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Hedgehogs under Pressure, the Role of Rodenticides on Their Decline

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Abstract: *Erinaceus europaeus*, commonly known as the Western European hedgehog, is a well-known and widespread mammal in Europe. These small spiny mammals are insectivores and play a significant role in controlling invertebrate populations. However, they face several threats, including habitat loss, road accidents, and encounters with certain chemicals, including rodenticides. Rodenticides are chemical agents used to kill rodents. These compounds are often designed to be attractive to rodents but can also be consumed by other animals, including hedgehogs, either directly or through the ingestion of poisoned prey. Unfortunately, secondary poisoning through the consumption of poisoned rodents is a significant risk for hedgehogs and other non-target species. The ingestion of rodenticides can lead to severe health issues and even death. This brief review aims to present the impact that rodenticides have on European hedgehogs (*European Erinaceus*, Linnaeus 1758).

Keywords: Erinaceus europaeus, mammals, rodenticide, pollution.

REVIEW PAPER

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INTRODUCTION

Rodenticides are the most used pesticides around the world to combat rodent pests. They have been available on the market for over 60 years in different forms and different compositions (Walker *et al*., 2008). They are divided into first (FGAR) and second generation (SGAR), with SGARs having greater toxicity, higher mortality rates and slower elimination rates from the organism and ecosystem (Badry *et al*., 2022; Walker *et al*., 2008). Its mechanism of action is based on inhibiting the vitamin K cycle in the liver, preventing blood clotting and causing death from haemorrhage (Lambert, 1997). SGARs have become a problem for non-target species, in particular avian and mammalian predators, who are exposed to these compounds through secondary poisoning after consuming poisoned prey (Langford *et al*., 2013). Non-target animals can also consume anticoagulant rodenticides through direct ingestion of bait (primary intoxication) (Peetris, 2019). In addition to predators, some studies have shown that small insectivorous mammals can also be affected (Koivisto *et al*., 2018). This brief review aims to present the impact that rodenticides have on European hedgehogs (*European Erinaceus*, Linnaeus 1758).

Erinaceus Europeus Threats and Conservation Status

Erinaceus europaeus commonly known as the Western European hedgehog, is a small mammal well-known and widespread throughout the European continent, including some islands (Amori, 2016; Lukešová *et al*., 2021). These small spiny mammals are insectivores and play a significant role in controlling invertebrate populations such as snails, slugs, earthworms, caterpillars, earwigs, millipedes, and beetles (Haigh *et al*., 2014; Rasmussen, *et al*., 2019). They can also feed on rats, snakes, small birds, bird eggs, berries, flowers, fruits and pet food when they find these foods available (Hernández, 2020; Zacharopoulou *et al*., 2022). According to the IUCN Red List, E. europeans have a conservation status of "Least Concern" (Amori, 2016).

Normally *E. europeus* are associated with the agricultural landscape, but in recent decades they can be easily found in the green areas of urban areas (Taucher *et al*., 2020). There is currently a greater density of animals in urban areas in some regions than in rural areas (Hubert *et al*., 2011). These animals have adapted to this niche, since in an urban environment there are more attractive conditions such as greater availability of food, better quality of habitat, better climatic conditions, protection against natural predators and greater

availability of material for building shelters (Gering & Blair, 1999)

However, they face several threats, especially in urban environments. Habitat loss, road accidents, predators (pets), intensive agricultural practices, injures do to outdoor work machines, trap into holes, climate change and pollution are some of these threats (Haigh *et al*., 2014; Rasmussen *et al*., 2019; Rasmussen, *et al*., 2019). Although the European hedgehog population has remained stable, its distribution has been decreasing over the last few decades in some regions (Garcês *et al*., 2020; Rasmussen *et al*., 2019; Riber, 2004), and in particular rural hedgehogs appear to be most affected by this decline (Taucher *et al*., 2020). In the UK since 2002 30-50% of this species has been lost, therefore as been classified as Vulnerable to extinction on Great Britain's Red List for mammals (Mathews & Harrower, 2020)

