

# Causes of admission and mortality in European Hedgehog (*Erinaceus europaeus*, Linnaeus, 1758) – a review



A. Garcês\* and I. Pires

## Abstract

*Erinaceus europaeus*, a key indicator species for health ecosystems, faces various threats that impact the survival of the species. Most factors of threat are associated with human activity. The authors present a review of *E. europaeus* admission causes in wildlife rehabilitation centres and the mortality pattern of free-ranging animals. The review includes 20 papers spanning a considerable timespan from 1981 to 2024. The main causes of admission to wildlife rehabilitation centres are

hoglets and starvation. The main causes of death in hedgehogs are vehicle collision and predation. It can be concluded that humans and human activity play a significant role in the mortality of these animals. In the future, a more standardised analysis of hedgehog carcasses is necessary to understand their threats and diseases and to design significant measures to protect the species.

**Key words:** *Erinaceus europaeus*; mortality; roadkill; disease; endangered

## Introduction

*Erinaceus europaeus* (Linnaeus, 1758), the European hedgehog, is a small nocturnal mammal belonging to the family *Erinaceidae* that is native to Europe, from the Iberian Peninsula to Scandinavia and even parts of Russia (Amori, 2016; Lukešová et al., 2021). Hedgehogs are known for their spiny coat, which serves as protection against predators. They primarily feed on insects, worms, snails, and other small invertebrates (Rautio, 2009; Haigh et al., 2014; Efendić et al., 2019). They hibernate to conserve ener-

gy during colder periods from late September/October to around mid-April/May (Hernández, 2020; Rasmussen et al., 2019a). They may live to more than ten years of age, although the average life expectancy is three years, and they are found in both rural and urban areas (Zare and Ghorbani-Choboghlo, 2015). According to the IUCN Red List of Threatened Species, the conservation status has been assessed as Least Concern (Amori, 2016), although in some regions, such as the UK, a decline has been

Andreia GARCÊS\*, DVM, MSc, PhD Exotic and Wildlife Service at the University of Tras-os-Montes and Alto Douro; Centre for Research and Technology of Agro-Environmental and Biological Sciences, CECAV, University of Tras-os-Montes and Alto Douro, Vila Real, Portugal (Corresponding author, e-mail: andreamvg@gmail.com); Isabel PIRES, DVM, MSc, PhD CECAV, University of Tras-os-Montes and Alto Douro, Vila Real, Portugal

observed in some populations (Rasmussen et al., 2019a).

Human activity has a significant impact on *E. europaeus*. Urbanisation and habitat fragmentation lead to the loss and degradation of hedgehog habitats, limiting their foraging areas and breeding grounds (Bearman-Brown and Baker, 2022). Additionally, road traffic poses a considerable threat, causing numerous hedgehog fatalities each year as they attempt to navigate fragmented landscapes. Pollution, including pesticides and chemical contaminants, can adversely affect hedgehog health, while encounters with domestic pets, such as cats and dogs, may result in injury or predation (Garcés et al., 2020a; Molina-Lopez et al., 2024). Molluscicide and rodenticide poisoning are also common (Dowding et al., 2010a). Climate change further exacerbates these challenges, altering habitat suitability and affecting prey availability. Understanding the consequences of human activities on hedgehog populations is crucial for implementing conservation measures to mitigate these threats and ensure the persistence of this iconic species in the face of ongoing environmental change (Kristiansson, 2009; Hubert et al., 2011; Hernández, 2020).

Understanding the admission causes and mortality patterns in *E. europaeus* is vital for effective conservation efforts (Crespo Martínez et al., 2014). By identifying the primary threats leading to hedgehog admissions and mortality, conservationists can target interventions to mitigate these risks and protect populations. Whether caused by habitat fragmentation, road traffic accidents, or disease, analysing these patterns informs the development of tailored conservation strategies, such as implementing wildlife corridors, erecting

road signage, promoting responsible pet ownership, and enhancing habitat management practices (Rasmussen et al., 2019; Hernández, 2020). Moreover, monitoring changes in admission causes and mortality patterns over time provides valuable insights into the health of hedgehog populations and their ecosystems, enabling adaptive management strategies to address emerging threats and support the long-term survival of this iconic species (Dowding et al., 2010b; Garcés et al., 2020b; Gama, 2023).

