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Roadkill on islands: where road and island ecology meet

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Human alteration of nature comes in an array of shapes and forms, with the construction and operation of road networks being a prominent and constantly expanding pressure in both geographical extent and intensity. Roads affect wildlife both directly and indirectly, with roadkill being one of the most widely researched phenomena globally in the past decade. Currently research though, mainly concerns mainland areas, with sparse information on how roads affect ecosystems on islands, which due to their isolation and size provide species with limited resources while often constitute biodiversity hotspots. In this review, we conducted a PRISMA analysis in order to source studies focused on roadkill in Small-Medium Islands (SMI), resulting in 29 studies, which we use as a basis to further discuss the topic. We highlight that research is limited, and often focused on specific species of interest (i.e. endemics), and while studies showcase a wide geographical distribution with data from islands of the Pacific, Atlantic and Indian Ocean, as well as the Mediterranean Sea, the Gulf of Mexico and the Great Australian Bight, the number of individual islands is not representative of the inhabited SMI worldwide. We also bring attention to the issue of tourism, which affects wildlife, and roadkill risks through the creation of season traffic conditions, as well as more intense construction and operation of infrastructure of all kinds. Road networks are expected to intensely expand in length in the following decades while islands are being progressively more affected by human activities despite being important biodiversity reserves. This literature review is the first step to identify the effects of road networks on islands which need to be followed by monitoring, and mitigation measures.

KEYWORDS

island ecosystems, road networks, small-medium islands, wildlife-human interactions, tourism and wildlife

1 Introduction

As we are settling into the Anthropocene (Russell and Kueffer, 2019; Finn et al., 2023), human alterations to the natural environment are influencing wildlife more intensely than ever, resulting in intensified wildlife-human conflict (Soulsbury and White, 2015; Nyhus, 2016; Pooley et al., 2021). Roads are one of the most prominent characteristics of the human-made world, integral to commerce, cultural and social aspects (Perz et al., 2012)

which enhance accessibility (Faiz et al., 2012; Labi et al., 2019) This is even more important in cases of rural, or isolated, but inhabited areas, where prior to transport infrastructure people's access to medical resources, or education and work opportunities was limited Additionally, road and other networks are proven to boost and fortify the economic growth of small communities through opportunities for commerce (Bryceson et al., 2008; Ng et al., 2018; Takada et al., 2021). Despite their undeniable importance, roads' negative impacts on species and ecosystems are well-documented (Coffin, 2007; D'Amico et al., 2018). As road networks worldwide are constantly expanding (Laurance et al., 2014; Schwartz et al., 2020), there is an urgent need to investigate their effects and offer mitigation measures. This has led to the development of road ecology, a scientific field that has been well established in the past two decades (Forman et al., 2003; van der Ree et al., 2011; Bíl et al., 2019).

The construction, use, and management of any road system results in direct (e.g. soil sealing, landscape fragmentation) and indirect ecosystem impacts (e.g. chemical, light, and noise pollution) (Ament et al., 2008; Teixeira et al., 2020). One of the principal effects of roads on biodiversity, is wildlife species mortality due to collision with vehicles commonly referred to as "roadkill", has been at the forefront of road ecology research worldwide (Shilling et al., 2015; Rendall et al., 2021).

Roadkill, the direct killing of wildlife by vehicles (Litvaitis and Tash, 2008; Hill et al., 2019), can have devastating consequences for wildlife, contributing to the depletion of species populations or local extinctions (Benítez-López et al., 2010; van der Ree et al., 2015). Road ecology has sought to explain the spatial and temporal dynamics of roadkill incidents (Fabrizio et al., 2019; Morelli et al., 2020; Grilo et al., 2025) followed by impressive recent advances in the field due to the wide uptake of technology (i.e. smartphones for data recording, monitoring of animals through collars or camera traps to inform drivers of their presence and prevent collisions) and extensive research and mitigation efforts (i.e. long-term monitoring and implementation of measures) (Lester, 2015; Garriga et al., 2017; Helldin and Petrovan, 2019). The majority of research on roadkill comes from mainland areas with USA, Brazil and Australia dominating. There have been more than 50 literature reviews on the topic since 1998, with more than 40% of them published after 2020 (per Scopus). Estimates of vertebrate species killed in traffic accidents every year reach the millions (Grilo et al., 2020; 2025) while relevant numbers for invertebrates are both understudied and expected to be even higher (Baxter-Gilbert et al., 2015; Reck and van der Ree, 2015).