European Hedgehogs and Anticoagulant Rodenticide

Studies have shown that small birds and mammals can enter bait boxes in search of food and consume the bait directly (Hughes *et al*., 2013). Additionally, invertebrates (insects, molluscs) may also enter bait boxes and consume the bait, eat rodent feces and contaminated rodent carcasses, or ingest soil-bound waste *(Broughton et al*., 2022; Dowding *et al*., 2010). They can retain ingested compound in their bodies for four weeks or longer. These insects are in turn consumed by insectivorous animals, such as the European hedgehog (*E. europeaus*), explaining the presence of residues of these compounds in these species (Dowding *et al*., 2010; Hadler & Buckle, 1992) (Figure 1).

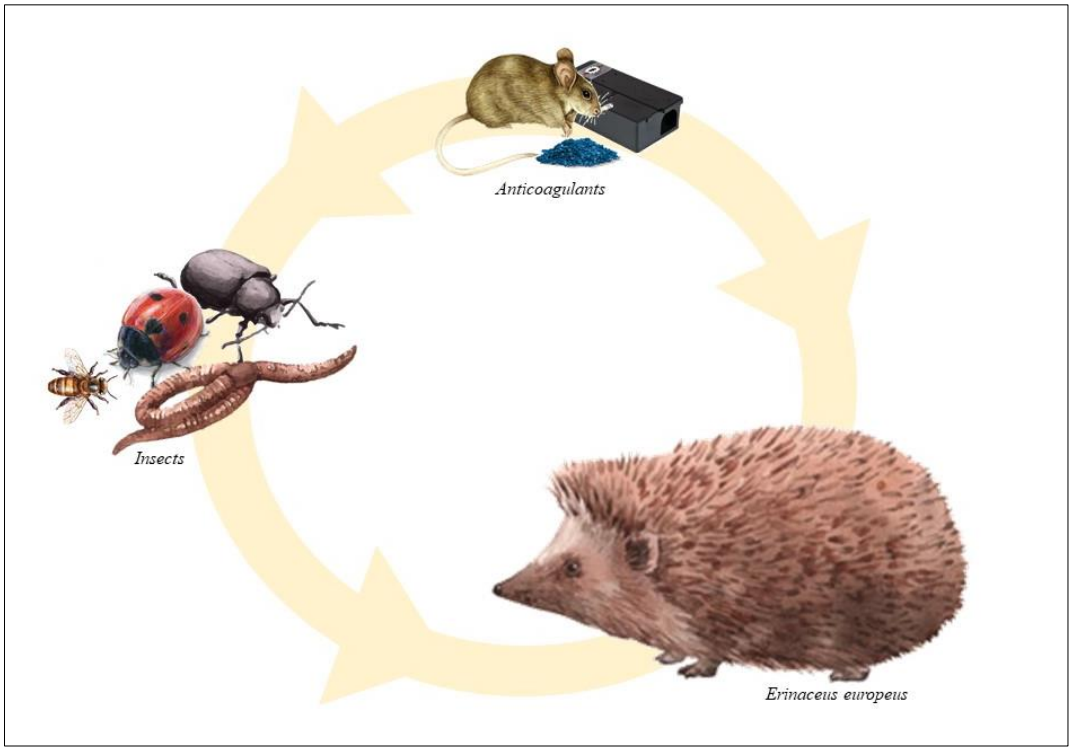

Figure 1: Conceptual model of ecotoxicology in rodents and *Erinaceus europeus* (Graphic Andreia Garcês).

The ingestion of rodenticides can lead to severe health issues and even death in hedgehogs. Common symptoms of rodenticide poisoning in hedgehogs include internal bleeding, lethargy, weakness, loss of appetite, and in severe cases, seizures and death (Figure 2) (Albert *et al*., 2010; Dowding *et al*., 2010; Elliott *et al*., 2016).

Figure 2: *Erinaceus europeus* lethargic and weakened, and in the figure of the right hemorrhagic lung (Photo Andreia Garcês).

