciones accidentales o secundarias de los envenenamientos intencionados, que han sido discutidos previamente. Desde una perspectiva histórica, hay que destacar la importancia de las intoxicaciones en la regresión de las poblaciones de un gran número de especies en la segunda mitad del siglo XX, especialmente como consecuencia del efecto de los pesticidas organoclorados (Newton, 1979). Las intoxicaciones pueden agruparse de la siguiente forma:
    - Debidas a la aplicación de productos fitosanitarios o plaguicidas, como los rodenticidas (Murray, 2011) o los inhibidores de la acetil-colinestersa (Goldstein *et al.,* 1999)
    - Sustancias contaminantes de origen industrial como las dioxinas, los bifenilos policlorados o los metales pesados. A pesar de su importancia como tóxicos ambientales, su relevancia como causa de ingreso en CRF de aves rapaces es difícil de evaluar. Mención especial merece el plomo, cuyo efecto en las aves rapaces ha sido ampliamente estudiado en todo el mundo. En efecto, la intoxicación por plomo ha afectado a un gran número de especies (Wayland *et al.,* 2003; Church *et al.,* 2006; Mateo, 2009), debido a la ingestión de perdigones de plomo presentes en la carroña o en las presas. Además, la intoxicación subletal, se ha asociado con un mayor riesgo de sufrir traumatismos u otro tipo de accidentes (Kramer y Redig, 1997). Sin embargo, en el ámbito de los estudios retrospectivos sobre causas de ingreso en los CRF, la proporción de intoxicaciones es baja debido a razones económicas, ya que el diagnóstico está supeditado a la posibilidad de realizar las analíticas correspondientes.

1.2.1.3. OTRAS CAUSAS DE INGRESO

En cuanto a las causas de ingreso no asociadas con enfermedad o heridas, la más destacada es la de las aves jóvenes huérfanas, compuesta por pollos y volantones, sobretodo de especies de rapaces nocturnas. En la mayoría de casos no se trata de animales abandonados, sino de ejemplares que se alejan del nido para explorar el entorno y que son recogidos y trasladados a CRF. Aunque suele tratarse de animales sanos, hay que destacar que el volumen de ingresos es alto, está concentrado en un periodo relativamente corto y demanda la atención especializada de cuidadores (Stocker, 2005).

Por último, la categoría de causa indeterminada o desconocida, incluye todos aquellos ingresos en los que no ha sido posible concluir la causa.

Sin duda, no existe un sistema universal de clasificación de las causas de ingreso de las aves en los CRF, de forma que en algunos casos pueden producirse solapamiento de categorías en situaciones confusas, hecho que dificulta la comparación entre trabajos publicados (Harden *et al.,* 2006).

1.2.2. ESTUDIO DE LOS RESULTADOS DE LA REHABILITACIÓN DE AVES RAPACES SALVAJES

El objetivo principal de la rehabilitación de la fauna salvaje es el retorno del animal en perfectas condiciones físicas y de comportamiento a su medio natural. De acuerdo con Cooper (1987), los resultados de la rehabilitación de aves salvajes pueden encuadrarse en una de las siguientes categorías: liberación, muerte natural, eutanasia, y animales no rehabilitados, bien con discapacidad física o con alteraciones del comportamiento. Existen cuatro factores que hay que considerar antes de acometer el tratamiento y el proceso de rehabilitación de un ejemplar herido: el tipo y grado de lesión, el estado de conservación de la especie, los medios disponibles y las posibilidades económicas (Hunter, 1989). Además, se ha logrado un alto grado de consenso, basado en la evidencia, en la definición de los criterios que desaconseja la liberación de un aves de presa, como son: el déficit visual o las alteraciones oculares graves, las amputaciones que afecten las extremidades inferiores (incluidos los dedos), cualquier discapacidad de las alas o aquellas alteraciones de comportamiento que impiden la caza o la reproducción en el medio natural (Redig, 1993; Miller, 2012).

Sin embargo, la decisión de sacrificio o mantenimiento en cautividad depende de otros factores como la legislación de cada país, las consideraciones de tipo ético relacionadas con el bienestar animal o el valor en conservación de cada especie (Cooper y Cooper, 2006). Así, en determinados casos, los animales no liberados se destinan a proyectos de cría en cautividad o a actividades de educación ambiental.

Los resultados crudos de la rehabilitación de aves rapaces en centros de recuperación, han sido publicados por diferentes autores (Fix y Barrows, 1990; Ress y Guyer, 2004;

Kommenou *et al.*, 2005; Kelly, 2006; Harris y Sleeman, 2007), aunque existe cierta heterogeneidad en la forma de presentarlos. Así, en algunos estudios se engloban muertos y sacrificados en el mismo grupo (Sweeney *et al.*, 1997; Deem *et al.*, 1998; Punch, 2001). Por otro lado, los resultados estratificados por causas, especies o grupos de especies rara vez se han sido publicados (Ferrer *et al.*, 1989; Rodríguez *et al.*, 2010).

Especial atención merecen los estudios que intentan establecer la efectividad de la rehabilitación, basándose en la supervivencia de las aves liberadas. Dichos trabajos se basan en la recuperación de aves anilladas o en el radio-seguimiento (Martell *et al.*, 2000; Leigthon *et al.*, 2008; Griffiths *et al.*, 2010). Un aspecto crítico en el éxito de la liberación, es la selección solamente de aquellas aves que se hallen en óptimas condiciones físicas y que expresen un comportamiento completamente natural (Duke *et al.*, 1981).

1.2.3. FACTORES PRONÓSTICOS EN LA REHABILITACIÓN DE RAPACES SALVAJES

Se entiende por factor pronóstico a aquellos datos capaces de suministrar información sobre la evolución que puede experimentar un paciente. El valor de estos factores, tanto biológicos como clínicos, en la predicción de la muerte o de otros resultados clínicos de la enfermedad resulta, por tanto, de gran interés y utilidad desde la perspectiva de seleccionar un tratamiento coste-eficiente. En medicina humana han sido ampliamente descritos en diferentes procesos patológicos (Rao *et al.*, 2010; Chittiboina *et al.*, 2011; Gad *et al.*, 2011) y su aplicación a la medicina veterinaria está en aumento (Carr *et al.*, 2002; Schwartz *et al.*, 2008).

En el contexto de la medicina de animales salvajes, la información publicada es todavía escasa. En un estudio sobre factores pronósticos de la supervivencia de 8 especies de animales ingresados en cuatro CRF de Inglaterra, se concluyó que el predictor más importante era la gravedad del cuadro clínico (Molony *et al*., 2007). En otro trabajo realizado en California sobre factores pronósticos en la recuperación de focas comunes varadas, concluyeron que la masa corporal estaba asociada con la supervivencia, mientras que los parámetros hematológicos obtenidos en las muestras tomadas en el momento del ingreso en el CRF, no eran predictores de la supervivencia durante el proceso de rehabilitación (Greig *et al.,* 2010).

1.3. CONTROL DE CALIDAD HOSPITALARIA APLICADO A LA REHABILITACIÓN DE RAPACES SALVAJES

La calidad es uno de los elementos estratégicos en que se fundamenta la transformación y mejora de los sistemas sanitarios modernos y, por extensión, de la práctica clínica veterinaria.

Donabedian fue pionero en el desarrollo del control de calidad aplicado en salud pública y desarrolló los tres aspectos o elementos básicos del sistema a tener en cuenta en el control de calidad que son: la estructura, el proceso y los resultados. Para ello se emplean indicadores de calidad que son variables con características de cantidad, calidad y tiempo utilizados para medir, directa o indirectamente, los cambios en una situación y apreciar el progreso alcanzado en abordarla. Un buen indicador debe cumplir con alguna de las siguientes características: confiabilidad, validez, compresibilidad y sencillez (Marquet y Davins, 2003).

Aunque existen indicadores de calidad aplicable a cada uno de los elementos del sistema sanitario, aquellos basados en los resultados han constituido el eje central de la investigación para la monitorización de la calidad, ya que tienen la gran ventaja de ser fácilmente comprendidos.

Dentro de los indicadores de resultados se pueden identificar dos grandes grupos (Jiménez, 2004):

1. ”**Indicadores Centinela**”. Son aquellos que representan un suceso lo bastante grave e indeseable del resultado, como para realizar una revisión individual de cada caso en que se produzca.

2. “**Indicadores basados en proporciones o de datos agregados**”. Son aquellos que indican la necesidad de una revisión detallada, sólo si la proporción de casos en que se presenta el suceso de base sobrepasa un límite considerado aceptable por los propios profesionales (umbral). Los indicadores de datos agregados (continuos o basados en tasas) son los que miden el desempeño basándose en eventos que ocurren con cierta frecuencia. Son los más importantes para determinar el nivel de desempeño de una institución, detectar tendencias, hacer comparaciones con el pasado, con otras instituciones o con puntos de referencia establecidos.

En la tabla 4 se presentas algunos ejemplos de indicadores centinela e indicadores de datos agregados empleados en el ámbito hospitalario de medicina humana.

Tabla 4. Ejemplos de indicadores de calidad hospitalaria en medicina humana.

Indicadores centinelas	Indicadores de datos agregados
Gangrena gaseosa.	Tasa de mortalidad hospitalaria (general o por servicios).
Absceso del SNC.	Tasa de reingreso por la misma enfermedad.
Daño por anoxia cerebral.	Tasa de infecciones intrahospitalarias.
Punción o laceración accidental durante acto quirúrgico.	Tasa de complicaciones relacionadas a la hospitalización
Dehiscencia de sutura operatoria.	Tasa de incapacidad (física o psíquica al egreso).
Cuerpo extraño abandonado accidentalmente durante acto quirúrgico.	Tasa de accidentes quirúrgicos por número de operaciones.
Reacción ABO incompatible.	Tasa de mortalidad por complicaciones anestésicas por número de operaciones
Reacción Rh incompatible.	Tasa de mortalidad por resecciones pancreáticas.
Fallecimiento tras cirugía menor de bajo riesgo.	Tasa de mortalidad por insuficiencia cardiaca congestiva.
Muerte materna (ocurrida en el hospital).	Tasa de mortalidad por infarto del miocardio.

En medicina veterinaria existen unos estándares de calidad de hospitales veterinarios establecidos por la American Animal Hospital Association (AAHA) y otros aplicados a centros de rehabilitación de fauna (Miller, 2012). En el manual “Minimun standards for wildlife rehabilitation”, se contemplan diferentes aspectos de la rehabilitación de la fauna salvaje relacionados con las instalaciones, criterios de liberación, controles de salud, métodos de eutanasia o bienestar animal. Sin embargo la información sobre indicadores de calidad, entendidos como tales, es inexistente.

Los objetivos de la presente tesis doctoral son:

1. Determinar las causas primarias de ingreso de aves rapaces salvajes en un centro de recuperación de fauna salvaje.

✓ Estudio 1. *Causes of Morbidity in Wild Raptor Populations Admitted at a Wildlife Rehabilitation Centre in Spain from 1995-2007: A Long Term Retrospective Study*.

2. Determinar la evolución clínica de las rapaces durante su periodo de rehabilitación en el centro.

3. Proponer parámetros médicos para valorar la calidad de la práctica de la rehabilitación en rapaces salvajes.

✓ Estudio 2. *Final disposition and quality auditing of the rehabilitation process in wild raptors admitted to a wildlife rehabilitation centre in Catalonia, Spain, during a twelve year period (1995-2007).*

✓ Estudio 3. *Specie-specific analysis of final dispositions for auditing the rehabilitation process quality of wild raptors at wildlife rehabilitation center in Catalonia.*

4. Estimar los factores pronósticos del proceso de rehabilitación de rapaces salvajes.

✓ Estudio 4. *Prognostic factors associated with the mortality of wild raptors admitted at a rehabilitation centre of Catalonia, Spain*.

Estudio 1.

Causes of Morbidity in Wild Raptor Populations Admitted at a Wildlife Rehabilitation Centre in Spain from 1995-2007: A Long Term Retrospective Study. PLoS One. 2011;6(9):e24603.

Causes of Morbidity in Wild Raptor Populations Admitted at a Wildlife Rehabilitation Centre in Spain from 1995-2007: A Long Term Retrospective Study

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Abstract

Background: Morbidity studies complement the understanding of hazards to raptors by identifying natural or anthropogenic factors. Descriptive epidemiological studies of wildlife have become an important source of information about hazards to wildlife populations. On the other hand, data referenced to the overall wild population could provide a more accurate assessment of the potential impact of the morbidity/mortality causes in populations of wild birds.

Methodology/Principal Findings: The present study described the morbidity causes of hospitalized wild raptors and their incidence in the wild populations, through a long term retrospective study conducted at a wildlife rehabilitation centre of Catalonia (1995–2007). Importantly, Seasonal Cumulative Incidences (SCI) were calculated considering estimations of the wild population in the region and trend analyses were applied among the different years. A total of 7021 birds were analysed: 7 species of Strigiformes (n = 3521) and 23 of Falconiformes (n = 3500). The main causes of morbidity were trauma (49.5%), mostly in the Falconiformes, and orphaned/young birds (32.2%) mainly in the Strigiformes. During wintering periods, the largest morbidity incidence was observed in Accipiter gentillis due to gunshot wounds and in Tyto alba due to vehicle trauma. Within the breeding season, Falco tinnunculus (orphaned/young category) and Bubo bubo (electrocution and metabolic disorders) represented the most affected species. Cases due to orphaned/young, infectious/parasitic diseases, electrocution and unknown trauma tended to increase among years. By contrast, cases by undetermined cause, vehicle trauma and captivity decreased throughout the study period. Interestingly, gunshot injuries remained constant during the study period.

Conclusions/Significance: Frequencies of morbidity causes calculated as the proportion of each cause referred to the total number of admitted cases, allowed a qualitative assessment of hazards for the studied populations. However, cumulative incidences based on estimated wild raptor population provided a more accurate approach to the potential ecological impact of the morbidity causes in the wild populations.

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Introduction

Birds of prey are valuable sentinels of environmental changes because of their position at the top of the ecological food chain and because they are widespread across large geographical areas. In addition, they are particularly sensitive to ecological changes at a range of spatial scales [1,2] and, as such, some species of free-living birds of prey and owls have decreased in numbers and become threatened or even endangered around the world. In fact, in Europe, 36 species (64%) of the total 56 different raptor species have an unfavourable conservation status [3].

Morbidity studies complement the understanding of hazards to raptors by identifying natural or anthropogenic factors. Therefore, the analysis of morbidity and mortality reports of free-living raptors presented to rehabilitation centres has provided insight into the primary and secondary causes, as well as in the evaluation of the health status of wild populations [4,5]. However, there are few studies on morbidity in wild raptors of Spain, and these have focused on a limited number of species or specific causes [6–10]. In addition, global epidemiological studies of wild raptor diseases are also scarce, especially long term studies [11,12]. Finally, while the information reported by such studies is critical for the rehabilitation centres management, this information has been mainly based on the proportion of cases in the total number of admissions at the centre. Only rarely have the data been referenced to the overall wild population, that could provide a more accurate assessment of the potential impact of the morbidity/mortality causes in populations of wild birds.

The purpose of this study was to analyze the causes of morbidity in a large population of raptors admitted at one rehabilitation centre in Spain from 1995 to 2007 using specific epidemiological data (species, gender, age, season, and year) as well as the Seasonal

Cumulative Incidences (SCI) considering estimations of the wild population in the region for the different raptor species.

Results

Descriptive analyses

A total of 7553 admission reports were reviewed. Of those, 532 cases were excluded for not fulfilling the inclusion criteria. Thus, the final study population was 7021 individuals homogenously distributed in two orders: Order Strigiformes with 3521 animals corresponding to seven species of owls and Order Falconiformes with 3500 animals of 23 different diurnal raptor species. The majority of animals (89.5%, n = 6282) were alive when admitted. Within the species represented in the study, there were some important species catalogued as ''in danger of extinction'' (Gypaetus barbatus) and ''vulnerable'' (*Circus pygargus, Achila fasciata, Milvus milvus, Neophron percnopterus* and *Pandion haliaetus*) by the Spanish Catalogue of Menaced Species [13].

Most of the animals, 58.7% (n = 4119), were classified as undetermined gender, 22.5% (n = 1579) of raptors were sexed as female (F) and 18.8% (n = 1323) as males (M). Within the undetermined gender group, the majority of birds belonged to the Strigiformes order, representing 67% (2746/4119) of birds; the remaining 33% (1373/4119) of undetermined sex belonged to the Falconiformes order. Only three species -*Achila fasciata, Accipiter nisus* and *Otus scops*- showed significant differences between genders with ratios of 6F/15M (χ^2 = 105, P = 0.0001), 329F/96M (χ^2 = 4.69, P = 0.03) and 91F/61M (χ^2 = 12.58, P = 0.0004), respectively.

The age distribution showed that 44% (3091/7021) of birds were within the first year calendar, 32.7% (2294/7021) > 1 year calendar and 23.4% (1636/7021) were of unknown age (Table 1). The dynamic of cases throughout the study period showed a homogenous entry of cases per year (ranging from 478 to 643 cases), with similar number of cases of raptors by order, gender and age among the different years (Fig. 1).

Distribution of primary causes of morbidity

The two most frequent causes of admission were trauma (49.5%; 95% CI: 48.3–50.7) and orphaned young birds (32.2%; 95% CI: 31.1–33.3). The other primary causes had frequencies below 10% (Table 2). Trauma was more frequently observed in Falconiformes. This order showed the highest risk of gunshot or electrocution. Risks of falling into traps, power lines or being predated were similar between both raptor orders and traumas with motor vehicles and fences were considerably higher in nocturnal raptors likely due to their habit of hunting along roads and their feature to be easily dazzled (Table 2). It is interesting to note that owls and *Falco tinnunculus* (χ^2 = 21.39, P<0.0001) represented the largest group of animals found inside buildings (Table 3), while most of *Accipiter gentillis* birds were captured inside chicken farms (χ^2 = 153.70, P<0.0001). Trichomoniasis was the most frequent cause of infectious/parasitic disease with positive cases in the following species: *Falco tinnunculus* (19 cases), *Strix aluco* (7), *Tyto alba* (5), *Accipiter gentillis* (5), *Falco peregrinus* (4), and *Accipiter nisus, Circus pygargus, Bubo bubo* and *Achila fasciata* with 1 case each, respectively (Table 2). Fatal intoxication was diagnosed in: *Gyps fulvus* for lead toxicity (1), *Tyto alba* for Bromodiolone (2), *Buteo buteo* (2) and Circaeuts gallicus (1) for carbofuran, and Falco naumanni for cipermetrine (1).