Islands are relatively underrepresented in global roadkill-related literature, despite their unique ecological and societal conditions that differ from mainland. At the same time, island ecosystems are known as biodiversity and endemism hotspots worldwide, providing important habitats for wildlife often not present elsewhere (Courchamp et al., 2014). Small and medium-sized islands (SMI), with an area under 10,000km^2 are characterized by several traits, well studied by island ecology (Veron et al., 2019; Macinnis-Ng et al., 2021). Their size leads to limited species populations and impoverishment (Triantis et al., 2012; Jamero et al., 2019). These conditions create populations that are vulnerable to various pressures like climate change, invasive species and landscape fragmentation due to their inability to disperse, compete with invasive organisms (island syndrome) or adapt fast enough (Hall, 2012; Leclerc et al., 2020). Moreover, island tourism showcases seasonal fluctuations that can overlap with heightened wildlife activity (late spring and summer months), multiplying the risk of roadkill by combining increased traffic load with movement of species (Rendall et al., 2021; Abril-Colón et al., 2024).

Research interest in roadkill has expanded on larger islands, with prominent case studies from Taiwan, the UK, Honshu (the main island of Japan), and Tasmania (Hobday and Minstrell, 2008; Tatewaki and Koike, 2018; Chyn et al., 2019). However, SMI remain widely overlooked, despite their ecological and wildlife interest. By combining island ecology and road ecology, this literature review synthesizes the limited evidence available on roadkill in SMI, identifies knowledge gaps, and highlights priorities for future research and mitigation actions.

2 Methods

2.1 Literature search and initial screening

Following the PRISMA 2020 method for new systematic reviews (Page et al., 2021) we searched Scopus, Web of Science, Springer Link, and Taylor & Francis Online using the keywords "Island" AND "Roadkill". No year or language restrictions were implemented. After the initial search, duplicates and non-research articles were removed. Screening of publications took place by reading through their title and abstract, excluding irrelevant topics, mainland areas and islands larger than 10,000km^2. The remaining publications were read in full to ensure they fit the criteria and were then included in the present literature review (Figure 1).

2.2 Data extraction

The selected articles were thoroughly read and the following information were recorded for the aims of this review: A) Geography (Island, Island Area, Country and Climatic Region), B) Data collection method: opportunistic (Citizen Science), systematic (<1 year, or >1 year), secondary sources, C) Data Management (affiliation or not with existing roadkill monitoring scheme) and funding source (own or external funding), D) Animal groups recorded (Mammals, Birds, Reptiles, Invertebrates, Specific species), E) Discussion of tourism impacts and F) Discussion of roads secondary effects.

Information under A, E, and F were recorded as descriptive data (i.e. name of island, research question) while all other fields received a binary value (1 for "Yes" or 0 for "No") depending on the inclusion of the specific topic (i.e. part of existing monitoring scheme, accounting for the effects of tourism etc.) in the methods,