Research Studies on Anticoagulant Rodenticides in *Erinaceus Europaeus*

Unfortunately, there are not many studies on the accumulation of rodenticides in hedgehogs and their impact on the population. Some retrospective studies carried out in recovery centers indicate that animals admitted due to poisoning could be due to pesticides such as rodenticides, but almost never without confirmation from additional tests. As an example, in a study carried out in Czech Republic between 2010-2019, they reported that 53/16,967 animals admitted to the wildlife rehabilitation center due to poisoning could had been caused by rodenticides and other industrial chemical, but without confirmation (Lukešová *et al*., 2021). In other study performed betwenn 2002–2019 in Portugal 2/760 animals death to poisoning also could have been associeted to rodenticides due to the postmortem findings, but still without confirmation (Garcês *et al*., 2020).

Dowding *et al*., (2010) during 2004–2006 used 120 adult hedgehog carcasses collected from wildlife rehabilitation centers from Scotland, Wales, Midlands and West, South-Western, South-Eastern, and Eastern to assess the presence of rodenticide residues. SGARs were detected in 69 (57.5%) animals and FGARs in 27 (22.5%) animals. Fifty-three (44%) animals had liver residues of one compound; 21 (18%) of two, five (4%) of three and one (1%) of four compounds. The concentrations observed were 0.05 ±<0.01 µg/g ww brodifacoum, 0.59 ±0.24 µg/g ww bromadiolone, and 0.10 ±0.03 µg/g ww difenacoum. The results also showed that males are more prones to consume contaminated food due to their ranging behaviour (Dowding *et al*., 2010).

Spurr *et al*., (2005) carried out a study in which cereal-based baits containing 20 ppm brodifacoum were used in a Rotoiti Nature Recovery Project (New Zealand, Australia) from December 1997 to August 2000 to eliminate pests in the park. Brodifacoum residues were detected in the livers of 234 mammals, 36 of which were hedgehogs. Brodifacoum continued to be detected up to 9 months after using these compounds in these animals. Brodicaum concentrations ranged between <0.01 and >0.90 in the liver (Spurr *et al*., 2005).

DISCUSSION

Due to their natural behavior and diet, hedgehogs can be easily exposed to pesticides, either directly by ingesting bait, or indirectly by ingesting poisoned prey, as discussed previously. Studies have shown the presence of residues of anticoagulante rodenticides in hedgehogs, even up to 9 months after the use of such product in the area (Spurr *et al*., 2005). Some authors believe that hedgehogs may have the same level of exposure and potential effects as other non-target predatory animals (Dowding *et al*., 2010). Due to the significant decline in hedgehog populations in recent decades, particularly in more urban areas such as Great Britain, it is possible that rodenticide poisoning may have been a contributing factor (Elliott *et al*., 2016; Spurr *et al*., 2005).

Although there is no precise concentration of anticoagulants in the liver in hedgehogs that can be used as a reference for diagnosing lethal poisoning, studies in owls have shown that SGAR residues greater than 0.2 µg/g ww can be considered dangerous, and residues > 1 µg/g ww can be considered dangerous. lethal (Newton *et al*., 1999). In the data provided by Dowding *et al*., (2010) residues above 0.2 µg/g ww were detected, suggesting that lethal poisoning by rodenticides is likely to occur in some hedgehogs (Dowding *et al*., 2010). In addition to death for poisoning, anticoagulante rodenticides can have other effects such increasing the risk of pathogen infection among due to immune suppression (Murray & Sánchez, 2021). The monitorization of anticoagulant rodenticides in these animals is dificult, studies may underestimate poisoning events as animals with fatal doses may die in hidden locations (Dowding *et al*., 2010)

CONCLUSIONS

To protect hedgehogs and other non-target animals, it is crucial to use rodenticides responsibly, following all guidelines and precautions provided by manufacturers. Additionally, adopting alternative rodent control methods that are less harmful to non-target species, such as using traps or employing natural predators of rodents, can help minimize the risks associated with rodenticides. Moreover, maintaining hedgehog-friendly habitats and creating safe passages across roads can aid in preserving hedgehog populations. In the future more studies regarding the presence of anticoagulant rodenticides in hedgehog are necessary.

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