This study aims to improve the knowledge of *E. europaeus* by reviewing admission causes in wildlife rehabilitation centres and the mortality patterns of free-ranging animals.

## Materials and methods

A literature review was performed to determine the pattern of causes of admission and mortality of free-ranging European hedgehogs. The initial search included terms such as "hedgehog," "*Erinaceus europaeus*," "causes of admission," "small mammal," "Erinaceidae," "wildlife rehabilitation centre," "causes of death," "mortality," and "morbidity," resulting in a total of 350 articles from digital databases ResearchGate, Google Scholar and PubMed. Only articles providing detailed information on causes of admission and mortality in free-ranging European hedgehogs were considered as inclusion criteria. After screening abstracts, 100 articles were excluded based on the animals studied (57 articles were excluded because they did not focus on free-ranging hedgehogs), limited access to full text (Hubert et al., 2011), and duplicate studies (Burroughes et al., 2021). The final selection comprised 20 articles considered suitable for inclusion in this review, which was divided into two

**Table 1.** Distribution of the admission causes among *Erinaceus europaeus* in European countries, detailing the total number of animals (N) reported in the papers and causes of admission

Country	Year	N	Causes of admission													Ref		
			Hoglet	Starvation and exhaustion	Roadkill	Awakened hibernator	Injury from another animal	Infectious disease	Fall pits, traps, intrusions	Injuries	Accidentally found	Rescue transfer	Weather extremes	Poisoning	Other causes		Trauma unknown	Illegal captivity
<b>Czech Republic</b>	2010-2018	16,967	10,170	1558	614	674	728	332	319	742	644	24	30	53	1079	0	0	(Lukešová et al., 2021)
<b>Germany</b>	2022	370	0	0	0	0	0	0	370	0	0	0	0	0	0	0	0	(Berger, 2024)
<b>Spain</b>	1995-2020	3397	1319	0	0	0	571	0	624	0	0	0	0	0	280	456	0	(Molina-Lopez et al., 2024)
<b>Denmark</b>	2016	697	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(Rasmussen et al., 2019)
<b>Finland</b>	2004-2005	253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(Rautio et al., 2016)
<b>France</b>	2019-2020	35	0	14	0	0	0	0	6	0	0	0	0	0	2	13	0	(Zacharopoulou et al., 2022)
<b>Portugal</b>	2002-2019	740	197	228	0	0	0	0	138	0	0	0	0	0	0	0	0	(Garcés et al., 2020b)
<b>UK</b>	2005-2017	300	122	97	0	0	16	0	0	0	0	0	0	0	0	65	0	(Burroughes et al., 2021)
<b>Spain</b>	2009-2013	490	95	0	26	0	30	0	200	0	0	0	0	0	46	26	40	(Crespo Martínez et al., 2014)

**Table 2.** Sex, age, and season by admission causes among *Echinaceus europaeus* in European countries, detailing the total number of animals (N) reported in the papers (n/a – no information available)

Country	N	Season				Sex			Age		Ref
		Winter	Summer	Spring	Autumn	Male	Female	Adult	Juvenile		
<b>Czech Republic</b>	16,967	4404	833	7827	7474	n/a	n/a	n/a	n/a	[Lukešová et al., 2021]	
<b>Germany</b>	370	26	87	167	88	5633	4224	8754	8213	[Berger, 2024]	
<b>Spain</b>	3397	n/a	n/a	n/a	n/a	1441	1381	1207	1952	[Molina-Lopez et al., 2024]	
<b>Denmark</b>	697	n/a	n/a	n/a	n/a	177	109	n/a	n/a	[Rasmussen et al., 2019]	
<b>Finland</b>	253	n/a	n/a	n/a	n/a	87	63	81	62	[Rautio et al., 2016]	
<b>France</b>	35	5	5	9	16	18	17	n/a	n/a	[Zacharopoulou et al., 2022]	
<b>Portugal</b>	740	56	272	244	165	43	47	49	155	[Garcés et al., 2020b]	
<b>UK</b>	300	n/a	n/a	n/a	n/a	n/a	n/a	100	200	[Burroughes et al., 2021]	
<b>Spain</b>	490	n/a	n/a	n/a	n/a	81	n/a	207	143	[Crespo Martínez et al., 2014]	