No differences between genders related to any of the analyzed causes were observed (χ^2 = 17.73, P.0.05). However, the first year calendar group had a higher risk of metabolic and nutritional diseases (OR = 3.7; 95%CI: 2.7–5.1), and infectious diseases (OR = 3.1; 95%CI: 1.95–4.85) compared to older birds. Conversely, the >1 year calendar group had a slightly higher risk of trauma with motor vehicles (OR = 1.36; 95%CI: 1.01–1.76) compared to the other age groups.

Seasonality of specific causes of morbidity

A significantly higher number of cases were detected during the breeding period (χ^2 = 1226.97, P,0.001), mainly due to orphaned young birds (Table 4). Metabolic or nutritional disease was significantly lower during the wintering season. Gunshot was concentrated during the autumn-winter hunting season (87.2%). Only 3.2% (22/689) of gunshot cases were recorded during the small game period at the end of August. The remaining 9.6% of cases (66/689) were detected out of hunting season. No statistically significant differences were observed among proportions of infectious/parasitic (χ^2 = 1.76, P>0.05), fortuity (x^2 = 2.46, P>0.05) and electrocution (χ^2 = 5.88, P>0.05) casualties.

Seasonal cumulative incidence (SCI) of the overall causes of admission regarding the main raptor species (those with at least 100 cases) are summarized in Table 5. The highest number of incidences during the wintering period was observed in *Accipiter gentillis* mainly due to gunshot and *Tyto alba* due to vehicle trauma. Species such as *Falco tinnunculus* (mainly due to orphaned young) and *Bubo bubo* (due to electrocution and metabolic disorders) represented the highest affected populations during the breeding season (Table 5).

Inter-years distribution of specific causes of morbidity

The number of admissions increased throughout the study period and a significant increase of cases was observed among the twelve years of the study in orphaned young birds, infectious/ parasitic diseases, electrocution and unknown trauma. By contrast, a decreasing tendency was observed in the number of admissions due to undetermined cause, trauma with vehicles and captivity (Fig. 2).

Discussion

Descriptive epidemiological studies of wildlife are an important source of information about natural and non-natural hazards to the wild animal population. In addition, studies of the causes of mortality and morbidity in wildlife have become an important source for ecosystem health monitoring [14,15]. However, there are still important limitations of the information available due to lack of randomization, overrepresentation of human induced casualties, the heterogeneity of analytical methods [7,16] and the low number of cases of free-living birds of prey reported [4,5,8,17,18]. Moreover, in most studies, disease frequency is estimated as a proportion of the cases of disease in the total number of admissions at the centres, lacking any information concerning the wild bird population and the particular risk for each species in the area of study.

The data presented in the current study were based on a large number of cases of very diverse wild raptor species, admitted to a wildlife rehabilitation centre during a long term period (12 years). Besides descriptive frequencies of morbidity cases admitted at the centre, the data included Seasonal Cumulative Incidences (SCI) based on the estimated wild raptor populations, for both wintering and breeding seasons. Thus, depending on the type of analyses performed, different information and conclusions can be obtained. Whereas, disease frequencies of morbidity entities (calculated as the proportion of each cause referred to the overall number of admitted cases) could allow a qualitative assessment of the hazards, the SCI (based on estimated wild raptor population) provides a more accurate approach to the potential ecological impact of the

Table 1. Frequency of admission in the rehabilitation centre and demographic data of raptors included in the study during the period 1995-2007.

Species descriptive: Common name (*scientific name*)	Cases	Sex		Age (one year calendar)		
Order Strigiformes	Number	F/M*	Unknown	,1 year	.1 year	Unknown
Family Tytonidae						
Common barn owl (*Tyto alba*)	500	81/74	345	157	174	169
Family Strigidae						
Eurasian scops owl (*Otus scops*)	878	61/91	726	655	129	94
Eurasian eagle-owl (*Bubo bubo*)	198	54/62	82	28	110	60
Tawny owl (*Strix aluco*)	731	56/63	612	475	168	88
Little owl (*Athene noctua*)	1120	98/107	915	729	220	171
Northern long-eared owl (*Asio otus*)	82	18/7	57	19	25	38
Short-eared owl (*Asio flammeus*)	12	2/1	9	0	6	6
Order Falconiformes						
Family Pandionidae						
Osprey (*Pandion haliaetus*)	6	1/2	3	1	3	2
Family Accipitridae						
Western Honey-buzzard (*Pernis apivorus*)	61	12/8	41	19	22	20
Red kite (*Milvus milvus*)	7	1/6	17	1	4	2
Black kite (*Milvus migrans*)	24	1/1	5	6	7	11
Bearded vulture (*Gypaetus barbatus*)	2	0/2	0	0	2	0
Egyptian vulture (*Neophron percnopterus*)	2	0/0	2	1	1	0
Eurasian griffon (*Gyps fulvus*)	49	2/4	43	16	17	16
Short-toed Snake-eagle (*Circaetus gallicus*)	52	10/10	32	3	34	15
Western Marsh-harrier (*Circus aeruginosus*)	38	20/10	8	3	22	13
Hen harrier (*Circus cyaneus*)	14	6/4	4	0	11	3
Montagu's harrier (*Circus pygargus*)	13	3/8	2	8	5	0
Eurasian Sparrowhawk (*Accipiter nisus*)	466	329/96	41	103	227	136
Northern Goshawk (*Accipiter gentillis*)	231	108/84	39	93	106	32
Eurasian buzzard (*Buteo buteo*)	934	245/210	479	71	413	450
Golden eagle (*Aquila chrysaetos*)	7	3/3	1	1	5	1
Bonelli's eagle (*Aquila fasciata*)	31	6/15	10	6	16	9
Booted eagle (*Aquila pennata*)	30	5/10	15	4	17	9
Family Falconidae						
Lesser kestrel (*Falco naumanni*)	88	28/27	33	54	26	8
Common kestrel (*Falco tinnunculus*)	1295	382/361	552	591	451	253
Red-footed falco (*Falco vespertinus*)	2	1/1	0	0	2	0
Merlin (*Falco columbarius*)	7	3/3	1	0	4	3
Eurasian hobby (*Falco subbuteo*)	35	5/10	20	3	21	11
Peregrine falcon (*Falco peregrinus*)	106	38/43	25	44	46	16
Total	7021	1579/1323	4119	3091	2294	1636

*F/M, female/male ratio.
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morbidity/mortality causes in the wild populations than the raw data.

Based on the present data it is evident that the anthropogenic origin was confirmed as the most frequent cause of hospitalization, comprising direct persecution (gunshot, poisoning, illegal captivity or traps) to involuntary human induced threats (collisions with vehicles, fences or electric lines and electrocution). Another clear finding was the high numbers of young orphaned cases admitted to the centre, which represented 32% of the total cases, and the fact that these cases increased throughout the study period. These values slightly differ from the ones reported by others [5,17]. One of the most significant characteristics of this region is the large diversity of bird populations, in part due to its location within the migratory routes, in part to the great variety of habitats. On the other hand, this region is highly populated, and species with nesting areas close to urban settlements and other buildings are the most likely to be found and brought to the wildlife rehabilitation centres. In fact, *Falco tinnunculus* and *Otus scops*, the species with higher SCI for the orphaned category, use man-made structures to nest and so are directly exposed to anthropogenic interaction.

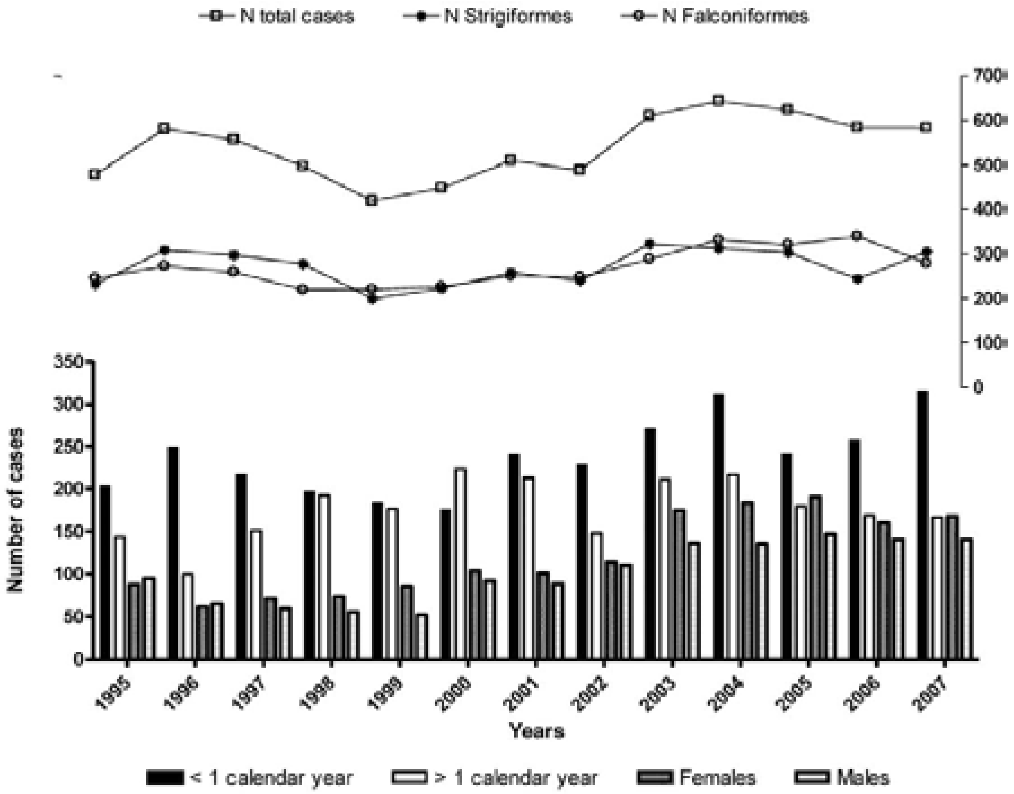

Figure 1. Admissions of birds of prey stratifying by raptor order, age and sex, yearly distributed along the period 1995-2007.
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The analysis of data collected during the period of this study revealed that the number of animals with known information about age and gender increased in the later years of the study, indicating an improvement in data examination and collection by the centre. The high number of specimens with undetermined gender (67%), especially in birds belonging to the Strigiformes order, was mainly due to the high number of young or immature animals seen at the centre.

Trauma represented the main cause of admission (50% of cases, 60% when excluding orphaned bird category), with a prevalence similar to that described in other studies [4,5,8,17–19]. The main source of traumas was either anthropogenic origin or unknown. The unknown trauma have been reported in very different proportions in the published reports, ranging from 32% of cases in Accipiter nisus [19] to 84% of cases in *Falco peregrinus* [20] and could be due to the different classification of the cases in the different studies.

Within the trauma category, gunshot represented the most common cause of admission (10% of the total). Although considerably lower than the 36% reported by Martínez et al. (2001) [8] in the East of Spain, it is of relevance that almost 10% of the casualties have been recorded out of the hunting season, as indication of deliberate prosecution. Even though birds of prey are legally protected species under Spanish law, shooting is still a major concern, especially in endangered species such as *Achila fasciata, Pandion haliaetus* and *Circus pygargus*. Interestingly, *Accipiter gentillis* and *Falco peregrinus* showed the highest SCI for gunshot. Both species have traditionally been considered as competing with small game hunters, and those values are again indication of deliberate shooting [21].

On the other hand, collision trauma with vehicle (8%) was the second highest cause of trauma, although in a lower proportion than previously reported in other studies [5,17,18]. This difference might be due to the high diversity of species analysed in the present study. Basically, the highest incidence of collision has been observed in owls -basically in *Athene noctua, Tyto alba* and *Strix aluco*-during the breeding and post-breeding period, which agrees with the results by Frı´as (1999) [22]. When we analyzed the SCI during the winter season, the highest risk was for *Tyto alba*, reinforcing the major vulnerability of this species for collision trauma [23]. In the Falconiformes order, *Buteo buteo* was the most affected species. This high risk could be related to its scavenging behaviour in the vicinity of roads. Moreover, we have also observed a winter peak of admissions in *Buteo buteo* and *Tyto alba*, possibly related to higher densities of these migratory species at this time of the year.

Another important cause of trauma was electrocution representing approximately 6% of the cases which is higher than studies in other areas [5,17,18]. The species distribution obtained in our study coincides with data published previously in Catalonia [24,25]. *Bubo bubo* was the most affected owl with the highest SCI value, highlighting the potential impact of electrocutions in their wild population [9]. For diurnal raptors, the highest SCI was for Accipiter gentillis during winter and *Buteo buteo* in the breeding season. Both species have similar anatomical features that make them highly vulnerable to electrocution. On the other hand, we found a higher percentage of electrocutions in *Falco tinnunculus* compared to a previous report in Spain [26]. Despite the small size of this falcon, the perching behaviour of this species is a well-known risk factor that could explain the present results.

Captivity of birds of prey, especially Falconiformes, is still an important cause of admission in Spain [8]. However, the frequency was clearly lower than the 18% reported by Martínez et al. (2001) [8]. Noteworthy, the most commonly captive species was *Falco tinnunculus* -mostly related with illegal trade of birds and

Table 2. Frequency of primary causes of admission and statistical comparison between Strigiformes and Falconiformes orders.

	Overall Prevalence		Strigiformes (N = 3521)		Falconiformes (N = 3500)		Odds Ratio (OR)	
Primary Causes	Total number	Percentage (95% CI)	Total number (%)	Percentage	Total number (%)	Percentage	OR (CI 95%)	p-value
Trauma:	3476	49.5 (48.3–50.7)	1182 (33.6)	100	2294(65.5)	100	0.3 (0.2–0.3)	,0.0001
Unknown	1817	25.9 (24.8–26.9)	694 (19.7)	58.7	1123 (32.1)	49	1.4 (1.2–1.7)	,0.0001
Gunshot	689	9.8 (9.1–10.5)	48 (1.4)	4.1	641 (18.3)	27.9	0.1 (0.08–0.1)	,0.0001
Vehicles	571	8.1 (7.5–8.7)	322 (9.1)	27.2	249 (7.1)	10.9	3.0 (2.5–3.6)	,0.0001
Electrocution	281	4.0 (3.5–4.5)	60 (1.7)	5.1	221 (6.3)	6.3	0.5 (0.3–0.6)	,0.0001
Buildings	58	0.8 (0.6–1)	28 (0.8)	2.4	30 (0.9)	1.3	1.8 (1.1–3.1)	,0.010
Traps	19	0.3 (0.2–0.4)	5 (0.1)	0.4	14 (0.4)	0.6	0.7 (0.2–1.9)	ns
Fences	24	0.3 (0.2–0.5)	21 (0.6)	1.8	3 (0.1)	0.2	13.8 (4.1–46.4)	,0.0001
Power lines	11	0.2 (0.1–0.3)	2 (0.1)	0.2	9 (0.3)	0.4	0.4 (0.1–1.9)	ns
Predation	6	0.1 (0.05–0.2)	2 (0.1)	0.2	4 (0.1)	0.2	0.9 (0.1–5.3)	ns
Orphaned young	2260	32.2 (31.1–33.29)	1768 (50.2)	100	492 (14.1)	100	6.1 (5.4–6.9)	,0.0001
Fortuity:	398	5.7 (5.1–6.2)	249 (7.1)	100	149 (4.3)	100	1.7 (1.3–2.1)	,0.0001
Buildings	289	4.1 (3.6–4.6)	191	76.7	98	65.8	1.7 (1.1–2.6)	0.0179
Others[a]	65	0.9 (0.7–0.2)	37	14.9	28	18.8	0.7 (0.4–1.3)	ns
Water ponds	44	0.6 (0.4–0.8)	21	8.4	23	15.4	0.5 (0.2–0.9)	0.0311
Undetermined	379	5.4 (4.8–5.9)	161 (4.6)	100	218 (6.2)	100	0.7 (0.5–0.8)	,0.005
Metabolic/nutritional:	235	3.3 (2.9–3.8)	76 (2.2)	100	159 (4.5)	100	0.4 (0.3–0.6)	,0.0001
Emaciation	151	2.1 (1.8–2.5)	52	68.4	99	62.3	1.3 (0.7–2.3)	ns
Others[b]	48	0.6 (0.5–0.9)	16	21.1	32	20.1	1.4 (0.7–2.6)	ns
MBD	36	0.5 (0.3–0.7)	8	10.5	28	17.6	0.5 (0.2–1.2)	ns
Captivity	158	2.3 (1.9–2.6)	47 (1.3)	100	111 (3.2)	100	0.2 (0.1–0.2)	,0.0001
Infectious/parasitic:	108	1.5 (1.2–1.8)	34(1)	100	74(2.1)	100	0.4 (0.2–0.6)	,0.0001
Others[c]	55	0.7 (0,5–1)	21	61.8	34	45.9	1.9 (0.8–4.3)	ns
Trichomoniosis	44	0.6 (0,4–0.8)	13	38.2	31	41.9	0.8 (0.3–1.9)	ns
Toxicoses	7	0.1 (na)	4 (0.1)	100	3 (0.1)	100	1.3 (0.3–5.9)	ns

CI: confidence interval. ns: no statistical significance (p.0.05). na: not applicable. MBD, metabolic bone diseases.
Others: a, manure heaps, bad weather;
b, rest of diagnoses grouped by organic systems such as musculoskeletal, digestive, nervous, integument, and ocular diseases; c, mycobacteriosis, helminthiasis, mites, abscess.
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falconry- followed by *Athene noctua* and *Otus scops*. Both owl species were probably captured when young birds and kept as pets in captivity. Finally, the proportion of undetermined causes showed similar values to other retrospective surveys [11,18,20], indicating that the lack of obtaining a specific diagnosis in birds of prey is around 10% of the total admissions.

Data from rehabilitation centres based on live birds is useful for detecting primary infectious or parasitic diseases. Digestive tract disease caused by *Trichomonas gallinae* was the most frequent disease observed in both diurnal raptors and owls, in agreement with Wendell et al. (2002) [5].