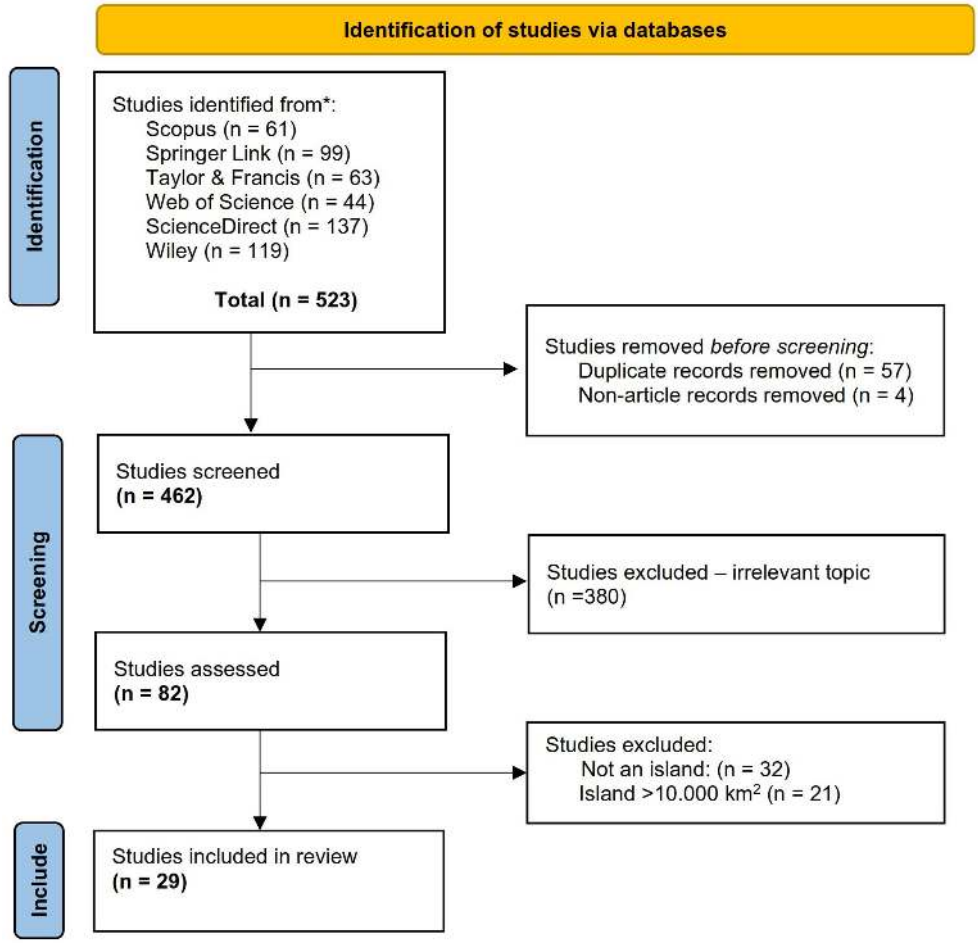

FIGURE 1
PRISMA screening diagram.

results, or discussion of the paper. Every field could have more than one "Yes" value. The binary answers were transformed into simple descriptive statistics (no. of Yes/No values) and used to guide the present literature review by highlighting the topics most and least represented in literature. These topics were then expanded through the review papers alongside information on roadkill and island ecology via global literature and implemented in the results of the present literature review.

3 Results

3.1 Geographical distribution of research

The screening process resulted in a total of 29 scientific publications (Figure 1) directly investigating roadkill events on SMI, dated from 2007 to 2025. Concerning our methodology for literature selection, we acknowledge the possibility of studies not using the word "island" in their titles or abstracts but still present research on SMI, which might have influences our results based on the search string used. However, following atrial of different combinations of keywords, we believe it is the most functional for the purpose of this literature review.

While the number of publications utilized in this review is limited, they cover a wide geographical range, with research efforts on islands of the Atlantic and Pacific Oceans, the Gulf of Mexico, the Mediterranean and the East China Sea. The publications cover a total of 17 different islands or island complexes (Figure 2).

The Canary Islands and Galapagos complex contributed the most, with four publications each, followed by San Clemente at the Channel Islands of California (n=3), while Bass Strait islands, Cyprus, the Florida Keys Complex and the Langkawi archipelago are represented by 2 publications each.