**Table 3.** Distribution of the mortality causes among *Erinaceus europaeus* in European countries, detailing the total number of animals (N) reported in the papers

Country	Year	N	Causes of mortality											Ref		
			Wounds from robotic lawnmowers and other machines	Roadkill	Infectious diseases	Attack from other animals	Other causes	Trauma unknown	Drowning	Starvation	Trapping	Poisoning	Winter mortality			
Germany	2022	75	1	0	0	0	0	0	0	0	0	0	0	0	0	(Berger, 2024)
Ireland	2008-2010	133	0	1	0	0	0	0	0	0	0	0	0	0	0	(Haigh et al., 2014)
UK	1976-1986	74	1	1	1	0	0	0	0	0	0	0	0	0	0	(Keymer et al., 1991)
Czech Republic	2010-2019	4826	0	1	0	1	0	0	0	0	0	0	0	0	0	(Lukešová et al., 2021)
Denmark	2016	697	0	1	1	0	1	0	0	0	0	0	0	0	0	(Rasmussen et al., 2019b)
Finland	2004-2005	54	0	1	1	1	1	1	1	1	0	0	0	0	0	(Rautio et al., 2016)
France	2019-2020	35	0	1	1	1	0	0	1	0	0	0	1	0	0	(Zacharopoulou et al., 2022)
Portugal	2002-2019	740	0	1	1	1	1	1	1	1	1	1	1	0	0	(Garcês et al., 2020b)
Poland	2001-2003	75	0	1	0	0	0	0	0	0	0	0	0	0	1	(Orłowski and Nowak, 2004)
Sweden	1972-1979	151	0	1	0	0	0	0	0	0	0	0	0	0	0	(Kristiansson, 1990)
UK, Netherlands	1999	83,580	0	1	1	1	1	1	0	0	0	0	0	1	0	(Reeve and Huijser, 1999)
UK	1988	109	0	1	0	0	1	0	0	0	0	0	0	0	0	(Dickman, 2009)
UK	1981	22	0	1	0	1	1	1	0	0	0	0	0	1	0	(Reeve, 1981)
UK	1992	8	0	1	0	1	1	1	0	0	0	0	0	1	0	(Burroughes et al., 2021)
UK	2019	7	0	1	1	1	1	0	0	0	0	0	0	0	0	(Yarnell et al., 2019)
UK	1998	7	0	1	1	1	1	1	0	0	0	0	0	0	0	(Reeve, 1998)
Finland	2016	106	0	1	1	1	1	1	1	0	0	0	0	0	0	(Rautio et al., 2016)
Denmark	2019	9	0	0	1	1	1	1	1	0	0	0	0	0	1	(Rasmussen et al., 2019b)

main sections – admission causes and mortality (Page, 1976).

## Results

### Causes of admission

A total of 10 papers were included in this review regarding the causes of admission of *E. europaeus* to wildlife rehabilitation centres (WRC) from 2016 to 2024. Table 1 describes the main causes of admission for each study. A total of 23249 animals in nine European countries were admitted to WRCs. The main causes of admission were hoglets ( $n=11,903$ ), starvation and exhaustion ( $n=1897$ ), and accidentally found ( $n=1612$ ). Table 2 presents information on the age, sex and season of the animals admitted. Not all articles had that information available in the text but based on the data available, most animals were male ( $n=7480$ ) or juveniles ( $n=10,725$ ). Spring ( $n=8247$ ) and autumn