Trichomoniasis was diagnosed by both direct examination and cytology (Diff-Quick stained) of scraping of oral or upper digestive tract lesions. Since we have focused our study in primary causes of admissions, the role of underlying infectious or parasitic diseases has been underestimated, because of no complete microbiological and parasitological analyses were done routinely in all cases due to financial constraints, autolysis or the statement of a primary diagnosis. Finally, intoxication was anecdotally included in our study due to financial limitations in the diagnosis.

Analysis of the principal causes of morbidity throughout the twelve years of study showed a decrease in the undetermined cause category that could be an indication of an improvement in the quality of the diagnostic protocols and staff experience. Similarly, the increase of hospitalized cases by electrocution and the decrease of casualties by captivity could be explained by increased efficiency of the wildlife police services. As suggested above, the increase of cases in the young orphaned category could be related to both the human demographic traits of Catalonia and a better knowledge by the inhabitants about the role of wildlife rehabilitation centres. On the other hand, the increased cases by unknown trauma could be due to a greater participation of people taking care of injured animals, but also suggest the difficulty in the trauma classification. Another interesting finding was that gunshot fatalities have become stable over the years, pointing out the enormous deficiencies in the police investigative process and the necessity of stronger legal action from the relevant authorities.

In conclusion, the long term epidemiological research conducted at the wildlife rehabilitation center determined the main environmental and anthropogenic causes of morbidity in wild raptor populations of Catalonia. In addition, the weight of different epidemiological markers such as the seasonal cumulative incidence can provide more accurate statistics about the dynamics of wild raptor populations in the studied area.

Table 3. Number of cases and frequency distribution by primary causes of admission and species.

	TRAUMA: Number of cases (%)									OTHERS: Number of cases (%)							
Species	Unknown	Gunshot	Vehicles	Electrocuted	Building	Fences	Traps	Power Lines	Predation	Orphaned young	Fortuity	Undetermined	Metabolic diseases	Captivity	Infectious diseases	Toxicity	Total
Accipiter gentillis	65 (28)	77 (33)	4 (2)	12 (5)	1 (0)	0	1 (0)	0	1 (0)	11 (5)	25 (11)	16 (7)	5 (2)	8 (4)	5 (2)	0	231
Accipiter nisus	224 (48)	122 (26)	26 (6)	1 (0)	20 (4)	2 (0)	1 (0)	1 (0)	0	12 (3)	11 (2)	27 (6)	7 (1)	5 (1)	7 (2)	0	466
Aquila chrysaetos	3 (43)	0	0	1 (14)	0	0	0	0	0	0	0	3 (43)	0	0	0	0	7
Asio flameus	6 (50)	6 (50)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
Asio otus	37 (45)	7 (8)	9 (11)	1 (1)	0	2 (2)	0	0	0	13 (16)	5 (6)	4 (5)	4 (5)	0	0	0	82
Athene noctua	255 (23)	16 (1)	105 (9)	4 (0)	6 (1)	5 (0)	3 (0)	0	0	585 (52)	59 (5)	43 (4)	16 (1)	18 (2)	5 (1)	0	1120
Bubo bubo	49 (25)	8 (4)	16 (8)	48 (24)	0	10 (5)	0	2 (1)	0	13 (7)	20 (10)	12 (6)	14 (7)	3 (2)	3 (2)	0	198
Buteo buteo	279 (30)	272 (29)	138 (15)	79 (8)	0	0	1 (0)	3 (0)	1 (0)	16 (2)	26 (3)	62 (7)	32 (3)	13 (1)	11 (1)	1 (0)	934
Circaetus gallicus	18 (35)	2 (4)	3 (6)	15 (29)	0	1 (2)	0	2 (4)	0	1 (2)	1 (2)	5 (10)	2 (4)	0	1 (2)	1 (2)	52
Circus aeruginosus	17 (45)	6 (16)	0	0	0	0	0	0	0	0	4 (10)	6 (16)	4 (11)	0	1 (3)	0	38
Circus cyaneus	6 (43)	6 (43)	0	0	0	0	0	0	0	1 (7)	0	1 (7)	0	0	0	0	14
Circus pygargus	7 (54)	1 (8)	0	0	0	0	0	0	0	0	0	1 (8)	1 (8)	0	3 (23)	0	13
Falco columbarius	4 (57)	2 (29)	0	0	0	0	0	0	0	0	1 (14)	0	0	0	0	0	7
Falco naumanni	21 (24)	0	4 (4)	0	0	0	0	0	2 (2)	22 (25)	2 (2)	14 (16)	9 (10)	12 (14)	1 (1)	1 (1)	88
Falco peregrinus	30 (28)	28 (26)	6 (6)	9 (8)	0	0	0	1 (1)	0	7 (7)	2 (2)	8 (7)	5 (5)	4 (4)	6 (6)	0	106
Falco subbuteo	15 (43)	6 (17)	2 (6)	1 (3)	0	0	0	0	0	0	2 (6)	2 (6)	2 (6)	2 (6)	3 (9)	0	35
Falco tinnunculus	373 (29)	89 (7)	54 (4)	87 (7)	6 (1)	0	11 (1)	0	0	415 (32)	63 (5)	54 (4)	45 (3)	66 (5)	32 (3)	0	1295
Falco vespertinus	0	0	0	0	1 (50)	0	0	0	0	0	0	1 (50)	0	0	0	0	2
Gypaetus barbatus	2 (100)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Gyps fulvus	6 (12)	3 (6)	2 (4)	0	0	0	0	0	0	2 (4)	0	2 (4)	33 (67)	0	1 (2)	0	49
Hieraetus fasciatus	7 (23)	4 (13)	0	5 (16)	0	0	0	1 (3)	0	0	2 (7)	8 (26)	2 (6)	0	2 (7)	0	31
Hieraetus pennatus	8 (27)	12 (40)	1 (3)	5 (17)	0	0	0	0	0	2 (7)	0	0	1 (3)	1 (3)	0	0	30
Milvus migrans	9 (37)	0	5 (21)	1 (4)	0	0	0	1 (4)	0	1 (4)	4 (17)	1 (4)	1 (4)	0	1 (4)	0	24
Milvus milvus	1 (14)	1 (14)	0	3 (43)	0	0	0	0	0	1 (14)	0	1 (14)	0	0	0	0	7
Neophron percnopterus	1 (50)	0	0	0	0	0	0	0	0	0	0	1 (50)	0	0	0	0	2
Otus scops	127 (14)	0	37 (4)	0	8 (1)	1 (0)	0	0	1 (0)	586 (67)	55 (6)	28 (3)	11 (1)	17 (2)	7 (1)	0	878
Pandion haliaetus	0	1 (17)	0	1 (17)	0	0	0	0	0	0	1 (17)	2 (33)	1 (17)	0	0	0	6
Pernis apivorus	27 (44)	9 (15)	4 (7)	1 (2)	2 (3)	0	0	0	0	1 (2)	5 (8)	3 (5)	9 (15)	0	0	0	61
Strix aluco	88 (12)	2 (0)	76 (10)	2 (0)	3 (0)	2 (0)	0	0	1 (0)	441 (60)	61 (8)	30 (4)	12 (2)	4 (1)	9 (1)	0	731
Tyto alba	132 (26)	9 (2)	79 (16)	5 (1)	11 (2)	1 (0)	2 (1)	0	0	130 (26)	49 (10)	44 (9)	19 (4)	5 (1)	10 (2)	4 (1)	500
Total	1817	689	571	281	58	24	19	11	6	2260	398	379	235	158	108	7	7021

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Table 4. Intra-year distribution of primary causes of admission at the wildlife center according to seasonal periods (cases registered from 1995 to 2007).

Cause category	Breeding		Post-nuptial migration		Wintering		Total
	n	%	n	%	n	%	n
Orphaned young	1994	53.7	224	14.9	42	2.3	2260
Unknown trauma	672	18.1	503	33.5	642	35.5	1817
Gunshot	41	1.1	171	11.4	477	26.4	689
Motor vehicles	215	5.8	140	9.3	216	11.9	571
Fortuity	212	5.7	95	6.3	91	5.0	398
Undetermined	168	4.5	95	6.3	116	6.4	379
Electrocution	132	3.6	60	4.0	89	4.9	281
Metabolic/nutritional	102	2.7	103	6.9	30	1.7	235
Illegal	64	1.7	43	2.9	51	2.8	158
Infectious	60	1.6	26	1.7	22	1.2	108
Others (,100 cases)							
Trauma with building	23	0.6	20	1.3	15	0.8	58
Fences	8	0.2	6	0.4	10	0.6	24
Trap	9	0.2	6	0.4	4	0.2	19
Power lines	3	0.1	5	0.3	3	0.2	11
Intoxication	5	0.1	2	0.1	0	0.0	7
Predation	4	0.1	1	0.1	1	0.1	6
Total	3712	100	1500	100	1809	100	7021

doi:10.1371/journal.pone.0024603.t004

Materials and Methods

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 from 1995 to 2007. The centre receives animals from all of Catalonia (North-East Spain, 3º19'-0º9' E and 42º51'-40º31' N), mainly from the South and Central areas. More than thirty species of diurnal raptors and eight different owl species have been observed in this area, most of which are breeding species [27].

The centre directly depends on the governmental Catalan Wildlife-Service. Thus, protocols, amendments and other resources were done according to the guidelines approved by the government of Catalonia.

Definition of variables

Species, gender, age, date and primary cause of admission were included in the data analyses. Sex was determined when possible by inspection in dimorphic species [28] or by gonadal examination at necropsy. Age was categorized as ''first year calendar'' and ''>1 year calendar'' according to Martínez et al. (2001) [8]. The year was divided into three seasons: breeding (from March to July), post-nuptial migration (August to October) and wintering (November to February).

Our general classification of primary morbidity causes was adapted from different studies [4,5,29] as follows: trauma, infectious/parasitic disease, metabolic/nutritional disease, toxicosis, orphaned young birds, and unknown/undetermined. Two more categories of causes were added: captivity and fortuity. The captivity category included wild birds maintained illegally in captivity for more than 6 months and the fortuity category included all animals with no associated medical primary cause (birds found inside buildings, farms, water ponds, entangled in plants or manure heaps). The orphaned young category integrated chicks and fledging raptors (Table 2). To assign these categories we used different information obtained from different sources: (a) the physical examination performed by the veterinarian at the admission instance; (b) the anamnesis of people that recovered the bird; (c) the medical reports or case history; and when possible

(d) from complementary diagnostic tools, as now radiography (basically to corroborate gunshots), blood chemistry and haematology, cytology and toxicology. Post-mortem diagnoses were done when birds arrived dead to the centre, when they had to be euthanized for bad prognoses or died due to the primary cause.

The trauma category was subdivided into: collision, electrocution, gunshot, trap, predation, and unknown trauma (for those cases with clinical signs of trauma but without clear information about the circumstances of the accident). Collision traumas were further subdivided into impacts with motor vehicles, buildings, power lines, fences, and others. The diagnosis of electrocution was based on the information recorded in the anamnesis and the clinical signs (presence of electric burns mainly affecting feathers, skin and soft tissues).

The metabolic and nutritional disorder category comprised birds with low body condition or weakness, suffering from metabolic bone diseases (MBD) and the rest of diagnoses were grouped by organic systems (Table 2). The infectious disease category was applied when a pathogenic microorganism was confirmed by microbiological, parasitological or histopathological diagnosis.

Statistical analysis

Descriptive statistics, normality test and inferential analyses were done at 95% of confidence with SPSS Advanced Models TM 15.0 (SPSS Inc. 233 South Wacker Drive, 11th Floor Chicago, IL

Table 5. Seasonal incidence rate values of the different raptors species admitted during the 12 years of the study.

	Number of total cases[a]		Estimated[b] population number		Overall causes[c]		Orphaned young[c]	Unknown trauma[c]		Gunshot[c]	Motor vehicles[c]		Fortuity[c]		Undetermined[c]		Electrocution[c]		Metabolic/ nutritional[c]		Infectious/ Parasitic[c]	
Raptor species*	W	B	W	B[d]	W	B	B	W	B	W	W	B	W	B	W	B	W	B	W	B	W	B
Accipiter gentillis	99	54	1438	750	5.74	0.73	0.15	1.39	0.20	2.78	0.12	0.01	0.64	0.08	0.46	0.05	0.17	0.08	0.00	0.03	0.06	0.01
Accipiter nisus	254	66	22954	1500	0.92	0.28	0.04	0.44	0.14	0.30	0.04	0.03	0.02	0.00	0.06	0.03	0.00	0.00	0.01	0.00	0.01	0.00
Athene noctua	112	844	5449	11669	1.71	0.67	0.65	0.81	0.11	0.18	0.24	0.04	0.11	0.03	0.06	0.03	0.02	0.00	0.03	0.01	0.02	0.00
Bubo bubo	56	95	1055	631	4.43	1.79	0.43	1.34	0.30	0.40	0.40	0.13	0.32	0.19	0.16	0.11	1.50	0.45	0.00	0.23	0.08	0.02
Buteo buteo	652	180	25710	1404	2.11	1.53	0.24	0.62	0.48	0.73	0.36	0.17	0.05	0.08	0.13	0.17	0.13	0.18	0.05	0.08	0.01	0.03
Falco peregrinus	37	36	1028	249	3.00	1.38	0.29	1.05	0.34	1.13	0.16	0.08	0.00	0.04	0.24	0.08	0.32	0.15	0.00	0.08	0.08	0.19
Falco tinnunculus	239	787	32003	3794	0.62	1.88	1.35	0.27	0.41	0.13	0.04	0.06	0.03	0.09	0.03	0.06	0.03	0.13	0.01	0.08	0.01	0.05
Otus scops	18	651	166	6515	9.06	0.93	0.98	2.01	0.12	0.00	0.50	0.03	0.50	0.06	0.00	0.03	0.00	0.00	0.00	0.01	0.00	0.01
Strix aluco	98	560	5981	13618	1.37	0.38	0.42	0.40	0.02	0.03	0.22	0.03	0.29	0.02	0.14	0.01	0.00	0.00	0.01	0.00	0.00	0.01
Tyto alba	124	240	1240	2765	8.34	0.76	0.52	3.16	0.13	0.34	2.22	0.08	0.74	0.07	0.94	0.04	0.07	0.01	0.07	0.02	0.13	0.02

[a]Total number of admissions at the center during the period of the study.

[b]Estimation of resident population (individuals) of the region during the wintering and breeding seasons according to the Catalan wintering bird Atlas 2009 and the Catalan breeding bird Atlas 1999-2002. Post-nuptial migration population is highly fluctuant and is not considered.

[c]Seasonal cumulative incidence (SCI) cases per 1000 animal/year = [(total season cases[a]/estimated season population[b])* 1000]/12.

[d]Number of individuals. Estimated population at the breeding season was calculated from the number of pairs multiplied by the number of chicks. *Only species with at least up to 100 cases are represented in the table.

W = Wintering period; B = Breeding period.

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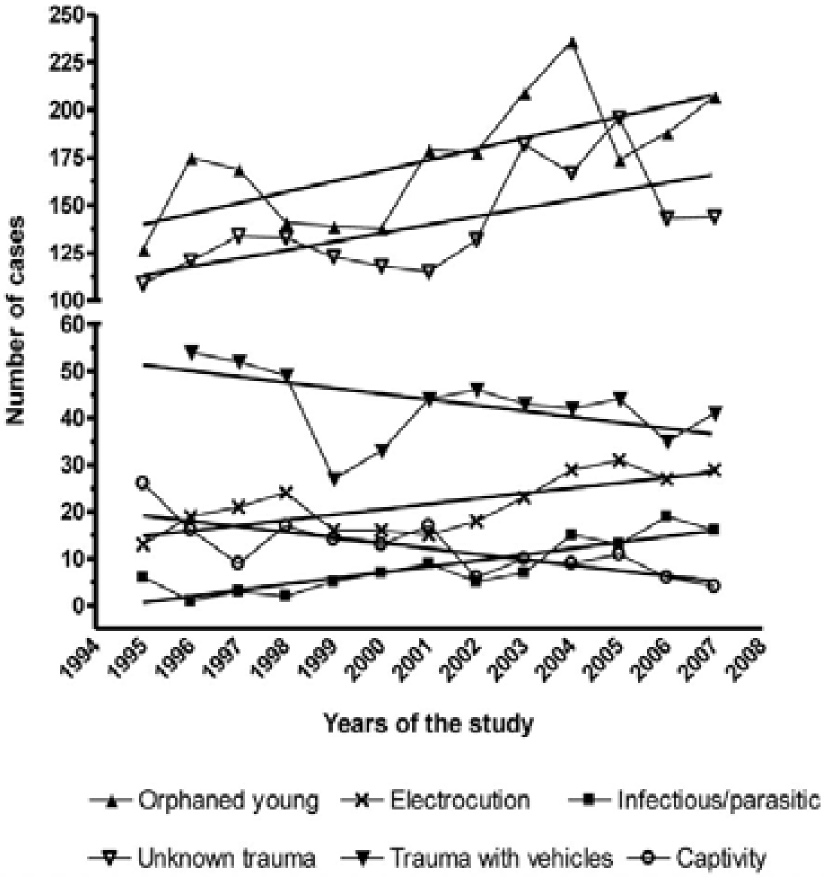

Figure 2. Different causes of admissions during the period 1995–2007 (number of cases). Only causes with significant statistical tendency are represented.
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60606-6412). Chi-square (x^2) or Fisher exact tests were used for comparison between proportions. Odds ratio measure of association was employed for disease comparisons. Seasonal cumulative incidences (SCI) were calculated for the wintering and breeding seasons, and were defined as the number of cases per season divided by the estimated population at that season. Results were expressed per 1000 animal and year. Reference populations of the region were obtained from published data [27,30]. Breeding and wintering estimated populations were considered as stable during the seasons and over the period of study. Trend analyses were applied for specific causes with a minimum of 100 cases in order to detect differences among years.

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Author Contributions

Conceived and designed the experiments: RM-L JC LD. Performed the experiments: RM-L. Analyzed the data: RM-L. Contributed reagents/materials/analysis tools: RM-L JC LD. Wrote the paper: RM-L JC LD.