These results cover only a small fraction of the islands globally with some form of road infrastructure (Lin, 2006; Adshead et al., 2021). Despite the consensus regarding the importance of islands for biodiversity (Vitousek et al., 2013; Courchamp et al., 2014) this varies from hotpots in the tropics and the Mediterranean (Taylor and Kumar, 2016; Vogiatzakis et al., 2016) to biodiversity coldspots in high latitudes (Melián et al., 2015). For island biodiversity hotspots, roads present an additional concern for endemic and rare species of fauna while on coldspots the risk is the

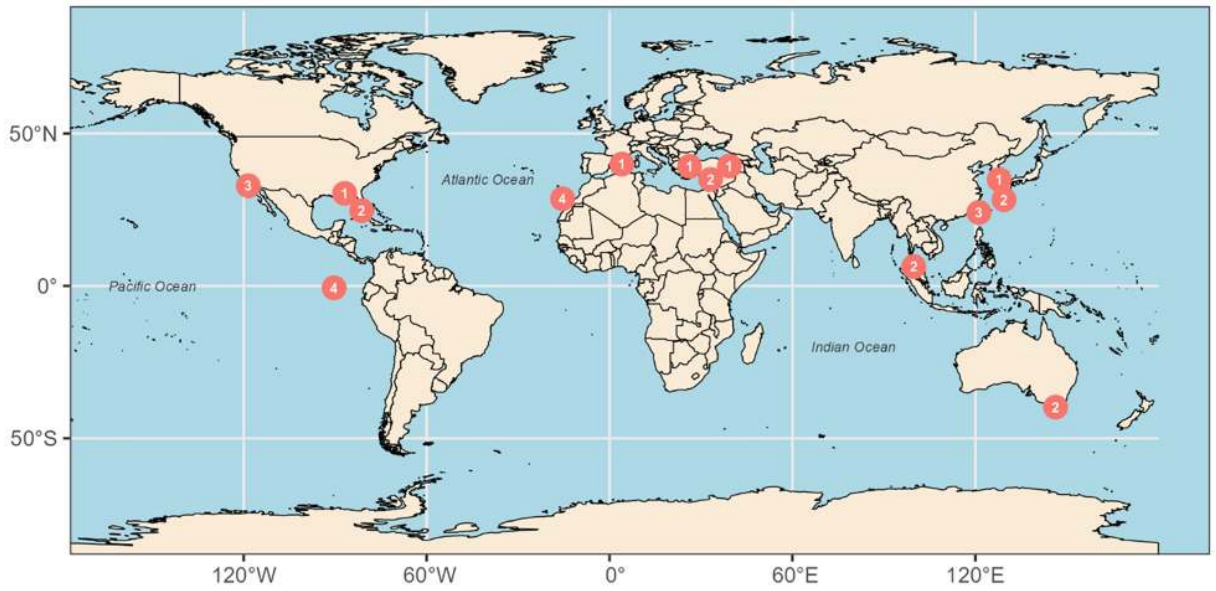

FIGURE 2
Geographical distribution of papers used with number of studies in each dot.

further reduction of population numbers of an already impoverished fauna.

3.2 Data management, monitoring schemes and funding

The majority of the research efforts (17, 59%) received funds in the form of research grants, local or national funding or private institutions (Ayob et al., 2020). This is noteworthy considering the various potential difficulties of research in small islands (Dornan, 2014; Weeks and Adams, 2018; Mackay et al., 2019). Data collection for roadkill related analysis can be expensive since systematically scanning of linear road systems (Loss et al., 2014; Henry et al., 2021) translates to gas and car maintenance costs. Although these costs decrease significantly when data are collected through citizen science, funding is still required for training volunteers, creation of educational material, and researcher involvement in the initiative (Cunha et al., 2017; Chandler et al., 2017).