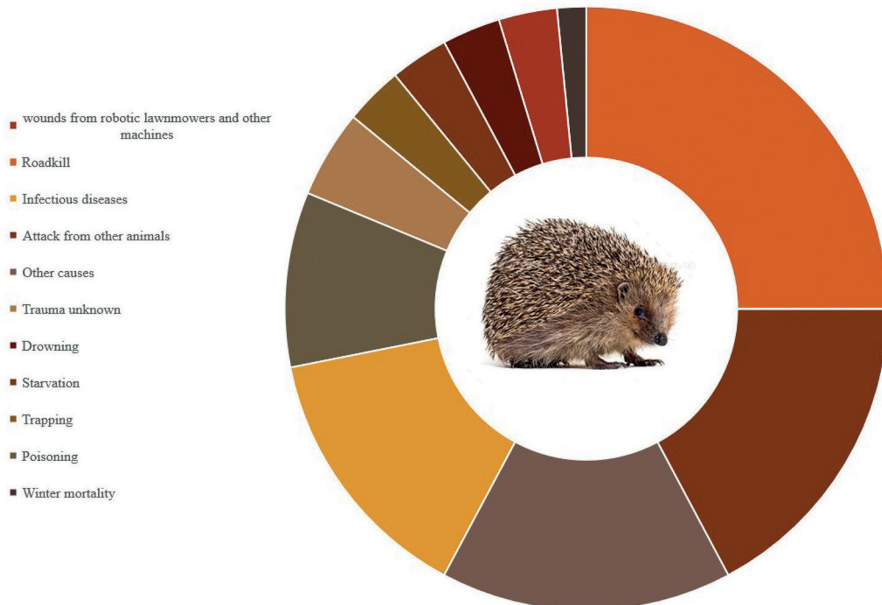
( $n=7743$ ) where the seasons were most animals have been admitted.

### Causes of mortality

A total of 18 papers included in this review examined the causes of mortality of *E. europaeus* from 1981 to 2024. Table 3 describes the main causes of death for each study.

Studies were collected from 11 European countries: the UK ( $n=7$ ), Finland ( $n=2$ ), Denmark ( $n=2$ ), Germany ( $n=1$ ), Netherlands ( $n=1$ ), Ireland ( $n=1$ ), Poland ( $n=1$ ), Portugal ( $n=1$ ), France ( $n=1$ ), Sweden ( $n=1$ ), and Czech Republic ( $n=1$ ).

The major causes of mortality described in the different papers were as follows: roadkill ( $n=16$ ), attack from other animals ( $n=11$ ), other causes ( $n=10$ ), infectious diseases ( $n=9$ ), poisoning ( $n=6$ ), trauma unknown ( $n=3$ ), wounds from robotic lawnmowers and other machines ( $n=2$ ), drowning ( $n=2$ ), starvation ( $n=2$ ), trapping ( $n=2$ ), and winter mortality ( $n=1$ ) (Figure 1).



**Figure 1.** Distribution of mortality studies worldwide in *Erinaceus europaeus*

## Discussion

*E. europaeus*, a key indicator species for health ecosystems, faces various threats that impact its survival (Cahill et al., 2011; Lawson et al., 2018). This very adaptive species can be found in urban and non-urban environments and is facing declines in some regions due to human-induced factors (e.g., roadkill, poisoning), habitat destruction, and pollution (Dowding et al., 2010a; Rasmussen et al., 2019b). Hedgehogs are one of the most common mammals admitted to WRCs in Europe, due to human empathy and the ease with which they can be captured (Molina-Lopez et al., 2024).

Admission causes and mortality studies in hedgehogs play a vital role in understanding the factors influencing wild populations, identifying key threats, and understanding population dynamics (Yarnell et al., 2019). They are important for future conservation efforts to ensure the long-term survival of the species (Reeve, 1998, 1981). This review paper examined the literature to identify trends in admission causes of *E. europaeus* to WRC and mortality causes.

Studies included in this review included 20 papers span a considerable timeframe from 1981 to 2024. The geographical analysis of the studies shows a wide distribution across European countries, with the UK having a higher number of studies ( $n=8$ ) (Reeve, 1998, 1981; Reeve and Huijser, 1999), indicating the importance of hedgehogs. Unfortunately, there are many data gaps. The number of animals admitted to WRCs throughout Europe is likely much higher, as many centres cannot document extensively or report this information as they are too busy caring for the hedgehogs, whose welfare comes before documentation (Berger, 2024).