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Estudio 2.

Final disposition and quality auditing of the rehabilitation process in wild raptors admitted to a wildlife rehabilitation centre in Catalonia, Spain, during a twelve year period (1995-2007). PLoS One, aceptado, 2013.

Abstract

Background: Variability in reporting and classification methods in previous published data of the final dispositions in the rehabilitation of wild raptors makes use of this data limited in trying to audit the quality of the rehabilitation process. Crude as well as stratified disposition rates are needed if quality auditing of the rehabilitation process is to be adequately performed.

Methodology: Final dispositions of 6221 hospitalized wild raptors admitted at a wildlife rehabilitation centre (WRC) of Catalonia during 1995-2007 were analyzed. These dispositions were calculated as the euthanasia (Er), unassisted mortality (Mr), release (Rr) and captivity rates (Cr). , time to death (Td) for dead and euthanized raptors, and length of stay for released (Tr) raptors was estimated. Stratified analyses by main causes of admission and clinical signs were performed.

Results: The disposition for the total population were: Er =30.6%, Mr=19.1%, Rr =47.2%, and Cr =3%. By main causes of admission, Er was higher in the trauma category (34.2%), whereas Mr was found similar between trauma (37.4%) and non-trauma categories (34.8%). The highest Rr was observed for the orphaned group (77.9%). Furthermore, Cr was low in all the categories (<4%). By clinical signs, the highest Er was found in animals suffering musculoskeletal (37.9%) or skin (32.3%) lesions; Mr was high in infectious/parasitic diseases (66.7%) and in case of neurological symptoms (64.5%).The euthanized birds had a median Td =1 day (P_{10}= 0-P_{90}= 59) for both trauma and non-trauma categories, and Td =36 days for the orphaned young group (P_{10}=0; P_{90}=596). The median Td in the unassisted dead birds was 2 days for all the categories (P_{10}=0-P_{90}=31). Finally, the median Tr in the centre was variable among categories.

Conclusions/Significance: Reporting of final dispositions in wildlife rehabilitation should include the crude and stratified rates (Er, Mr, Rr, and Cr), by causes and clinical presentation, as well as Td and Tr, to allow meaningful auditing of the rehabilitation process quality.

Introduction

Rehabilitation of wild raptors is a complex process that includes both veterinary care of the injured bird and physical recovery and reconditioning of this animal for subsequent release in the wild [1]. The direct benefits derived from the recovery of wild birds could be summarized in several aspects: the improvement of the welfare of the individual animal, the reinforcement of the natural population after the release, especially in endangered species or long-lived birds, the identification of the causes of morbidity and mortality, and the regulatory changes implemented as a consequence of determining human influences and causes of admission [2,3].

Data published from wildlife rehabilitation centres (WRC) have been mainly focused on the causes of admission [4-7], on the investigation of some specific infectious or parasitic diseases and toxicoses [8-10] or on the establishment of bio-pathological reference values [11]. On the other hand, the final dispositions of the rehabilitation cases are commonly summarized or briefly described [12-14], but a stratified analysis by causes of the final disposition is rarely reported. This kind of analysis is crucial for building an evidence base for wildlife rehabilitation medicine and management.

Quality assessment is one of the strategic elements for the improvement and transformation of the modern human health system [15]. Outcomes research is an essential part of the quality control process, and quality indicators of medical performance have been defined by consensus in order to determine the quality of care in a measurable way [16,17]. In wildlife medicine, some clinical practice guidelines have been published which deal with welfare rehabilitation standards [18] and pre-release health screening protocols [19] but no quality indicators of the rehabilitation process have been defined.

The main objective of the present study was to analyze the outcomes of the rehabilitation of wild raptors in a WRC, adopting the four categories of the final disposition, the time until death and the length of stay as indicators of the quality audit of the rehabilitation process before release back to the wild.

Materials and methods

Study design and animals. A retrospective study was performed using the original medical records of birds of prey admitted at the Wildlife Rehabilitation Centre (WRC) of Torreferrussa 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 guidelines in wildlife rehabilitation centres. The rehabilitation centres directly depend on the individual regional government wildlife services in Spain. Management and protocols were established according to the guidelines approved by each regional government according to legislation [20]. Animals that had to be euthanized for animal welfare reasons were administrated barbiturates by intravenous injection.

Definition of variables. Overall data about species, gender, age, date of admission, date of death or release, and primary cause of admission were included in the analyses. Classification of primary morbidity causes, criteria for sexing and ageing, as well as the geographical and demographical characteristics of the population were the same as those reported in a previous study [7].

The final disposition was divided into four categories adapted from Cooper (1987) [21]: euthanized animals (based on poor quality of life, or poor prognosis for survival on return to the wild), dead animals (with no human intervention), animals returned to the wild and permanently captive non-releasable animals (due to their 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 a given period of time; as a result, all four categories were expressed as rates: euthanasia rate (E_r), unassisted mortality rate (M_r), release rate (R_r), and captivity rate (C_r). In addition, R_r was analysed taking into account the season of admission and the season of release.

The final disposition was first analyzed based on the primary cause of admission grouped as trauma, non-trauma and orphaned young categories. It was then analyzed according to the main clinical signs of the animals at the time of the admission. This clinical presentation was based on the International Statistical Classification of Diseases and Related Health Problems-ICD-10 (WHO, 2004) [22] but adapting the categories to wildlife medicine. We have adopted a single-condition morbidity analysis in which the main condition was defined as the primary condition responsible for the patient's need for treatment or investigation. If there was more than one such condition, the one held most responsible for the greatest use of resources was selected. If no diagnosis was made, the main symptom, abnormal finding or problem was selected as the main condition. In this line, the initial signs were divided into the following categories: apparently healthy animals, infectious/parasitic diseases, endocrine/nutritional/metabolic diseases, behavioural abnormalities (imprinted or tame), eye and adnexa problems, skin and subcutaneous conditions, alterations in the different systems (nervous, respiratory, digestive and musculoskeletal), traumatic signs not classified in any of the previous categories, and others which included birds with different clinical signs not classified in the above categories. In order to minimize overlapping between diagnostic categories, the infectious/parasitic diseases category included all those diseases generally recognized as communicable or transmissible, despite the affected system.

Additional parameters such as time until death (T_d; difference between the date of admission and the date of the death) for euthanized and for dead animals, and length of stay in the centre for the released raptors (T_r; difference between the date of admission and the release date) were also evaluated. In order to study the cases with longest T_d, the percentiles 10 (P_{10}), 75 (P_{75}) and 90 (P_{90}) of this variable were selected as a cut-off point.

Quality indicators of the rehabilitation process conducted at the centre were evaluated based on different outcome variables following guidelines used in human medicine [23, 24]. The main indicators adopted in our work were the four categories of the final disposition, the time until death (T_d) and the length of stay at the centre for the released raptors (T_r).

Statistical analysis. Descriptive statistics, normality test and inferential analyses were done at 95% confidence levels with SPSS Advanced Models ™ 15.0 (SPSS Inc. 233 South Wacker Drive, 11th Floor Chicago, IL 60606-6412). Median (P_{50}). Percentiles 10, 75 and 90 ($P_{10;}$ $P_{75;}$ P_{90}) were provided for the descriptive analysis of the dispositions T_d and T_r. Comparisons of the median were evaluated using the U-Mann-Whitney and Kruskal-Wallis test. Chi-square

(χ^2) or Fisher exact tests were used for comparisons between the E_r, M_r, R_r and C_r and sex, age and order co-variables.

In order to compare the differences along the period of study of the final disposition categories, a ratio between the number of dispositions and the total number of cases per year was estimated. A linear regression model was used to estimate the trend of the dispositions during the period of study according to the main cause of admission categories and the order.

Results

Descriptive analyses of the total population.

During a period of twelve years (from 1995 to 2007), a total of 7553 raptor admissions were reported at the WRC. After a critical review of all the admissions, 1332 cases were excluded for not fulfilling the inclusion criteria (739 cases were admitted dead and 593 cases included captive birds, captive-borne or falconry birds). Thus, the final population of this study was 6221 individuals distributed in the following orders: 3241 Strigiformes and 2980 Falconiformes.

The age distribution demonstrated that 46.3% (2884/6221) of birds were within their first year of age, 32.3% (2009/6221) were >1 calendar year and 21.3% (1328/6221) were of unknown age. Most of the animals, 59.4% (n=3695), were classified as undetermined gender, 21.9 % (n=1363) of raptors were sexed as female and 18.7 % (n=1163) as males.

A crude analysis of the final disposition of the total raptor population showed the following rates: E_r =30.6% (1903/6221), M_r =19.1 % (1191/6221), R_r =47.2% (2939/6221), C_r =3% (188/6221) (Fig. 1).

Rehabilitation final dispositions by causes of admission

Stratifying by the primary cause of admission, 49.7% (3092/6221) of birds were classified into the trauma category, 15.7% (976/6221) in the non-trauma and 34.6 % (2152/6221) in the orphaned young category. The euthanasia rate was notably higher in the trauma category (34.2%) compared to the non-trauma (9.2%) or orphaned young (2%) (Fig. 1), and mainly due to those cases related to electrocution and collisions with power lines (Table 1). The unassisted mortality rate was similar in both trauma (37.4%) and non-trauma (34.8%) categories but lower in the orphaned young (18.9%). Within the traumatic causes, animals found in traps (52.6%), and collisions with vehicles (46.5%) or fences (47.8%) presented the highest unassisted mortality rate. In the non-traumatic causes, infectious/parasitic diseases had the highest rate of mortality (70%). The release rate was significantly higher in the orphaned young (77.9%) and in non-trauma (52.5%) categories compared to the trauma category (24.3%). In the last category, birds who suffered collision with buildings had the best rates of release compared to the other traumatic causes. Finally, low rates of captivity were found in the three categories (4.1% trauma, 3.5% non-trauma) and particularly in the orphaned young birds (1.3%) (Table 1).

In the subgroup of animals with known sex and age, the unassisted mortality rate was higher in males than in females, in both non-trauma (χ^2=6.6; p=0.0098) and orphaned young (χ^2=15.8; p=0.003) categories.

Rehabilitation final dispositions by clinical signs

The euthanasia rate (E_r) was higher in those animals suffering lesions at the skin level (32.3%), mostly affected by extensive wounds and electric burns, or at the musculoskeletal system, basically due to fractures and luxations (37.9%) (Fig. 1). By contrast, E_r was very low in adults presenting endocrine/nutritional/metabolic disorders (3.7%) and digestive disorders (5.3%). The unassisted mortality rate (Mr) was elevated in raptors with infectious/parasitic diseases (66.7%), mainly trichomoniasis, or with neurological symptoms like depression, ataxia and paralysis (64.5%). The highest rate of release was observed in the apparently healthy animals (88.9%), mostly represented by young orphaned birds and birds belonging to the fortuity category, including birds found inside buildings or other human structures. The R_r was also high for animals with behavioural abnormalities (57.3%) and in animals in the endocrine/nutritional/metabolic (54.1%) category when this comprised birds with low body condition and weakness as main general symptoms. Finally, the captivity rate was elevated in those animals with behavioural abnormalities (15.9%) and respiratory distress (10.5%) (Table 2).

Additional parameters: time until death and length of stay at the centre.

The group of euthanized birds had a median T_d =1 day (P_{10}=0; P_{90}=59) for the trauma (P_{10}=0; P_{90}=41) and non-trauma (P_{10}=0; P_{90}=171) categories, and T_d =36 days for the orphaned young group (P_{10}=0; P_{90}=596) (Table 3). Interestingly, the median T_d in the dead birds was 2 days for all the categories (P_{10}=0; P_{90}= 31). On the other hand, the median time of stay in the centre was highly variable among categories, presenting the trauma the longest times (T_r=115) compared to non-trauma (T_r=58) and orphaned young (T_r=59) groups (Table 3).

Taking into account the season of the admission because it is of relevance for the decision of approving the release of rehabilitated animals, the median T_r was statistically different among seasons (χ^2=269.933; p<0,001), with raptors admitted in spring presenting stays of 85 days (P_{10}=12; P_{90}=296), 53 days (P_{10}=16; P_{90}=212) if admitted in summer, 113 days (P_{10}=10; P_{90}=386) if admitted in autumn and 130.5 days (P_{10}=23; P_{90}=418) if admitted in winter.

Time evolution of dispositions along the study period

No statistically significant differences were observed among the final dispositions during the 12 years of the study in the overall group. However, in the traumatic category, a significant decrease in the unassisted mortality rate was observed (B= -0.12; p=0.035).

Discussion

Historically, wildlife programs were developed as a consequence of the concern of modern society with both animal welfare and the negative impact of human activities in wildlife population. Rehabilitation of birds of prey and owls has led to the development of many of these programs due to the sensitivity of wild birds to human threats, the unfavourable status of many species and the public interest in these predators [25].

A detailed description of primary causes of admission has been thoroughly reported [26] and welfare and general guidelines for rehabilitation of wild raptors are available [18]. However, the approach to the quality of audit in wildlife rehabilitation is poorly reported. In human medicine, quality indicators of the dispositions are employed to assess and improve the quality of care in many healthcare settings [27]. The data presented in the current study report the crude and stratified dispositions rates by cause and clinical entities, but also the time until death and the length of stay. All six parameters have been considered as quality indicators as a baseline for a quality audit.

From the data it is evident that less than half of raptors admitted to rehabilitation in Catalonia were successfully released. 52.8% of raptor admissions resulted in euthanasia, mortality or permanent captivity. Only 47.2% of birds were successfully returned to the wild.

Nevertheless, an estimation of the final dispositions based on the main causes of admission or the clinical entities is essential in order to compare the results. The most simplistic and realistic classification is that consisting of two groups: 1) healthy young birds requiring rearing, 2) injured and ill birds, including those that have been kept illegally in captivity. Orphaned young birds represent an important part of the admissions to the WRC [28], usually concentrated in a short period of time and resulting in filling of rehabilitation facilities to maximum capacity and needing labour intensive care. Moreover, many of the birds are likely not true orphans, but because they are easily found by humans are brought to the WRC [29] and are apparently in good overall health. The proportion of releases in this group is high, and this influences the overall dispositions and results.

Literature on the dispositions of bird of prey rehabilitation is variable, making comparison between studies difficult. Most studies emphasise the release rate [30] as the main outcome, but overall causes are also frequently estimated [13,31]. In fact, two basic dispositions could be considered: releases and non-releases, including death, euthanasia and captivity of non-releasable birds. In the authors' opinion, the four categories (release, unassisted death, euthanasia and permanent captivity) should be analysed individually as a basic assessment of the quality indicators of the rehabilitation process, due to their different biological and management implications.

Euthanasia is an essential option in all wildlife rehabilitation, based on both animal welfare and optimization of economical resources [1,32]. However, beyond the situations in which the rehabilitation of the bird is not a viable option and euthanasia is the most appropriate disposition, legal policies preclude the final disposition of a bird of prey in some countries [33]. In our study, the overall rate of euthanasia was 30.6%, and the highest values were found in the trauma category (34.2%) mainly due to electrocutions and collisions with power lines. In our experience these animals frequently cannot be rehabilitated for release due to the severity of their injuries.

Mortality rate has been used as a quality indicator parameter in human medicine [34]. Unfortunately, in wildlife rehabilitation this parameter has been variably reported in most studies without defining criteria, making the comparison of results difficult. In some studies the mortality rate includes the proportion of deaths as well as the proportion of euthanized animals while others do not [13,35]. This approach may lead to overestimations of the actual rate of non-human intervention results. In our opinion, unassisted mortality rate and proportion of euthanized should be estimated separately and included in the general disposition report.

Our data demonstrated a similar rate of mortality for trauma (37.4%) and non-trauma (34.8%) cases. In the non-traumatic group, the higher M_r was due to infectious diseases, particularly trichomoniasis. It has previously been reported that the majority of cases demonstrating lesions produced by *Trichomonas spp* affecting the oral cavity and choanal slit, have a poor prognosis [36], and our findings confirmed this. In this study, the unassisted mortality rate due to gunshot was 33.5%, greater than that reported by Richards et al, 2005 (14%) [37] or Ress and Guyer, 2004 (<20%) [38].This is due to regional differences in firearms availability, hunting and legislation. In our work M_r had an approximate 30% value in the three most prevalent causes of trauma. Most of those cases suffered severe trauma with multiple body systems affected. Finally, the unassisted mortality rate found in our young orphaned group (18.9%) was similar to other reports (16.1%) [39].

According to the classification of clinical signs, M_r was over 50% when the nervous, respiratory or digestive systems were primarily affected or in cases of general systemic infectious or parasitic disease. The M_r was higher in birds with integument and musculoskeletal conditions. On the other hand, the higher M_r in animals apparently healthy on admission or with nutritional and metabolic conditions is suggestive of captivity-related complications and requires further investigation. In the authors' opinion, the present classification focusing on clinical signs allows a more accurate assessment of the rehabilitation protocols than those based on the primary cause of admission. Both classifications are useful; clinical classification allows a veterinary perspective, while the primary cause of admission allows an assessment of environmental causes and problems, and should be included in the analysis of dispositions of the rehabilitation of wild birds of prey.

The release rate in our study was higher in the orphaned young group, followed by fortuity and captive birds that were mainly affected by minor health conditions. The overall release rate of trauma cases was 24.3 % (ranging from 1% of electrocution cases to 61.5 % of birds suffering impacts with buildings). The release rates of gunshot, collision with vehicles and unknown trauma were very similar to those previously reported [14, 37, 38], being under 35% in all cases. On the other hand, the permanent captivity rate differs and needs special consideration. The final disposition of a non-releasable bird depends on the welfare and legal policies of the country or of the centre. Therefore, comparison of this rate could be useless if the rehabilitation criteria and policies are not specified. In our centre, euthanasia decision-making is based on welfare and economical criteria; thus the rate of permanently captive birds is relatively low.

Length of stay is a quality indicator parameter frequently used in human medicine [40]. In rehabilitation of wild raptors the decision of when to release an animal is based on the criteria related with the rehabilitation process (health status, fitness and behaviour), but also on external/ecological factors [41]. In fact, the longest periods of stay observed in birds admitted in winter and autumn were explained by the dates of the hunting season in the area of the study, as well as adverse weather conditions. Some migratory species such as *Circaetus gallicus, Pernis apivorus* and *Otus scops* were maintained at the centre until the next spring migration. As a general rule, the length of stay must be as short as possible in order to reduce the risk of captive-related complications, infectious and parasitic disease, and behavioural abnormalities [42]. The length of stay is thus a critical parameter in assessing the quality of rehabilitation protocols.