Regarding safekeeping and of the project results and future utilization, only 10% (n = 3) publications mentioned upkeep and organization of the collected data in some kind of database, while only one scheme, the Cyprus Roadkill Observation System (CyROS), was conducted as part of a national wide monitoring effort (Zotos and Vogiatzakis, 2018). The limited interest can be attributed to the small number of scientists that conduct relevant research, predominantly driven by the island ecosystem or specific species of their interest rather than the phenomenon of roadkill combined with these traits (Snow et al., 2011; Olgun et al., 2022). For this reason, many of the papers included in the present review place individual species or biodiversity hotspots on the foreground (Mizuta, 2014; Marcel et al., 2022), with roadkill being just one of the many pressures to investigate in the context of planning mitigation measures or further understanding a species needs (Tanner and Perry, 2007; Ryu and Kim, 2020; Miyamoto et al., 2021).

Although many of the islands included in the review belong to countries with long-term roadkill monitoring schemes (Japan, Taiwan, USA), often when results of these schemes are reported, islands are not included. The lack of existing (national) monitoring schemes expanding towards islands can be attributed to various reasons, like lack of researchers if there is no academic station on the island, lack of data to kickstart further efforts, or lack of citizen scientists to contribute if the island has few inhabitants and is mostly seasonally populated by tourists.

Roadkill monitoring requires time and financial investment, while often putting researchers in hazardous situations (i.e. walking close to busy roads). Therefore, collecting roadkill data without funding and in absence of a well-structured (local or national) monitoring scheme can be a complex and overwhelming endeavor, regardless of the methodology.

3.3 Data collection methods

Short-term and long-term data collection were utilized in 41% (n = 12) and 38% (n = 11) of the studies respectively. Secondary data were used in 31% (n = 9) cases while only 10% (n = 3) made use of Citizen Science data. Four publications made use of two data collection methods (i.e. secondary data with short-term monitoring) in order to have access to a larger number of roadkill and be able to compare historical with current datasets.

While long-term systematic monitoring produces more robust results (Tejera et al., 2018; Jiménez-Uzcátegui et al., 2024), the

resources required make it difficult to sustain without adequate support. Short-term systematic data collection is a good alternative, especially when focused on key locations (i.e. animal passages, areas close to water) and in key periods (mating and migratory periods, or high traffic load periods due to tourism) (Roig-Munar et al., 2012; Moraleda et al., 2022). However it might not be representative of the phenomenon as a whole and results should be treated with caution while methodological el adjustments might be necessary to minimize possible biases.

Additionally, it is noteworthy that only 11 out of the 29 papers included in this review explicitly stated information on road characteristics (road width, traffic volume and speed limits), which is a vital part of roadkill research. All studies that provided relevant information were conducted in paved roads with 2 or more lanes, ranging from 5 to 16 meters width. Speed limits ranged from 40km/h to >80km/h, while some roads have different speed limits for day and nighttime. Traffic volume in most cases was extracted through national or other datasets and was not specific for the road transects or the timeframe of the study. Road characteristics, combined with roadkill data and landscape traits are important information in order to have a better understanding of the phenomenon drivers, and should be a priority in future research.

Secondary sources may provide long-term information collected often in a systematic manner, although their focus is usually human health and safety rather than ecology (Durkin and Cohen, 2019; Vogiatzakis et al., 2025). Their use is often supplementary to long- or short-term monitoring. Irrespective of the methods, which are resources dependent, all scientific efforts to quantify, research and mitigate the phenomenon contribute to global research and expansion of the current knowledge. Many of the islands that host biodiversity hotspots have protected areas with allocated personnel (Ferretti-Gallon et al., 2021; Bišćan et al., 2022) which could assist in collect in targeted roadkill data collection during their day-to-day activities.

Engaging the local communities in monitoring is also important, although there are shortcomings. While islanders have well-documented tight communities, CS initiatives require resources, including scientists as educators both to take off, and be sustained long term. Additionally, small SMI communities might not be familiar with CS practices, further complicating the process. It is strongly recommended that researchers on islands should utilize CS tools to involve the locals.