Although the data was not included in this review, the studies analysed suggest that the admission of animals to sanctuaries and WRCs has been increasing in recent years all over Europe. This phenomenon can be associated with an increase in awareness and willingness of people to deliver injured animals to WRCs or as a result of anthropogenic activities (e.g. increase in urbanisation, road construction, climate change) (Lukesova et al., 2022).

More than 80% of animals were admitted during spring ( $n=8247$ ) or autumn ( $n=7743$ ) (Molina and Darwich, 2011; Grogan and Kelly, 2013; Crespo Martínez et al., 2014; Garcês et al., 2020b; Grogan and Kelly, 2013; Lukesova et al., 2022), with a decline in admissions in winter. Both spring and autumn are periods of significant environmental change, with fluctuations in temperature, precipitation, and food availability. Hedgehogs may face challenges adapting to these changes, leading to stress-related health issues or difficulties finding sufficient nourishment (Reeve, 1981; Rasmussen et al., 2019b). Spring is the breeding season for hedgehogs, during which they become more active in their search for mates. This increased activity can lead to a higher likelihood of encountering hazards such as road traffic or getting trapped in urban areas, resulting in injuries or other issues requiring rehabilitation (Bearman-Brown et al., 2020). In both seasons, juveniles emerge from their nests and venture out on their own and may struggle to find adequate food sources or suitable shelter, increasing their vulnerability to injury or illness (Crespo Martínez et al., 2014). Human activity, such as landscaping or agricultural practices, may also play a role in hedgehog admissions during these seasons. For example, spring and autumn

are times when garden maintenance, construction, and harvesting activities are common, increasing the likelihood of hedgehogs encountering hazards such as machinery, pesticides, or garden tools (Rasmussen et al., 2021). Regarding sex, more males ( $n=7480$ ) were admitted. This is expected since male hedgehogs tend to have larger home ranges and may wander more extensively in search of food, mates, or territory. This increased mobility can expose them to a greater number of hazards such as road traffic, urban development, or encounters with predators, resulting in injuries or other issues requiring rehabilitation (Morris et al., 1993; Rasmussen et al., 2019b, 2021).

The main objective of hedgehog rehabilitation is release in the wild, which was seen in around 40% according to studies conducted in Portugal (66%) (Garcés et al., 2020b), Czech Republic (44.39%) (Lukešová et al., 2021), and Spain (69%) (Crespo Martínez et al., 2014; Molina-Lopez et al., 2024). Unassisted mortality is around 30% in studies conducted in Portugal (33%) (Garcés et al., 2020b), Czech Republic (25%) (Lukešová et al., 2021), or Spain (28%). The number of hedgehogs admitted to WRCs may vary depending on the selected criteria on which the authors based the classification of animals into individual admission groups (Rautio et al., 2009). The authors try to create categories to homogenise the information collected. The main causes of admission were hoglets ( $n=11,903$ ). As in other wildlife species (e.g., fawn), young wildlife are often removed from the wild and brought to WRC unnecessarily due to public ignorance. The general public may often consider a young animal found on its own to be abandoned, even if it is not (Lukesova et al., 2022; Molina-Lopez et al., 2024). Nevertheless, in

some cases, human help is needed, such as injured hoglets or those born in the first litter of very young inexperienced females, as these young are particularly vulnerable (Garcés et al., 2020b; Zacharopoulou et al., 2022). The second most common cause of admission was starvation and exhaustion ( $n=1897$ ). Juveniles and weak or injured individuals are the most affected (Morris et al., 1993). Hedgehogs require a steady supply of food to maintain their energy levels and body condition, especially during periods of high activity such as the breeding season or when dispersing to new territories. However, various factors can contribute to hedgehogs becoming malnourished and fatigued. Habitat loss and fragmentation limit access to suitable foraging areas, forcing hedgehogs to travel longer distances in search of food (Reeve, 1998; Hubert et al., 2011). Additionally, changes in land use practices and the use of pesticides in agricultural areas can reduce the availability of prey species, further exacerbating food scarcity for hedgehogs. In urban environments, hedgehogs may encounter human-related hazards such as litter, garden netting, and contaminated water sources, which can hinder their ability to find food and lead to starvation. Furthermore, injuries or illnesses can impair hedgehog mobility and foraging abilities, making it difficult for them to meet their nutritional needs (Morris et al., 1993; Kadlec and Schwarz, 2008).