The parameter time to death provides direct insight into the initial assessment and prognostication, the overall rehabilitation process, as well as the validity of veterinary protocols. This complements understanding of the mortality and euthanasia rates. In all time dependent variables we have included the extreme values because they highlight the real daily work of the rehabilitation centre, with birds remaining in captivity for unknown reasons. Interestingly, the median time to euthanasia was 1 day. That means that the decision is taken at the moment of the admission, resulting in optimization of welfare and financial resources. On the other hand, the median time of death was 2 days even for the young orphaned group. This fact suggests that special care and a complete clinical evaluation should be performed on all young birds, despite their apparently healthy appearance.

In our work, we paid attention into the M_r and E_r over the P_{90} of the T_d, as an indicator of undesirable or unexpected dispositions. The decision of euthanasia over 59 days was mostly taken due to complications related to trauma or musculoskeletal conditions. In our protocols, at 59 days most birds are in outside enclosures undergoing active flight conditioning. At this stage the decision to euthanize is taken in birds with musculoskeletal problems as well as those demonstrating abnormal behaviour incompatible with release to the wild.

Finally, a significant decrease in the unassisted mortality rate was observed in the traumatic category. This finding could be consequence of the improvement of both diagnostic and therapeutic protocols applied in the last years. The optimization of protocols for identifying specimens that are non-viable, has permitted the early euthanasia of these animals, avoiding unnecessary animal suffering and improving the management efficiency of resources.

In conclusion, the basic outcome research of the rehabilitation process of wild birds of prey and owls should include the four final disposition rates (Mr, Er, Rr and Cr), but also the parameters time until death (Td) and length of stay at the centre (Tr). The reports should also include the overall rates and the stratified analysis according to the cause of admission and the clinical entities. Moreover, both Td and Tr should be estimated by the overall group, but also stratifying by final decision and cause of admission and clinical entities. These six parameters are measurable items that should be considered as a baseline indicators for quality audits. Our results could represent a reference of a large amount of parameters related with the outcomes of the wildlife rehabilitation process that could be adapted by other centres as a start-point for further comparison. Finally, consensus of the professionals involved in rehabilitation of wild birds of prey is essential in order to develop evidence-based clinical guidelines and recommendations that will lead to an improvement of the rehabilitation procedure.

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Table 1. Description of the number and percentage of raptor cases according to their final disposition and the cause of admission at the wildlife rehabilitation centre.

Primary cause	Total	Euthanasia		Mortality		Release		Captivity	
Categories	N	n	Rate (%)	N	Rate (%)	n	Rate (%)	n	Rate (%)
Trauma	**3092**	**1058**	**34.2**	**1157**	**37.4**	**750**	**24.3**	**127**	**4.1**
Unknown trauma	1691	560	33.1	658	38.9	385	22.8	88	5.2
Gunshot	627	183	29.2	210	33.5	207	33.0	27	4.3
Vehicles	471	136	28.9	219	46.5	108	22.9	8	1.7
Electrocution	197	162	82.2	30	15.2	2	1.0	3	1.5
Building	52	3	5.8	17	32.7	32	61.5	0	0.0
Fences	23	9	39.1	11	47.8	3	13.0	0	0.0
Power lines	9	5	55.6	2	22.2	2	22.2	0	0.0
Trap	19	0	0.0	10	52.6	8	42.1	1	5.3
Predation	3	0	0.0	0	0.0	3	100.0	0	0.0
Non-trauma	**976**	**90**	**9.2**	**340**	**34.8**	**512**	**52.5**	**34**	**3.5**
Fortuity*	346	8	2.3	99	28.6	235	67.9	4	1.2
Undetermined	165	27	16.4	71	43.0	63	38.2	4	2.4
Metabolic/nutritional	223	27	12.1	95	42.6	94	42.2	7	3.1
Captivity	156	13	8.3	27	17.3	100	64.1	16	10.3
Infectious parasitic	84	15	17.9	46	54.8	20	23.8	3	3.6
Toxicoses	2	0	0.0	2	100.0	0	0.0	0	0.0
Orphaned young	**2153**	**43**	**2.0**	**406**	**18.9**	**1677**	**77.9**	**27**	**1.3**

*Fortuity includes all raptors found in manure heaps, bad weather conditions, etc, as previously defined by Molina-Lopez et al. (2011).

Table 2. Description of the number and percentage of raptor cases according to the final disposition and clinical signs presented at the admission at the wildlife rehabilitation centre.

Primary clinical signs	Total	Euthanasia		Mortality		Release		Captivity	
	N	n	Rate (%)	n	Rate (%)	n	Rate (%)	n	Rate (%)
Infectious and parasitic	42	10	23.8	28	66.7	3	7.1	1	2.4
Endocrine/ nutritional/ metabolic	862	32	3.7	355	41.2	466	54.1	9	1.0
Behavioural abnormalities	82	6	7.3	16	19.5	47	57.3	13	15.9
Nervous system	324	45	13.9	209	64.5	67	20.7	3	0.9
Eye and adnexa	206	29	14.1	70	34.0	96	46.6	11	5.3
Respiratory system	19	0	0.0	10	52.6	7	36.8	2	10.5
Digestive system	75	4	5.3	39	52.0	29	38.7	3	4.0
Skin and subcutis	679	219	32.3	166	24.4	273	40.2	21	3.1
Musculoeskeletal system	2110	799	37.9	751	35.6	456	21.6	104	4.9
Multi-organic trauma	19	1	5.3	8	42.1	10	52.6	0	0.0
Healthy	1610	8	0.5	157	9.8	1432	88.9	13	0.8
Others*	193	38	19.7	94	48.7	53	27.5	8	4.1

*Included all cases with other clinical signs not classified in any of the described categories.

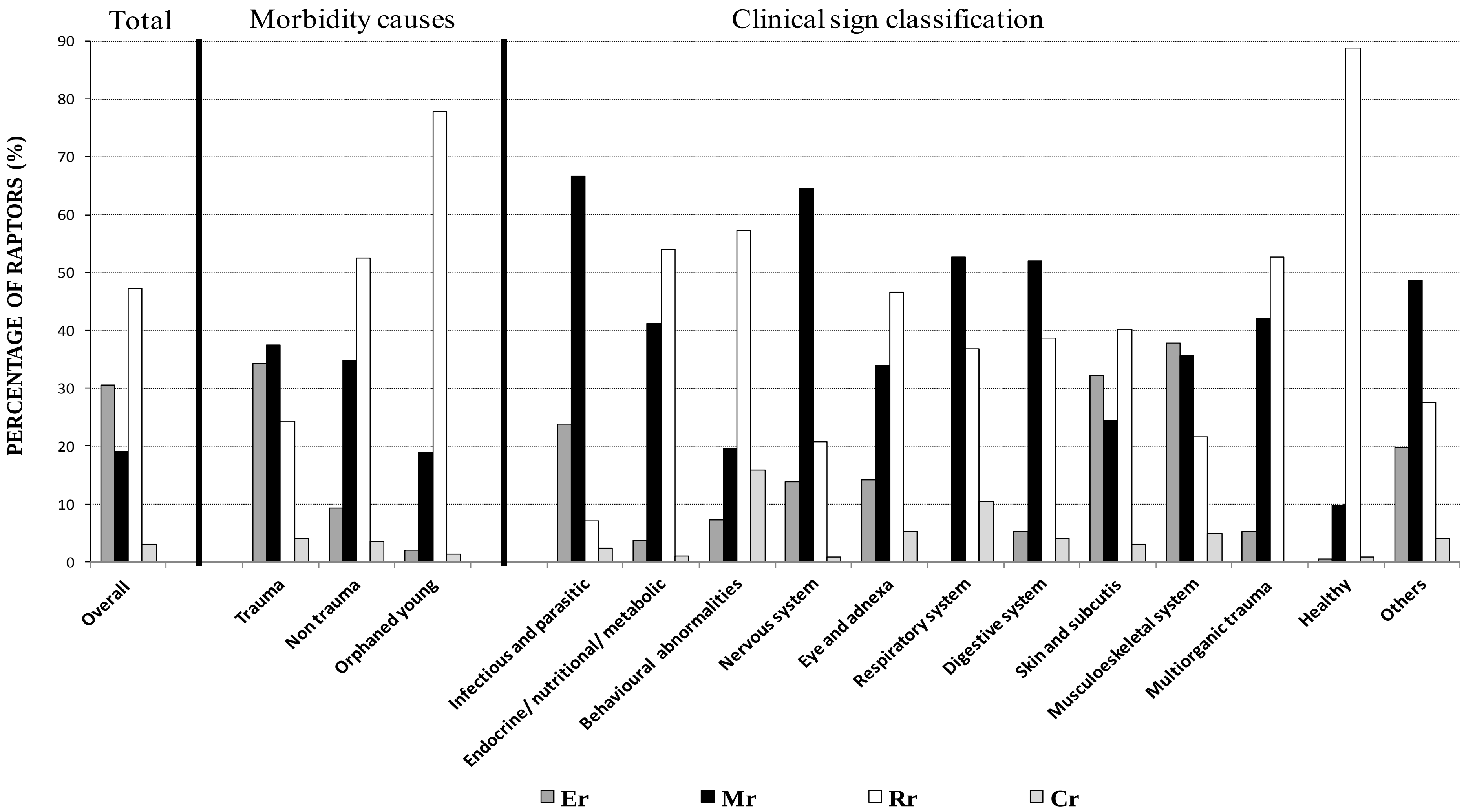
Table 3. Statistical descriptive of time that animals were keep in the rehabilitation centre until the final disposition.

	Time (days) from admission to final disposition											
	Euthanasia rate				Unassisted Mortality rate				Release rate			
Admission Causes	P_{10}	P_{50}	P_{75}	P_{90}	P_{10}	P_{50}	P_{75}	P_{90}	P_{10}	P_{50}	P_{75}	P_{90}
Trauma	0	1	7	41	0	2	5	26	24	115	265	443
Unknown trauma	0	1	7	57	0	2	5	27	24	94	240	416
Gunshot	0	2	22	82	0	3	7	74	66	207	320	621
Vehicles	0	1	10	28	0	2	5	15	14	95	239	485
Electrocution	0	0	1	4	0	2	4	7	N/A	N/A		N/A
Building	0	0	0	0	1	2	6	18	1	45	133	241
Fences	0	1	3	0	1	2	7	477	1	22	Na	N/A
Trap	0	N/A	N/A	N/A	N/A	8	11	15	5	15	148	N/A
Non-trauma	0	1	25	171	0	2	5	16	2	58	163	372
Fortuity	0	0	3	298	0	2	4	25	1	37	116	311
Undetermined	0	0	2	156	0	1	3	8	7	51	128	393
Metabolic/nutritional	0	1	25	96	0	2	5	18	11	63	110	280
Captivity	0	16	119	399	0	2	13	68	21	158	320	516
Infectious/parasitic	0	8	19	138	0	2	6	13	30	60	108	372
Orphaned young	0	36	187	596	0	2	14	51	18	59	87	179

P_{10}, P_{50}, P_{75}, P_{90}: percentiles 10, 50 (or median), 75 and 90; N/A, not applicable (just one case).

Fig 1. Resolution rates of euthanized (Er), dead (Mr), released (Rr) and captive (Cr) raptors relative to the overall population, the principal cause of the admission and the clinical signs.

Fig. 1



Estudio 3.

Specie-specific analysis of final dispositions for auditing the rehabilitation process quality of wild raptors at wildlife rehabilitation center in Catalonia.

Abstract

Aims: This study aimed to investigate the final disposition of different raptor species attended at a wildlife center as an approach of the quality auditing of the rehabilitation process.

Methods: A total of 6221 hospitalized wild raptors (3241 Strigiformes; 2980 Falconiformes) admitted at a wildlife rehabilitation centre of Catalonia from 1995 to 2007 were analysed. The principal quality indicator was the final disposition, which included: euthanasia (E_r), unassisted mortality (M_r), release (R_r) and captivity (C_r) rates. Stratified analyses by main causes of admission and raptor species were performed.

Major findings: Falconiformes presented higher rates of euthanasia (33.9%) than Strigiformes (18.6%), being *B. buteo* (45.7%) and *M. migrans* (47.6%) in the Falconiformes and *B. bubo* (33.6%) in the Strigiformes, the species with the highest E_r. The M_r of owls was higher than the Falconiformes for trauma (13.2%; χ^2=49.97; p<0.001), non trauma (12.7%; χ^2=17.41; p<0.001) and orphaned young categories (4.9%; χ^2=5.4; p=0.02). The release rate was similar between orders: *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 diurnal raptors, being *S. aluco* the specie with the best rates (84%) and *B. bubo,* that with the worst values (50%).

Conclusions: Specie-specific differences were found in the final dispositions of the rehabilitation process regarding to the cause of admission. The analyses of final dispositions could be useful for quality auditing of the rehabilitation process and for identifying possible menaces for particular raptor species.

Keywords: Wild raptor species; Final disposition; Quality audit; Wildlife Rehabilitation.

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. Moreover, the benefits of this practice has been observed on the recovery of some endangered species (Martell *et al.,* 1991), the identification and understanding of many menaces to the wild populations (Harris & Sleeman, 2007) and, the improvement of animal welfare (Kirkwood & Sainsbury, 1996). The final purpose of the rehabilitation of wildlife species is the release of stabilized individuals to the natural habitat after a physical and behavioral recovery. However, before implementing curative protocols, welfare concerns but also a critical evaluation of the actual likelihood of survival of the animal in the wild should be considered.

The analysis of the outcomes or final dispositions 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 the rehabilitation practice. In a previous work conducted in a large cohort of wild raptors admitted at a wildlife rehabilitation centre in Spain, revealed that half of the animals died during the first week of admission due to euthanasia decisions or unassisted or natural mortality, and the other half were released to the environment (Molina-Lopez *et al.,* unpublished data). However, from a clinical and biological point of view, it will be interesting to analyze these dispositions by raptor species and the principal cause of admission, in order to identify menaces for determined species. Thus, using the same cohort of animals, we aimed to present more detailed information about the final dispositions as a principal quality audit of the rehabilitation process by the different species of wild raptors and the main cause of admission.

Materials and methods

Study design and animals. A retrospective study was performed using the original medical records of birds of prey admitted at the Wildlife Rehabilitation Centre (WRC) of Torreferrussa 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 guidelines in wildlife rehabilitation centres. The rehabilitation centres directly depend on the individual regional government wildlife services in Spain. Management and protocols were established according to the guidelines approved by each regional government according to legislation (R.D.1201/2005 of the Ministry of Presidency of Spain). Animals that had to be euthanized for animal welfare reasons were administrated barbiturates by intravenous injection.

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.

Quality indicators of the rehabilitation process conducted at the centre were evaluated based on different outcome variables following the guidelines used in human medicine (Braun *et al.,* 2010; Weiner *et al.,* 2006). The main indicator adopted in our work was the final disposition, which was divided into four categories as previously described (Net *et al.,* 1986; Cooper, 1987): euthanized animals (based on poor quality of life reasons), dead animals (with no human intervention), animals returned to the wild and permanently captive non-releasable animals (due to their 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 for each specie in a given period of time; as a result, all four categories were expressed as rates: euthanasia rate (E_r), unassisted mortality rate (M_r), release rate (R_r), and captivity rate (C_r) (Molina-lopez *et al*., under review).

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.

Results

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).

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%) 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 2).

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%; χ^2=49.97; p<0.001), non trauma (12.7%; χ^2=17.41; p<0.001) and orphaned young categories (4.9%; χ^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. 2).

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 2). 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).

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%).

Discussion

In the present study, final dispositions of a long-term retrospective study of a large cohort of wild raptors admitted at a rehabilitation center have been presented by species and the main cause of admission. 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 & Sleeman, 2007), but rarely combining both variables (Ress & Guyer, 2004). Up to date, it is difficult to compare results among different studies because either the number of cases or the methodological approaches are not homogeneous. For all these reasons, the presentation of the final dispositions in rates can be an optimal approach to compare and extrapolate results of the rehabilitation process among different centers and species.

The euthanasia criteria of wild birds have been clearly established (Miller, 2000), 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 the 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.,* unpublished data). 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, 2007).

As regards the mortality rate, when this rate was estimated based on the different causes of admission, owls presented a higher mortality in all the different causes 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 with 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 & 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 lesions, other factors like the management in captivity of high metabolic species, or the difficulty for feeding some specialized species, could increase the mortality rate (Naisbitt & Holz, 2004). The M_r in birds related to traumatic casualties was higher than 50% in the majority of species, and specially associated to an unknown trauma and gunshot. In most of the cases, the trauma was associated with severe musculoskeletal, neurological and multi-organic 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, 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 (Deem *et al.,* 1998). 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 & 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 (Stocker, 2005). 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 & 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 & Margalida, 2009) and the number of these incidents has also increased, as has been observed in other centers in Spain (Generalitat 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.* (1986) in United States (46.7 %), and R_r of *A. nisus* (22%) was similar to that reported by 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 and included in the breeding in captivity 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 (Pomarol, 1990). 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 & Darwich, 2011).

In conclusion, the analyses of final dispositions of the wildlife rehabilitation centers considering the primary causes but also stratifying by species allows an initial auditing of the quality of the rehabilitation practice. Moreover, this information can be useful to identify possible menaces to particular species.

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1. Conception and design, acquisition of data, or analysis and interpretation of data;
2. Drafting the article or revising it critically for important intellectual content.
3. Final approval of the version to be published.

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

Species	Adults not orphaned category (n)	Only orphaned category (n)
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**

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

Species	Total raptor admissions, N*	Euthanazited		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.

		Number and percentages of euthanized raptors (Er) 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	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	**N**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
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 (Mr) 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	**N**	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
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 wild according to main causes of admission.

Species	Overall	Unknown Trauma		Vehicles		Gunshot		Electrocution		Fortuity		Metabolic Nutritional		Captivity		Infectious Parasitic	
		Number and percentages of released raptors (Rr) Principal causes of admission*															
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	**N**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
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.