3.4 Species, roads and islands

In this literature review, 28% (n = 8) of the papers collected data for multiple animal groups (mammals, birds, reptiles, invertebrates) while 38% (n=11) focused only on a specific group. A significant 34% (n = 10) focused on a single species which was either endemic (San Clemente foxes (Snow et al., 2011; 2012; 2014), Galapagos lava lizards (Tanner and Perry, 2007), Zanzibar red colobus (Olgun et al., 2022), Amami Woodcock (Mizuta, 2014), Florida Key deer (Parker et al., 2011; Huijser and Begley, 2022) or showcased important ecological behaviors like mass migration in the case of two species of crab (Ryu and Kim, 2020; Rung-Tsun et al., 2025).

Species bias in ecological research is a long-standing phenomenon (Colléony et al., 2017; Albert et al., 2018), with "charismatic" species overshadowing other organisms that might not appeal to researchers or the public (Krause and Robinson, 2017; Troudet et al., 2017). This is often the case on islands with peculiar biodiversity and endemic species. For example, the mouflon in Cyprus or the giant tortoises of Santa Cruz in addition to their ecological significance have also socio-cultural significance. These aspects of how species are viewed by the public can indirectly influence research through resource allocation (McGinlay et al., 2017; Connelly et al., 2022).

As roadkill interferes with natural cycles, dispersal corridors and expected ecological behaviors (van der Ree et al., 2011; Konstantopoulos et al., 2020), the root causes can be different for each species (Barthelmess and Brooks, 2010; Rytwinski et al., 2016), making data analysis on overall fauna difficult. Additionally, there can be other obstacles preventing accurate roadkill data, like scavenger species feeding on carcasses (Loss et al., 2014), removal of the carcasses from the road (for safety or aesthetic reasons) (Teixeira et al., 2013) and the disappearance of small animals after being run over multiple times (Zotos et al., 2018; Santos and Ascensão, 2019).

Taking these into account, more effort should be made to include a wider part of island biodiversity in studies related to roadkill, including invertebrates and especially insects, as well as small, non-endemic vertebrates. Endemic species receive the most interest and make up the majority of research, as well as showcase research continuity (i.e. possibility of long-term studies, or follow-up studies) such as the Clementine Island Fox and the Florida Keys Deer (Snow et al., 2011; 2012; 2014; Parker et al., 2011; Marcel et al., 2022). Small size animals seem to be less studied, with invertebrates being represented by only two studies, and small reptiles following the same pattern, which can be attributed to the different methodology required for small animals due to the difficulty of detection and their large numbers of roadkill (Zotos et al., 2018; Chen et al., 2025).

Island characteristics are known to be manifested in certain species traits. Small population sizes (for endemic or non-endemic species) on SMI, especially when combined with dense road networks or high habitat fragmentation may lead to higher extinction risk when there are no migration options due to the island's size (Fahrig, 2002; Wood et al., 2017). Risks of population loss or extinction are also intensified due to the secondary effects of road operation which deplete natural resources through pollution, soil sealing and land use change among others (Coffin, 2007; D'Amico et al., 2018). Less studied, but no less important secondary effects are the noise and light pollution generated by road networks, which over time can negatively affect daily patterns of animal activity, night predation, mating opportunities and nesting sites (Ryu and Kim, 2020; Fielding et al., 2021; Miyamoto et al., 2021). Combined with the limited resources of island ecosystems, these pressures can lead to population losses indirectly, by affecting population dynamics over time.

3.5 Roads, islands and tourism

Out of the 17 islands/island complexes included in the literature review, only one does not constitute a tourist destination (San Clemente of the Channel Islands of California – a military base), while only one third (n=10, 34%) of the papers discuss the effects of tourism in the context of roadkill incidents, with only one focus around the specifics phenomenon (i.e. increased usage of motorbikes by tourists resulting in more roadkill) (Chen et al., 2021).