In 18 papers, it was observed that the main cause of death was roadkill ( $n=16$ ). Collisions with traffic are often fatal for hedgehogs or cause serious injuries to the limbs and head (Mullineaux and Keeble, 2016; Orłowski and Nowak, 2004). Hedgehogs are nocturnal creatures that often travel considerable distances at night in search of food, mates,



and suitable habitat. Unfortunately, their natural behaviours bring them into proximity to roads, where they are at risk of being struck by vehicles (Coffin, 2007; Orłowski and Nowak, 2004). Most collisions occur in summer, which is the peak of hedgehog activity in urban areas and on sites with dense vegetation along roads and barriers (Coffin, 2007; Haigh et al., 2014). The second most common cause of mortality was attack by other animals ( $n=11$ ). Hedgehogs, while equipped with defensive spines, are not immune to predation, especially when they are injured, sick, or vulnerable due to other factors. In urban areas, they can encounter domestic animals such as dogs or cats, increasing the risk of predation. Other wild animals such as foxes, badgers or birds of prey can also predate on hedgehogs (Cahill et al., 2011; Lukešová et al., 2021). Disease and parasitism further exacerbate mortality rates, with hedgehogs susceptible to various pathogens and parasites that compromise their health and resilience.

## Conclusions

Understanding hedgehog mortality and the causes of admission to WRCs is crucial for effective conservation efforts and the preservation of hedgehog populations. By analysing mortality patterns and admission data, conservationists can identify the primary threats facing hedgehogs, such as road traffic accidents, habitat loss, predation, and disease. This information enables targeted conservation strategies, including the implementation of wildlife corridors, road signage, habitat restoration, and public education campaigns aimed at reducing human-induced threats and promoting hedgehog welfare. Moreover, monitoring trends in mortality and ad-

mission causes over time provides valuable insights into the health of hedgehog populations and their ecosystems, facilitating adaptive management strategies to address emerging challenges and ensure the long-term survival of these iconic mammals.

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## Uzroci prijema i smrtnosti europskog ježa (*Erinaceus europaeus*, Linnaeus, 1758) – pregledni članak

Andreia GARCÊS\*, DVM, MSc, PhD Exotic and Wildlife Service at the University of Tras-os-Montes and Alto Douro; Centre for Research and Technology of Agro-Environmental and Biological Sciences, CECAV, University of Tras-os-Montes and Alto Douro, Vila Real, Portugal; Isabel PIRES, DVM, MSc, PhD CECAV, University of Tras-os-Montes and Alto Douro, Vila Real, Portugal

*Erinaceus europaeus*, je jedna od ključnih indikatorskih vrsta zdravog ekosustava, koja je izložena različitim prijetnjama koje utječu na njezino preživljavanje. Većina čimbenika koji prijete ovoj vrsti je povezana s ljudskom aktivnošću. Autori predstavljaju pregled uzroka prijema *E. europaeus* u Centre za rehabilitaciju divljih životinja i obrazac smrtnosti životinja koje žive na slobodi. Studije uključene u ovaj pregled uključuju sveukupno 20 različitih radova koji pokrivaju dugo vremensko razdoblje od 1981. do 2024. godine. Glavni uzroci

prijema u centre za rehabilitaciju divljih životinja su mladunci i glad. Glavni uzroci smrti ježeva su sudari s vozilima i predatori. Moguće je zaključiti da ljudi i ljudske aktivnosti imaju značajnu ulogu u smrtnosti ovih životinja. U budućnosti će biti potrebna standardizirati analizu leševa ježeva da bi se saznalo što im prijete, koje su njihove bolesti, da bi se osmislile potrebne mjere za njihovu zaštitu.

**Ključne riječi:** *Erinaceus europaeus*, smrtnost, pregažena životinja, bolest, ugrožen