Species	**Orphaned young category number (rate, %)**		
	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)

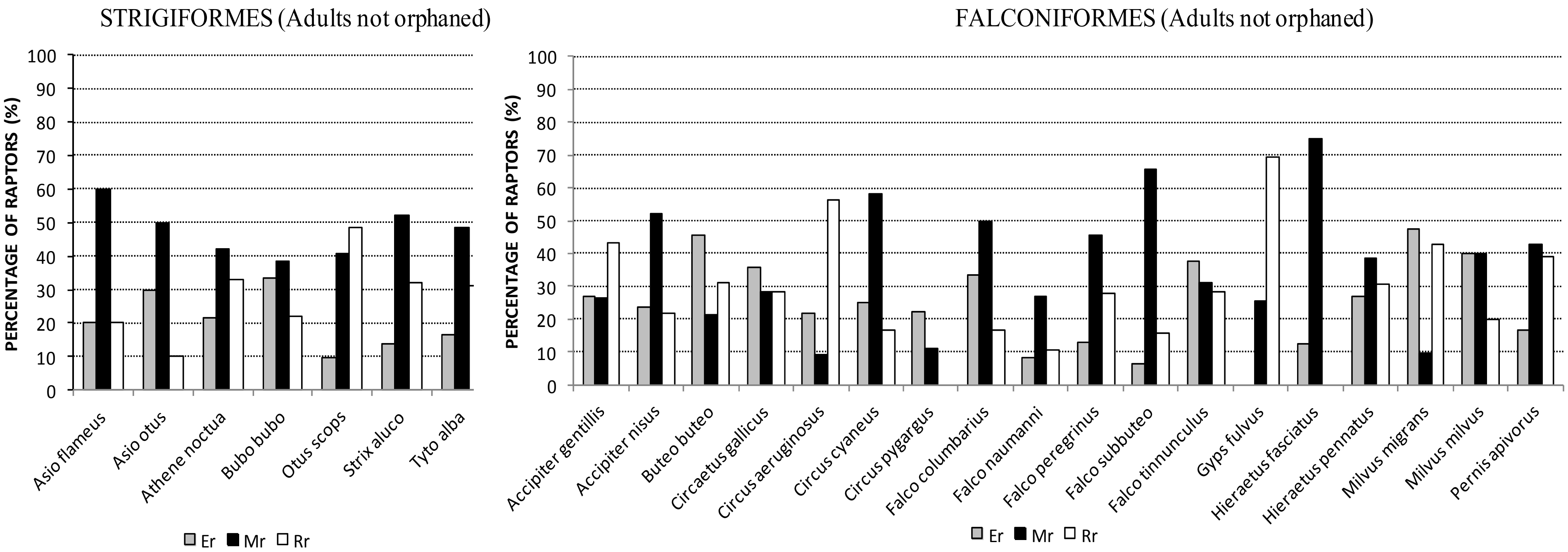

Fig. 1 Euthanized (Er), unassisted mortality (Mr) and released (Rr) rates of the different species of not orphaned raptors admitted in the WRC in Catalonia.

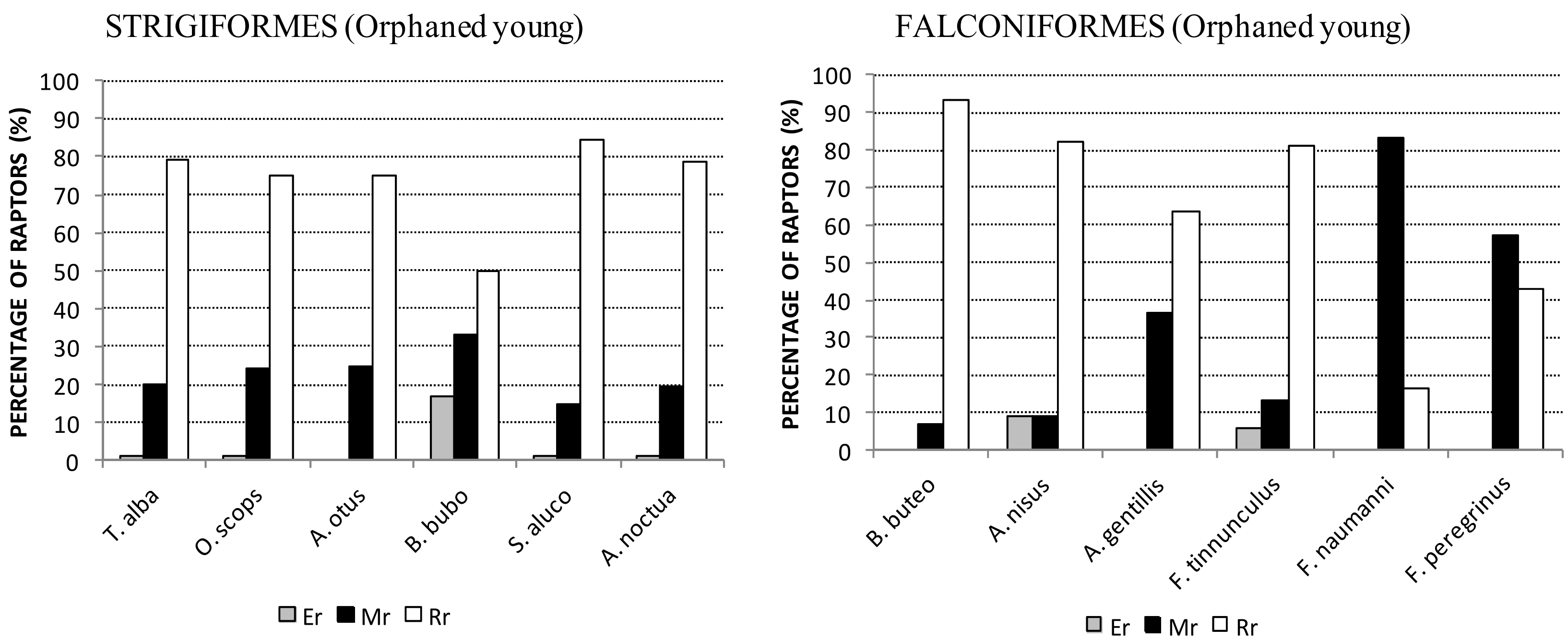

Fig 2. Euthanized (Er), unassisted mortality (Mr) and released (Rr) rates of the different species of orphaned young raptors admitted in the WRC in Catalonia

Estudio 4.

Prognostic factors associated with the mortality of wild raptors admitted at a rehabilitation centre of Catalonia, Spain.

Abstract

Background:

The assessment of the prognostic factors of wildlife casualties is a critical point in the rationale of the rehabilitation protocols and needs to be implemented in order to optimize the economical resources and warrant animal welfare. Prognostic studies allow the assessment of factors which relate baseline clinical covariables to outcomes. However, these studies are scarce in wildlife rehabilitation medicine. The objective of this study is to identify the prognostic factors associated with the mortality of wild raptors admitted at a rehabilitation centre.

Methodology/Principal Findings: A retrospective study was performed using the complete medical records of 1722 wild raptor cases (382 orphaned young; 1340 adults not orphaned) attended at the Wildlife Rehabilitation Centre of Torreferrussa (Catalonia, Spain) from 1995 to 2007. The outcome variable was the final disposition categorized as death (unassisted mortality) or live (released to the wild) during the first week of stay at the centre. Bivariate and multivariate generalized linear mixed model were performed to determine which factors were associated with mortality. The clinical variables included in the analysis were the order, sex, body condition (normal versus abnormal when sternum becomes prominent as a bird's muscles atrophy with weight loss), clinical signs and available haematological and biochemical parameters. In both animal groups, an abnormal body condition was associated with a worse prognosis. After adjusting variables in the multivariate regression model, BC was excluded due to co-linearity with all other variables, and presenting neurological signs (OR=4.0; 95%CI: 1.9-8.8) or a total solids <5mg/dL (OR=20.4, 95%CI: 2.6-158) were the prognostic factors related to an increment of the mortality in the adult not orphaned group.

Conclusions/Significance: The unassisted mortality in raptor care during the first week at the centre is strongly associated with affectation of the nervous system and suboptimal levels in the total solids. Thus, complete neurological examination of animals and the application of fluid therapy and an equilibrate diet protocols at the moment of admission are critical for the survival of these animals.

Introduction

Wildlife rehabilitation has significantly contributed to the development of wild animal medicine and in consequence, to the conservation of some endangered species (Redig, 1995; Sleeman, 2008). Moreover, the improvement of the rehabilitation protocols has allowed a better clinical recovery, but also an advance in the welfare of the captive wild animal in care (Hernández, 1992; Cousquer, 2005). However, the assessment of outcomes in the wildlife rehabilitation practice, has indicated a release rate lower than 50% in the majority of the reported studies (Ress and Guyer 2004; Rodriguez *et al.,* 2010) and 60% of survival rate after 48 hours post-admission (Kirkwood, 2003).

Prognostic studies have been designed for the assessment and early objective quantification of the prognosis with the aim of improving the care of the patients (Rehns *et al.,* 2011). Moreover, the identification of factors related with the survival in care of the free-ranging animals, is critical for both animal welfare and economical concerns. Despite the publication of clinical guidelines for rehabilitation (Miller, 2012), the number of prognostic studies in wildlife rehabilitation medicine is still scarce. It has been reported in a broad taxonomic animal study in England that the severity of the injury or illness was determined as the most predictive factor associated with the survival of wild animal casualties (Molony *et al.,* 2007). However, in our knowledge there is no clear evidence that blood values can be predictive of the survival rate during the rehabilitation process (Greig *et al.,* 2010).

The main objective of the present study is to identify the prognostic factors associated with the death in care of wild birds of prey and owls during the first week of admission in a wildlife rehabilitation centre of Catalonia, Spain.

Materials and methods

Study design and animals. A retrospective study was performed using the original medical records of birds of prey admitted at the Wildlife Rehabilitation Centre (WRC) of Torreferrussa, Catalonia, Spain, from 1995 to 2007. From the 7553 raptor admissions reported at the WRC, 1332 cases were excluded for not fulfilling the inclusion criteria (739 cases were admitted dead and 593 cases included captive birds, captive-borne or falconry birds). Thus, the population comprised 6221 individuals (Molina-López *et al.,* 2013) but only 1722 cases presented complete information in all the selected variables and in consequence, were included in the analysis.

The centre is under the direction of the governmental Catalan Wildlife-Service. Samples were collected in compliance with the Ethical Principles in animal research guidelines in wildlife rehabilitation centres. The rehabilitation centres directly depend on the regional government wildlife services in Spain who establishes the management and protocols according to the Spanish legislation [R.D.1201/2005 of the Ministry of Presidency of Spain].

The analysis was done in two separate groups of animals according to the differences on the rehabilitation protocols. Thus, a group of “orphaned young” raptors comprised all chicks found orphaned in the wild, and a second group of “adults” comprised the remaining not orphaned animals. The classification of primary morbidity causes adopted in this work, the criteria for sex and age determination and the geographical and demographical characteristics of the study population have been previously described (Molina-López *et al.,* 2011). The final disposition was categorized in four entities as previously described by Cooper (1987): release, unassisted mortality, euthanasia and captivity due to non releasable. Euthanized and captive birds have been excluded to the study, thus two disposition categories have been used in the final analysis: mortality and release. The cut-off of the survival time was fixed in 7 days after the admission, according to the percentile 75 (P_{75}) of the variable "time until the death" previously defined (Molina-López *et al.,* 2013).

Definition of variables. The variables included in the analysis were the following: The order (Strigiformes or Falconiformes), specie, sex, age, date of admission, date of death, primary cause of admission (traumatic and non traumatic injury), clinical signs grouped in the principal organic system involved (musculoskeletal, cutaneous, nervous, ocular, digestive, respiratory and systemic), multisystemic disease (MD, categorized as no affectation, one-system and multisystemic affectation). Moreover, the body condition (BC), subjectively evaluated by palpation of the pectoral muscles and determining the ratio of muscle mass to sternum and the body weight was categorized as normal (solid rounded pectoral muscles with a slight dip on either side of the sternum) and abnormal (sternum becomes prominent as a bird's muscles atrophy with weight loss) (Harrison and Ritchie, 1994).

Samples for haematological and biochemistry determinations were obtained during the general clinical examination at the moment of admission. Blood samples were collected from the jugular vein (*vena jugularis dextra*) or the basilic vein (*vena cutania ulnaris*). Haematological and chemistry parameters included packed cell volume (PCV, %), total solids (TS, mg/dl), hemoglobin (Hgb; g/dl), total protein (TP; g/l) and protein electrophoresis, aspartate aminotransferase (ASAT; UI/l), creatinine kinase (CK;UI/l), bile acids (μmol/l), uric acid (mg/dl), total cholesterol (mg/dl), urea (mg/dl), creatinine (mg/dl), triglycerids (mg/dl), amylase (UI/l) and lipase (UI/l). Samples were sent to the laboratory and analyzed the day of sampling. Serum chemistry analyses were performed using a wet chemical system.

Protein electrophoresis was performed on serum samples by capillary electrophoresis. TS and PCV were estimated at the rehabilitation center by the refractometric method and microhematocrit centrifugation respectively.

An overall inspection for parasites was carried out including a direct wet preparation and a Zinc sulphate flotation. The results of the first positive fecal analysis were categorized as a binary variable (positive/negative).

Statistical analysis. Chi-square (χ^2) or Fisher exact tests were used for comparison between proportions. One-way analysis of variance and non-parametrical Mann-Whitney test were used to compare means. Descriptive statistics, normality test and inferential analyses were done at 95% of confidence. Briefly, bivariate analysis was performed to determine which of the variables were associated with unassisted mortality. All variables found to be significant by the bivariate analysis or clinically relevant ($p<0.10$) were tested for co-linearity. Almost all variables present co-linearity except the hematological parameters PCV and TS, and the affectation in cutaneous, ocular, digestive or nervous systems, which were independent enough to be included in a generalized linear mixed model using a binomial function. The BC variable was excluded from the multivariate adjusted model because it was directly associated with the principal clinical variables.

The cut-off point that best divided each significant continuous variable into two subgroups was determined with a receiver operating characteristic curve analysis (ROC) to minimize false negative and false positive results. The selected variables were transformed into a dichotomous variable based on the most appropriated cut-off points. All analyses were performed with SPSS Advanced Models ™ 15.0 (SPSS Inc. 233 South Wacker Drive, 11th Floor Chicago, IL 60606-6412) except then generalized linear mixed model that was performed with R (glmer procedure).

Results

The analysis was performed on 1722 animals from witch we had complete information in all the selected variables. The final groups were composed by 382 orphaned young and 1340 adults not orphaned raptors (Table 1).

Due to the high co-linearity between variables only the bivariate analysis was used to examine the different parameters as predictors of the mortality in the orphaned young category. Affectation of the nervous system, systemic signs and multi-systemic failure were associated to higher mortality. A bad BC was also strongly associated to worse prognosis (Table 2).

In the adult not orphaned raptors, to have abnormal BC or presenting lesions in the several organic systems, were the most significant variables associated with raptor mortality (Table 3).

Values of PCV and TS were available in 41% (544/1340) and 40% (531/1340) respectively in the not orphaned group and 19% (71/382) and 18% (68/382) in the orphaned group. Of all the biochemical markers, only two blood parameters had significant area under the curve (AUC) as predictors of the final disposition during the first week of rehabilitation. These parameters were TS= 0.77 (0.7-0.84) and PCV= 0.83 (0.77-0.90). These variables were categorized as binary, choosing the cut-off points that maximized the sensitivity and specificity which were: 40% for the PCV and 5mg/dL for TS. Significant correlations were observed between TS and TP (Spearman's Rho=0.681; p= 0.00).

The PCV and TS values were statistically associated with the final disposition (mortality) in the adult not orphaned group for the bivariate analysis (Table 3). Basically, PCV values <40% or TS values < 5mg/dL signified an increment of the mortality risk (OR=11.2, 95%CI: 4.7-26.2 and OR=4.4, 95%CI:

2.1-8.9, respectively). These differences were not observed in the young orphaned birds. The final generalized linear mixed model considering the species as random variable included two significant variables: the TS (OR=20.4, 95%CI: 2.6-158) and the clinical signs related to nervous system (OR=4.0; 95%CI: 1.9-8.8).

Discussion

The assessment of prognostic factors is one of the main objectives in clinical research. Identifying the best predictors structures the basis of the guiding principles for the triage and the selection of the best complementary diagnostic techniques and treatment options. The research of prognostic factors in wildlife medicine is very limited and difficult to extrapolate due to the heterogeneity of species. In the present study, we offer a preliminary approach of the most significant predictors of the prognosis in the rehabilitation practice of wild raptors. Taken into account the differences between the orphaned young and the adult not orphaned animals (Molina-López *et al,* 2013), we have reported the results in two independent groups. In fact, the number of young animals that died during the first week is low considering the number of young animal admissions. Our objective was focused on the unassisted mortality in care during the first week, including not only the clinical signs but also some biopathological parameters. The most relevant result was to find the body condition (BC) as the main prognostic factor related to the mortality of birds regardless the age category. However, when this variable was not introduced in the adjusted regression model, lesions in the nervous system and total solids<5mg/dL, were the variables related to an increment of the mortality in the adult not orphaned group.

The body mass is a well recognized indicator of health in veterinary medicine. Nevertheless, the value of this variable as predictor is controversial in the survival tests of wildlife rehabilitation. Whereas some authors described a direct association between the mass measured in harbor seal pups (*Phoca vitulina*) and the survival prognosis (Greig *et al.,* 2010), others did not observed any relation in some species of raptors and passerines, hedgehogs, red foxes or *Pipistrellus spp* bats (Molony *et al.,* 2007). As regards birds of prey, there is a reverse sexual dimorphism that in diseased animals may be an overlap of body weights between sexes. On the other hand, the BC is a variable strongly related to the grouped clinical signs. Indeed, animals that have suffered from traumatic damage have more difficulty for feeding or hydrating; in these cases, BC can be considered as a "consequence" of the primary illness. For this reason, we decided to exclude the BC in the adjusted risk model to see the effect of the primary clinical sings at the admission.

It has been described that the severity of the injury or illness was the most important predictor of mortality (Molony *et al.,* 2007). In that study the clinical diagnosis were grouped according to the severity of symptoms, and some of the categories included clinical signs affecting different body systems. Despite the high co-linearity between the independent variables, we have found that affectation of the nervous system was the only variable significantly associated with mortality in the adjusted regression model. These results suggest that the severity of lesions involving neurological structures have usually fatal prognosis, in spite of having a good BC.

A large number of studies on reference hematological and biochemical values and its application in the veterinary practice on wild raptors have been published (Spagnolo et *al.,* 2008; Gelli *et al.,* 2009; Hernández and Margalida, 2010; Black *et al.,* 2011). However, its application as prognostic factors is still scarce. In a study conducted on wild seals admitted at a recovery center, found that blood parameters had no predictive value on the survival during the rehabilitation process (Greig *et al.,* 2010). In our study, complete blood analysis has only been able to conduct in some cases, due to budget constraints. Two parameters were predictive in the bivariate analysis: package cell volume and total solids. Interestingly, TS, were also predictive factors in the multivariate model and they can be cheaply and easily estimated in most rehabilitation or veterinary centers. Furthermore, the significant correlation between total protein and TS, suggests that TS could be considered as useful prognostic factors. While some authors (Lumeij and De Bruijne, 1985; Lumeij and Maclean, 1996) have shown that the refractometric method is unreliable for using in avian blood, a refractometric conversion factor could be applied, and then the TS could be used as a rough estimate of the total protein. Up to date and taking into account these preliminary results, conducting biochemical profiles of high costs seems to be not necessary in terms of prognostic markers. On the other hand, the relationship between body condition and PCV in birds of prey is controversial (Dawson and Bortolotti, 1997). Some authors have considered starvation as a cause of anemia in birds (Fudge, 2000) and we also have found direct correlation between BC and PCV. However, more extensive studies should be done to confirm these first results.

This study has some limitations that should be discussed; to obtain complete analytical information of all the cases most of the time is difficult due to financial constraints or to the health fragility of these patients that usually die within the first 48h of the admission (Molina-López *et al.,* 2013). In addition, a large variety of species are represented as a whole into the two principal orders. In consequence, some of the cut-off points for biochemical or hematological parameters can differ among species.

In conclusion, the presence of neurological signs and suboptimal levels in the total solids are directly related with a higher mortality in these animals. Thus, complete neurological examination and the application of fluid therapy and an equilibrate diet protocols at the moment of admission are critical for the survival of these animals

Acknowledgments

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Table 1. Descriptive parameters of the raptor groups of the study.

	Not orphaned group	Orphaned Young group
Overall population (N)	1340	382
Number of Deaths (% of mortality, M_r)	1220 (91)	280 (73.3)
Number of Alive (% of release, R_r)	120 (9)	102 (26.7)
Sex (ratio Female/Male)	415/411	52/65
Ratio Strigiformes/Falconiformes	604/736	283/99
Falconiformes especies, n (%)		
Accipiter gentillis	37 (2.76)	2 (0.52)
Accipiter nisus	180 (13.43)	1 (0.26)
Buteo buteo	143 (10.67)	1 (0.26)
Circaetus gallicus	10 (0.75)	-
Circus aeruginosus	3 (0.22)	-
Circus cyaneus	7 (0.52)	1 (0.26)
Circus pygargus	3 (0.22)	-
Falco columbarius	4 (0.30)	-
Falco naumanni	15 (1.12)	7 (1.83)
Falco peregrinus	34 (2.54)	5 (1.31)
Falco subbuteo	19 (1.42)	-
Falco tinnunculus	232 (17.31)	80 (20.94)
Falco vespertinus	1 (0.07)	-
Gypaetus barbatus	1 (0.07)	-
Gyps fulvus	10 (0.75)	-
Hieraetus fasciatus	6 (0.45)	-
Hieraetus pennatus	4 (0.30)	1 (0.26)
Milvus migrans	1 (0.07)	-
Milvus milvus	3 (0.22)	-
Pandion halietus	1 (0.07)	-
Pernis apivorus	22 (1.64)	1 (0.26)
Strigiformes especies, n (%)		
Asio flameus	5 (0.37)	-
Asio otus	24 (1.79)	4 (1.05)
Athene noctua	174 (12.99)	83 (21.73)
Bubo bubo	49 (3.66)	4 (1.05)
Otus scops	98 (7.31)	113 (29.58)
Strix aluco	108 (8.06)	38 (9.95)
Tyto alba	146 (10.90)	41 (10.73)

Table 2. Risk factors associated with the mortality rate of orphaned young raptors during the first week of rehabilitation.

Orphaned young group		**Bivariate regression model***		
Variable description	**N**	B	SE	Odds ratio (95%CI)
Clinical signs related to:	**345**			
Nervous system		3.7	1	42.3 (5.8-308.6)
Systemic signs		2,8	0.4	15.9 (6.6-37.2)
Body condition (BC): Abnormal	**267**	2.66	0.5	14.39(4.95-41.78)
Multisystemic affectation:	**345**			
One- system (1 organ)		2.06	0.38	7.86(3.69-16.7)
Multisystemic (≥2 organs)		3.62	0.73	37.5(8.93-157.49)

*Variables with statistical significance only represented. CI, confidence intervals.

Table 3. Risk factors associated with the mortality rate of adults not orphaned raptors during the first week of rehabilitation.

Adults not orphaned raptors		**Bivariate regression model**		
Variable description*	**N**	**B**	**SE**	**Odds ratio (95%CI)**
Clinical signs related to:				
Traumatic damage	**1340**	2.06	0.21	7.8 (5.2-11.9)
Cutaneous system	**1193**	0.75	0.27	2.1 (1.2-3.6)
Digestive system	**1193**	2.01	1.01	7.5 (1.0-54.5)
Systemic signs	**1193**	2.20	0.31	9.0 (4.9-16.8)
Nervous system	**1193**	2.48	0.43	11.9 (5.1-27.6)
Musculoskeletal system	**1193**	2.50	0.37	12.1 (5.8-25.3)
Body condition (BC):	**780**			
Abnormal		3.67	0.37	32.9 (19-81.2)
Multisystemic affectation:	**1193**			
One- system (1 organ)		2.80	0.28	16.5 (9.4-29.1)
Multisystemic (≥2 organs)		4.03	0.33	56.5 (19.5-108.3)
Packed cell volume (%) Binary (< 40 %)	**544**	2.41	0.44	11.2 (4.7-26.2)
Total solids (mg/dL) Binary (< 5mg/dL)	**531**	1.47	0.37	4.4 (2.1-8.9)

*Variables with statistical significance only represented. CI, confidence intervals.

Discusión

La continua modificación del medio natural por parte del hombre ha llevado a la sociedad occidental a preocuparse por la conservación del medio ambiente en general y de la preservación de las distintas especies de fauna y flora en particular.

Los estudios epidemiológicos sobre las causas de mortalidad y morbilidad en animales salvajes, proporcionan información sobre qué factores naturales o antropogénicos pueden representar una amenaza para sus poblaciones. Además, estos estudios se han convertido en una fuente importante de datos acerca del estado de salud de los ecosistemas (Brown y Sleeman, 2002; Sleeman, 2008). La presente tesis está dirigida a ampliar y profundizar este tipo de estudios epidemiológicos y su aplicación a la conservación de las aves rapaces salvajes en el territorio catalán. Aparte, se pretende ofrecer unos criterios generales para valorar los resultados de la rehabilitación este tipo de aves en los CRF. Por último, con el fin de optimizar recursos humanos y financieros y asegurar el bienestar animal, se determinan los factores más relevantes en el pronóstico clínico en el momento del ingreso en el CRF.

El principal valor de la presente tesis viene dado por el elevado tamaño muestral -más de 7000 casos de rapaces salvajes- y la gran diversidad de especies que se valoran. Las causas de ingreso y su repercusión a nivel poblacional abarcan un periodo de 12 años, de manera que permiten determinar los posibles cambios ocurridos a lo largo de este tiempo. Para valorar la frecuencia de los distintos procesos se introduce por primera vez en la práctica de la rehabilitación de fauna salvaje, el concepto de Incidencia Acumulada Estacional (SCI), referida a las poblaciones estimadas de las diferentes especies, tanto en el período de invernada como en la época de reproducción. Por lo tanto, mientras que el valor de la frecuencia permite una valoración cualitativa de las amenazas, la SCI, proporciona una aproximación cuantitativa del impacto potencial de cada factor en las poblaciones de cada especie y permite la comparación con los datos de otras zonas.

Los resultados del primer estudio evidencian que las causas antropogénicas son las más frecuentes, e incluyen tanto la persecución directa (disparos, envenenamiento, cautiverio ilegal o trampas), como causas indirectas (colisiones con vehículos, vallas o líneas eléctricas y la electrocución). Los traumatismos representaron la principal causa de ingreso con una frecuencia del 50%, en concordancia a la descrita en otros estudios (Morishita *et al.,* 1998; Deem *et al.,* 1998; Wendell *et al.,* 2002; Kommenou *et al.,* 2005; Kelly, 2006). La principales causas de traumatismos fueron de origen antropogénico, aunque la categoría más prevalente fue el traumatismo de causa desconocida. Este hecho se puede explicar por la falta de información en las anamnesis que impide determinar la causa del mismo. Uno de las observaciones más relevantes dentro de los traumatismos fue la prevalencia de casos debidos al disparo con arma de fuego (10% del total). Hay que destacar que las especies con la mayor SCI fueron *Accipiter gentillis* y *Falco peregrinus*, especies consideradas como competencia por los cazadores, indicando una persecución deliberada (Mañosa, 2002). La colisión contra vehículos, la segunda causa de traumatismo, afecta básicamente a rapaces nocturnas como *Athene noctua, Tyto alba* y *Strix aluco,* durante el período de reproducción y post-cría, lo que concuerda con otros estudios (Frías, 1999; Martínez y Zuberogoitia, 2004). Las electrocuciones (4 %) supusieron un porcentaje más alto que el previamente descrito en otras áreas (Wendell *et al.,* 2002; Deem *et al.,* 1998; Kommenou *et al.,* 2005), y las especies afectadas coincidían con los resultados de otros estudios realizados en Cataluña (Mañosa, 2001; Tintó *et al.,* 2010). *Bubo bubo* fue la especie con la mayor SCI por esta causa. Finalmente, la enfermedad parasitaria primaria más frecuente tanto en Falconiformes como en Strigiformes, fue la tricomoniasis, tal como han descrito otros autores (Wendell *et al.,* 2002).

El análisis de la evolución de las principales causas de morbilidad en los doce años de estudio mostró una disminución en la categoría de causa indeterminada, que podría ser una indicación de una mejora en la calidad de los protocolos de diagnóstico y de la experiencia profesional. Del mismo modo, el aumento de los casos ingresados por electrocución y la disminución de casos de captura ilegal podría estar relacionado con la mejora en la labor de las autoridades competentes en tareas de policía medioambiental. Por otra parte, el elevado número de casos de aves jóvenes huérfanas ingresadas en el centro podría estar relacionado con factores demográficos, como por el mayor grado de conocimiento de la ciudadanía sobre la existencia de los CRF. Otro hallazgo interesante fue que los ingresos por disparo se han mantenido estables a lo largo de los años, señalando las enormes dificultades del proceso de investigación policial.

Existen manuales o guías que contienen las directrices básicas sobre bienestar animal y protocolos de rehabilitación de aves rapaces salvajes (Miller, 2012). Sin embargo, el enfoque de la evaluación de la calidad de la atención al paciente, tal como se conoce en medicina humana, en los CRF está todavía en sus inicios. Por ello creemos que significa un avance para la rehabilitación de aves rapaces la novedad de informar de los resultados desde la perspectiva del control de calidad, analizando los resultados de la rehabilitación estratificados por causa, especie y signos clínicos. Además, establecer los parámetros básicos para poder valorar la calidad universal y adecuada para todos los CRF es de gran importancia para poder comparar los distintos estudios en un futuro. Este tipo de análisis aparece escasamente descrito en los trabajos revisados, ya que algunos autores priorizan las causas de ingreso (Richards *et al.,* 2005) o la especie (Harris y Sleeman, 2007), pero rara vez la combinación de ambas variables (Ferrer *et al.,* 1989; Ress y Guyer, 2004).

Basándose en los datos crudos del segundo y tercer estudios, es evidente que el balance global de la rehabilitación es negativo, con 52,8% de resultados de fracaso (que incluye la muerte natural, la eutanasia y las aves no recuperadas pero mantenidas en cautividad) y 47,2% de aves liberadas al medio natural. En la mayoría de estudios, se enfatiza como principal resultado la tasa de liberación (“release rate”, Rr) (Duke *et al.,* 1981; Fix y Barrows, 1990; Deem *et al.,* 1998.), sin diferenciar entre causas o entre especies y omitiendo la información sobre los otros tipos de resolución de los casos. Es evidente, que tanto desde el punto de vista de la gestión como del control de calidad, es necesario presentar los datos sobre tasas de liberación, de mortalidad (“unassisted mortality rate”, Mr), de eutanasia (“euthanasia rate”, Er) y de no recuperados o mantenidos en cautividad de por vida (“captivity rate”, Cr).

La eutanasia es una decisión esencial en cualquier protocolo de rehabilitación de fauna salvaje, y su justificación se basa tanto en criterios de bienestar animal, como económicos o legales (Sleeman, 2008; Redig *et al.,* 2007; Millsap *et al.,* 2007). En nuestro estudio, la Er global fue de 30,6%, y los valores más altos se produjeron en la categoría de trauma (34,2%), principalmente debido a las electrocuciones y colisiones con líneas eléctricas.

La Mr es un parámetro que se ha utilizado como indicador de calidad en medicina humana (Jiménez, 2004). Desafortunadamente, en otros estudios retrospectivos de CRF, este índice no se ha definido de forma homogénea, lo que hace difícil la comparación de los resultados. Por ejemplo, en algunos de ellos, dicha tasa incluye tanto la proporción de muertes naturales como la de animales eutanasiados (Deem *et al.,* 1998; Punch, 2001). Por lo tanto, este enfoque introduce un sesgo ya que se sobreestima la tasa real de muertes naturales. En nuestra opinión, la Mr y la Er se deben estimar por separado e incluir en los resultados generales.

La Mr según la causa de ingreso fue más elevada en las enfermedades infecciosas/parasitarias, básicamente debido a tricomoniasis, afectando sobre todo a *F. peregrinus, T. alba y S. aluco.* Por otro lado, la Mr estimada en función del sistema orgánico afectado en lugar de la causa de ingreso, fue superior al 50% en los casos de afectación primaria del sistema nervioso, sistema respiratorio, digestivo, o enfermedades infecciosas o parasitarias sistémicas.

La tasa de liberados, Rr, fue mayor en las categorías: aves jóvenes huérfanas, mantenidas en cautividad de forma ilegal, o procedentes de hallazgos fortuitos, ya que se trataba de animales con problemas leves de salud. Tal y como se había descrito en el sureste de Estados Unidos (Ress y Guyer, 2004), la Rr fue ligeramente mayor en las rapaces nocturnas que en las diurnas. Por último, la tasa de cautividad (Cr) merece una discusión especial, puesto que el destino de las aves que no pueden ser liberadas, depende tanto de los protocolos de bienestar animal, como de la legislación vigente en cada país y de las estrategias de conservación. Por lo tanto, la comparación de esta tasa podría ser inútil si los criterios de rehabilitación y las prioridades de conservación no se especifican en cada estudio. Así, en nuestro estudio, *F. naumanni* y *C. pygargus,* son destinados a proyectos de cría en cautividad y reintroducción, con lo que el número máximo de las aves no liberables fueron derivadas a la cautividad (Pomarol, 1990).

La duración de la estancia hospitalaria es un parámetro indicador de calidad de uso frecuente en medicina humana (OEDC, 2011). En la rehabilitación de rapaces salvajes, la decisión de cuándo liberar un animal se basa no sólo en criterios relacionados con el proceso de rehabilitación (estado de salud, condición física y comportamiento), sino también de factores externos (Arent, 2001). De hecho, las estancias más largas observadas en las aves ingresadas en otoño e invierno, se justifican tanto por las características climatológicas adversas como por la coincidencia con la temporada de caza. Por otra parte, algunas especies migratorias como *Circaetus gallicus, Pernis apivorus* o *Otus scops*, son mantenidas en el centro hasta la época de migración de la primavera siguiente. Como regla general, la duración de la estancia debería ser lo más breve posible con el fin de reducir el riesgo de muertes relacionadas con la cautividad (Cooper y Cooper, 2006).

El índice denominado "tiempo hasta la muerte" ("time to death", Td) proporciona una visión directa de la efectividad de los protocolos médicos y del proceso de toma de decisiones, como complemento de la comprensión de Mr y Er. El tiempo medio hasta la eutanasia fue de 1 día, lo significa que la decisión se tomó en el momento del ingreso. Este hecho permite la optimización de los recursos económicos y la reducción del sufrimiento innecesario del ave. Por otra parte, el tiempo medio de muerte fue de 2 días, incluso para el grupo de aves jóvenes huérfanas. Por último, es interesante destacar la utilidad de estimar las Mr, Er y Cr en aquellos casos con "tiempo hasta la muerte" por encima del P_{90}, como parámetros indicadores de un resultado inesperado, como consecuencia de complicaciones de los traumatismos y, especialmente, de enfermedades musculo-esqueléticas y alteraciones del comportamiento.

En conclusión, la definición de indicadores de calidad en los centros de rehabilitación de vida silvestre es un elemento necesario con el fin de proporcionar índices comparables que puedan conducir a una mejora de la misma. Por tanto, la información básica sobre los resultados de rehabilitación ha de incluir las tasas anteriormente descritas de mortalidad, eutanasia y cautividad indefinida, así como la duración de la estancia y el tiempo hasta la muerte. El análisis estratificado de los resultados considerando las causas primarias, la especie y los signos clínicos permite una primera evaluación de la calidad de la práctica de rehabilitación. Por otra parte, esta información puede ser útil para identificar en cada especie, los factores de riesgo relacionados que son esenciales para hacer estudios comparables e implementar protocolos de rehabilitación que sean útiles en todo el mundo.

Finalmente, se ha abordado el tema de los factores pronósticos en la rehabilitación de aves rapaces de vida libre, como punto crítico en la preparación de protocolos clínicos, teniendo en cuenta criterios de bienestar animal y de optimización de recursos económicos. Este tipo de estudio es todavía escaso en medicina de animales salvajes, a pesar de que los resultados de liberación rara vez superan el 50 % y que la tasa de supervivencia las primeras 48 horas es del 60% (Kirkwood, 2003). Los resultados del último estudio integrante de esta tesis indican como factores predictivos de mortalidad durante la primera semana de ingreso, la presencia de signos neurológicos y una concentración de sólidos totales inferior a 5mg/dl, en el grupo de aves adultas. Estos datos sugieren que es necesario realizar un examen neurológico completo en el momento del ingreso y aplicar pautas de rehidratación y nutrición clínica adecuadas.

Conclusiones

1. El cálculo de Incidencias Acumuladas Estacionales, aporta información adicional al estricto cálculo de frecuencias de causas de ingreso en los centros de rehabilitación de fauna salvaje (CRF); puesto que proporcionan una aproximación cuantitativa del impacto potencial de cada causa en las poblaciones de cada especie de rapaces, permitiendo la comparación de datos entre zonas.

2. En el área de estudio, las causas más frecuentes de ingreso de aves rapaces en el CRF de Torreferrusa son de tipo antropogénico, debidas tanto a una persecución directa (disparos, envenenamiento, cautiverio ilegal o trampas), como a causas indirectas (colisiones con vehículos, vallas o líneas eléctricas y electrocuciones).

3. La importancia de los disparos en las rapaces (10%), que no ha experimentado un descenso a lo largo del período de estudio, requiere un mayor control y persecución por parte de las autoridades competentes.

4. El incremento de huérfanos sanos, especialmente Strigiformes, ingresados en el CRF sugiere un aumento de la concienciación social hacia la protección de la fauna, pero se debería informar a la ciudadanía de no recoger pollos sanos y reducir así estos ingresos innecesarios.

5. La estimación individual de los siguientes parámetros: tasa de liberación, tasa de mortalidad no asistida, tasa de eutanasia, tasa de cautividad, tiempo de estancia en el centro previa a la liberación y tiempo hasta la muerte, es crítica para valorar el éxito de la rehabilitación, y debe permitir optimizar los recursos económicos y la mejora del bienestar animal.

6. El análisis estratificado de los resultados considerando las causas primarias de ingreso, la especie y los signos clínicos permite una primera evaluación de la calidad de la práctica de rehabilitación. De esta forma, es posible identificar los factores de riesgo relacionados con cada especie y proporcionar resultados comparables entre estudios, paso previo a la normalización de protocolos de rehabilitación de fauna salvaje.

7. La presencia de signos neurológicos y una concentración de sólidos totales inferior a 5mg/dl, se pueden utilizar como predictores de mortalidad de aves rapaces durante la primera semana de ingreso en el CRF. Estos datos sugieren la necesidad de realizar un examen neurológico completo en el momento del ingreso y aplicar pautas de rehidratación y nutrición clínica adecuadas para estos animales.

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Causes of admission of little owl (Athene noctua) at a wildlife rehabilitation centre in Catalonia (Spain) from 1995 to 2010.

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Causes of admission of little owl (*Athene noctua*) at a wildlife rehabilitation centre in Catalonia (Spain) from 1995 to 2010

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Abstract
*Causes of admission of little owl (*Athene noctua*) at a wildlife rehabilitation centre in Catalonia (Spain) from 1995 to 2010.*— This retrospective study analyzes the causes of morbidity of little owl (*Athene noctua*) admitted to the Wildlife Rehabilitation Centre of Torreferrussa from 1995 to 2010. A total *of* 1,427 little owls were included in the study, with an average of 89 cases per year (range: 73–116). As regards the sex category, 80.7% animals (1,152/1,427) were classified as undetermined gender, 9.1% (130/1,427) were sexed as females and 10.2% (145/1,427) as males. The overall age distribution according to the calendar year showed that 66.6% (951/1,427) of birds were '1st calendar year and 16.6% (237/1,427) were '> 1 calendar year'. Age could not be determined in 16.7% of birds. Primary causes of admission were orphaned young (53.2%), unknown trauma (24.7%), impact with motor vehicles (5.6%), other cause (5.5%), undetermined (3.7%), illegally captive (2.1%), natural diseases (2.1%), and gunshot (1.1%). Within the breeding season the frequency of admissions due to traumas –unknown trauma (χ^2 = 147.108; p < 0.001)– and impact with motor vehicles (χ^2 = 28.528; p < 0.001) and other cause (χ^2 = 11.420; p = 0.003) were the most important causes. In winter, admissions were mainly related to unknown trauma and gunshot. Over the fifteen years we observed a significant increase in the orphaned young category.

Key words: Little owl, Rehabilitation centres, Morbidity, Epidemiology.

Resumen
*Causas de la admisión de mochuelos comunes (*Athene noctua*) en un centro de rehabilitación de animales salvajes de Cataluña (España) desde el 1995 al 2010.*— Este estudio retrospectivo analiza las causas de morbilidad de los mochuelos comunes (*Athene noctua*) admitidos en el Centro de Recuperación de Fauna Salvaje de Torreferrussa desde 1995 a 2010. En este estudio se incluyeron un total de 1.427 mochuelos comunes, con un promedio de 89 casos por año (rango: 73–116). Con referencia a la categoría sexual, el 80,7% de los animales (1.152/1.427) se clasificaron como de género indeterminado, un 9,1% (130/1.427) como hembras, y un 10,20% (145/1.427) como machos. La distribución general de edades, calculadas en años naturales, mostraba que un 66,6% de las aves (951/1.427) tenían un año natural, y que el 16,6% (2.37/1.427) eran menores de un año. En el 16,7% de las aves no se pudo determinar la edad. Las principales causas de admisión fueron jóvenes huérfanos (53,2%), trauma desconocido (24,7%), impacto de vehículos a motor (5,6%), otras causas (5,5%), por causas indeterminadas (3,7%), cautividad ilegal (2,1%), enfermedades naturales (2,1%), y disparos (1,1%). Durante la estación de cría, la frecuencia de admisiones debidas a traumas –trauma desconocido (χ^2 = 147,108; p < 0,001) e impacto por vehículo a motor (χ^2 = 28,528; p < 0,001)– y otras causas (χ^2 = 11,420; p = 0,003), fueron las causas más importantes. En invierno, las admisiones se producían principalmente en relación con traumas desconocidos y disparos. Durante el periodo de 15 años observamos un aumento significativo en la categoría de jóvenes huérfanos.

Palabras clave: Mochuelo común, Centros de Recuperación, Morbilidad, Epidemiología.

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Introduction

Birds of prey and owls have become valuable sentinels of environmental changes because of their position on the ecological food chain (Kovács et al., 2008; Sergio et al., 2006). Moreover, identifying and understanding causes of the variation or decline of wildlife population is essential in order to implement conservation measures (Salafsky et al., 2008). Morbidity and mortality studies, including those based on data from wildlife rehabilitation centres (WWC), have complemented the understanding of menaces posed to raptors by identifying the underlying natural and anthropogenic factors. WWCs have therefore become a key data source, providing valuable information concerning the health of ecosystems (Sleeman, 2008).

The population of free–living little owls (*Athene noctua*) in Europe is considered to be in moderate decline (Burfield, 2008). The decrease has been related to changes in their habitat, resulting in a fragmented and isolated breeding population (Exo, 2005). Catalonia is an Autonomous Community in Spain located in the Mediterranean subregion of the western Palaearctic (3º 19'–0º 9' E and 42º 51'–40º 1' N). Eight different owl species have been observed in this area, most of them being breeding species (Estrada et al., 2004). In Catalonia, a decrease in their distribution area has also been reported and the little owl is considered near threatened (Framis, 2011).

Epidemiological studies of little owl focusing on morbidity and mortality are scarce (Hernández, 1988), especially those covering a long period of time. The objective of the present study was to analyze the main causes of morbidity and mortality of the little owl population admitted to the Wildlife Rehabilitation Centre of Torreferrussa (Catalonia) over a fifteen–year period.

Methods

Study design and animals

A retrospective unicentric study was performed using the original medical records of wild little owls hospitalized at the Wildlife Rehabilitation Centre of Torreferrussa (Catalonia, North–East Spain) from 1995 to 2010. Non–wild born individuals and cases with no epidemiological information were excluded from the analysis.

Definition of variables

The following variables were included in the analyses: species, sex, age, date and primary cause of admission. Sex was determined when possible by gonadal inspection during clinical diagnostic procedures or at necropsy. Age was categorized as '1st calendar year' and '> 1 calendar year' according to Martínez et al. (2001). The year was divided into three seasons: breeding (from March to July), post–nuptial migration (from August to October) and wintering (from November to February), according to Herrando et al. (2011).

General classification of primary morbidity and mortality causes was adapted from the categories defined by different authors (Morishita et al., 1998; Wendell et al., 2002; Naldo & Samour, 2004) and were based on definitive diagnoses, as follows: trauma, toxicosis, infectious and parasitic diseases, metabolic or nutritional diseases, orphaned young birds, and undetermined. The metabolic, nutritional, infectious, and parasitic categories were grouped as natural disease. The overall trauma category was subdivided into specific causes as follows: collision, electrocution, gunshot, trap, predation and unknown trauma. Collision traumas were further subdivided into impacts with motor vehicles, buildings, power lines, fences and other. The orphaned young category was composed of chicks and fledging raptors, and also included healthy young birds that were unable to survive in the wild unassisted.

Two further causes, illegal captivity and other causes, were used. Basically, the illegal captivity category referred to wild birds maintained illegally in captivity for more than six months. 'Other causes' was considered when no medical primary cause could be attributed; this category included animals found inside buildings, farms or other human structures, animals with dirty feathers, animals entangled by plants or found wet or disoriented after storms.

Clinical diagnoses were based on veterinarians´ reports and case history. These included physical examination at the time of admission and data from complementary diagnostic tools.

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). χ^2 test was used to compare proportions when appropriate. Causes were analyzed for variations between gender, age and differences within the year or among different years of the study. Trend analyses were applied when appropriate for specific causes to detect differences among years.

Results

A total of 1,427 birds were included in the study, with an average of 89 (SD = 13.2; range 73–116) cases per year. Most animals (94.8%, n = 1,352) were alive on admission to the Centre.

As regards the sex category, most animals, 80.7% (n = 1,152), were classified as undetermined gender, 9.1% (n = 130) were sexed as females and 10.2% (n = 145) as males. The overall distribution of age according to the calendar year showed that 66.6% (n = 951) of the birds were within the '1st calendar year', 16.6% (n = 237) '> 1 calendar year', and the age was unknown for 16.7% (n = 239) of the birds. Seventy–six percent (n = 999) of the admissions were derived from regions near the rehabilitation centre, mainly from the province of Barcelona (North–East Spain, 3º 19'–0º 9' E and 42º 51'–40º 31' N).

The most frequent causes of admission were orphaned young, 53.2% (n = 759), and unknown trauma,

Table 1. Causes of little owl admission according to sex and age: 1cy. 1st calendar year; > 1cy. > 1 calendar year; Unk. Unknown.

Tabla 1. Causas de admisión de mochuelos comunes, según el sexo y la edad. (Para las abreviaturas, ver arriba)

	Sex			Age		
Cause of admission	Female	Male	Unk	1cy	> 1cy	Unk
Gunshot	2	4	9	2	7	6
Illegally captive	1	3	26	10	11	9
Impact with motor vehicles	11	8	61	29	28	23
Natural disease	7	6	17	12	13	5
Orphaned young	28	39	692	729	9	21
Other	5	3	20	12	9	7
Undetermined	2	11	40	11	12	30
Unknown trauma	64	67	222	115	122	116
Other cause	10	4	65	31	26	22
Total	130	145	1,152	951	237	239

24.7% (n = 353). In decreasing order of frequency, the other primary causes were: trauma with motor vehicles, 5.6% (n = 80); other cause, 5.5% (n = 79); undetermined, 3.7% (n = 53); , illegally captive, 2.1% (n = 30); natural diseases, 2.1% (n = 30); and gunshot 1.1% (n = 15). Other causes included 56 cases found inside buildings, 14 of them trapped in chimneys. Causes with frequencies below 1% have been grouped in a whole category named 'others' (2%), which included animals suffering from predation (n = 6), trauma with building (n = 8), traps (n = 4), electrocution (n = 4), or fences (n = 6). No cases of intoxication were diagnosed. Table 1 summarizes the diagnostic categories by sex and age.

Differences between gender and age were analysed for causes in more than 15 cases: orphaned young, unknown trauma, trauma with motor vehicles, illegally captive, natural diseases and other causes. Significant differences between genders was only observed in the undetermined category (χ^2 = 5.567; df = 01; p = 0.018), with a higher frequency of males. For age–related comparisons, after removing the orphaned young category (which included all individuals at the 1st calendar year), from the analysis we did not observe any differences between ages in any of the admission categories.

As regards the seasonal effect on the prevalence of morbidity causes, we observed that the highest number of orphaned young cases was concentrated during the breeding period, as expected (table 2). Moreover, within the breeding season, the frequency of admissions due to traumas –unknown trauma (χ^2 = 147.108; p < 0.001) and impact with motor vehicles (χ^2 = 28.528; p < 0.001)– and 'other causes' (χ^2 = 11.420; p = 0.003) were the most important causes. During the post–nuptial migration period, we observed an increase in cases admitted due to traumatisms, but we also had the lowest prevalence of illegally captive animals. Finally, in the winter, cases were mainly related to unknown trauma and gunshot.

Trend analyses of the morbidity causes over the fifteen years of the study revealed a significant increase in the orphaned young category (Test of trend Z = 2.9; p = 0.003).

Discussion

Epidemiological studies of wildlife based on review of the morbidity and mortality reports of free–living animals admitted to rehabilitation centres are an important source of information about the health status and non–natural menaces of wild populations (Sleeman & Clark, 2003). Many such studies, however, may be biased due to lack of randomization or overrepresentation of anthropogenic casualties (Real et al., 2001; Newton, 2002). Moreover, reports on owl morbidity and mortality in Spain are scarce (Fajardo, 1990; Fajardo et al., 1994; Martínez et al., 2006), specifically those including little owl casualties (Martínez et al.,1996). The originality of the data presented in the present study is based on the large series of cases of little owl and the long study period.

Anthropogenic origin has been confirmed as the most frequent cause of admission, ranging from direct persecution (gunshot, illegal captivity or traps) to involuntary human–induced threats such as collisions with vehicles or buildings, fences, electrocution and other causes.

The most evident finding in the present study was the high proportion of young orphaned birds admitted to the centre. They represented 53% of the total cases and furthermore, the number tended to increase over

Table 2. Causes of little owl admissions over the year.

Tabla 2. Causas de admisión de mochuelos comunes durante el año.

	Season			Total
Cause of admission	Breeding	Migration	Wintering	N
Gunshot	3	1	11	15
Illegally captive	14	6	10	30
Impact with motor vehicles	42	28	10	80
Natural disease	19	9	2	30
Orphaned young	713	40	6	759
Others	17	6	5	28
Undetermined	35	15	3	53
Unknown trauma	182	93	78	353
Other cause	47	18	14	79
Total	1,072	216	139	1,427

the study period (1995 to 2010). This value is higher than that reported by Martínez et al. (30.4%, n = 79) in 1996. One explanation may be that t the region of our study has a high human population density and there has been a marked transformation of land. Nesting of little owls in this area occurs in a variety of sites, such as buildings, roof tiles, rock piles and cavities of trees. Thus, when chicks and fledging owlets become 'branchers' and climb around the nest they are more likely to be found and brought to the wildlife rehabilitation centres. Education and information programmes need to be implemented to reduce the capture of those birds unless it is confirmed they have been deserted by the parents or if signs of illness are evident.

Trauma was the second cause of admission, but unknown trauma still remains the most important category in this group. To solve these limitations of classification, information should be systematically collected at the centres at the time of admission whenever possible. Impact with motor vehicles was the second traumatic cause with 5.6% of prevalence, but lower than the 10% (n = 26) reported by Martínez et al. (1996). The highest incidence of collisions was observed during the breeding and post–breeding period, coinciding with results reported by Hernández (1988) and Frías (1999). Vehicle strikes have also been widely described in Catalonia by Baucells (2010) and are one of the most important causes of human–induced mortality in Europe (Van Nieuwenhuyse et al., 2008).

Although the number of cases is very low, we recorded six cases of electrocution, a finding rarely reported in this species. Despite the size of the little owl, its perching behaviour could be considered a risk factor for electrocution, especially in low power lines.

Even though owls are a legally protected species in Catalonia (Departament de la Presidència, 2008), we found 15 cases of gunshot, most of which occurred during the winter hunting season (12/15). Although incidental hunting could be a reasonable explanation for this finding, deliberate persecution could not be discarded, as suggested by Mañosa (2002).

The third cause of admission was the 'other cause' category, which comprised birds found inside buildings or other human constructions. Trappings in chimneys and immersions in water ponds are well documented causes of mortality in Europe (Van Nieuwenhuyse et al., 2008) and seem related to the vicinity of little owl territories to human settlements, allowing animals incidental visits to the buildings. In our report, most little owls found inside buildings were found alive but they had poor body condition and feather damage, resulting in worse clinical prognosis.

Illegal captivity of wild little owls is still a cause of admission in rehabilitation centres in Spain (Martínez et al., 1996). Such little owls were probably, captured when young and maintained as pets in captivity. Natural diseases, such as metabolic, nutritional, infectious, or parasitic diseases, made up a miscellaneous list of clinical entities. Data on live birds from rehabilitation centres allow the description of primary or secondary natural diseases. In mortality studies, natural causes of death are underestimated due to the decomposition of the carcasses (Newton et al., 1999). In our study, the most frequent primary clinical presentation was poor body condition and weakness, followed by ocular alterations. No cases of intoxication were diagnosed, but this cause has probably been underestimated in our review. Further investigation is necessary to ascertain the relevance of this cause. Finally, the proportion of undetermined causes presented similar values to those in other retrospective works (Kommenou et al., 2005), demonstrating that the limitation of obtaining a specific diagnosis in wild birds remains, a subject of concern.

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