Tourism is an important, but often overlooked, aspect of human pressure on wildlife (Green and Giese, 2004; Cui et al., 2021), its effects are more intense in biodiversity hotspot areas, which tend to attract larger crowds due to the presence of protected areas, creating increased traffic loads (Rendall et al., 2021; Abril-Colón et al., 2024). Something difficult to measure, but certainly acting as a contributing factor, is also that tourists are not familiar with local road conditions, which makes them more prone to cause a roadkill (Barrientos et al., 2020; Chen et al., 2021). Research on mainland areas has established the connection of tourism associated with higher traffic loads and increased roadkill risk. The number of tourists continues to rise for many destinations worldwide, with a large percentage of them preferring to hire and self-drive vehicles instead of joining guided bus tours or utilizing public transport (Rendall et al., 2021; Leurs et al., 2024).

Tourism industry and transport infrastructure are intertwined in many SMI, with roads networks constantly expanding because of tourism. While it is difficult to quantify the actual effects of tourist-related vehicles on roadkill incidents, it is well established that in addition to increased traffic during tourist season (Saenz-de-Miera and Rosselló, 2012; Vergori and Arima, 2022) tourism development leads to soil sealing and land take (Kizos et al., 2017; Gao et al., 2021).

Tourism is presently one of the dominants drivers of traffic fluctuations on islands, yet its role and intensity of impact in roadkill risks and instances is severely under-investigated, with only a single study of the review explicitly researching the phenomenon (Chen et al., 2021). While planning roadkill mitigation measures on SMI, the increased traffic during tourist season has to be accounted for, assuming that relevant data has been collected to establish such seasonal changes.

This is currently lacking from most studies, which often only mention the number of tourists annually but not vehicles hired/driven. Moreover, the behavior of tourists should be also taken into account, e.g. if nightlife is important, resulting in increased evening traffic, or if during tourist season more vehicles like quad bikes or buses use the road.

3.6 Road network secondary effects

While roadkill is the primary effect of the road networks (Teixeira et al., 2020), there is a number of secondary effects (e.g. noise pollution, habitat fragmentation and intensified human presence) that should also be considered. However, only 24% (n=7) of publications included discussion of these effects and how they intertwine with roadkill.

Insights into the secondary effects can provide additional information on why specific locations act as roadkill hotspots, or why some species are more susceptible. This is because these effects "feed" into the phenomenon of roadkill in various ways, and the more intense they are, the higher the risk of roadkill is expected to be (Fielding et al., 2021; Sacramento et al., 2022; Galea et al., 2024). Habitat fragmentation is such an example. In particular on islands where dispersal is already limited, fragmentation will force an animal to cross barriers, including roads, in order to forage or mate, increasing its exposure to roadkill. Fragmentation by roads creates island habitats within geographical islands with the consequences of this double insular effect unknown. Islands are known to be vulnerable to IAS (Lamelas-López and Santos, 2021) and roads are considered as conduits of IAS expansion globally (Szilassi et al., 2021; Bagnara et al., 2022). Similarly, light pollution created by road usage (both cars and road lamps) is known to negatively affect mammals (i.e. deer, hares) (Rodrigo-Comino Jesús et al., 2021; Mayer et al., 2023).

4 Conclusions

While SMI are often biodiversity hotspots, roadkill on such ecosystems is a phenomenon severely under-researched. It is evident from this review that road ecology has not yet become a priority for island research which may in turn contribute to the intensification of road pressures before mitigation measures will be set in place. This lack of information and research interest is attributed mainly to the prioritization of other pressures, i.e. agriculture or tourism (Walker et al., 2021; Adrianto et al., 2021; Marrero and Mattei, 2022; Teng and Montesclaros, 2023) or often due to lack of resources to support research.

The majority of studies reviewed herein do not place enough emphasis on island ecosystems' unique ecological characteristics and how they influence wildlife and amplify human pressures, looking into roadkill as a phenomenon separate from the ecosystem itself. Our findings indicate that specific characteristics of island ecosystems (not present in mainland areas) can potentially clash with human pressures and even be further intensified seasonally by factors such as tourism (García-Carrasco et al., 2020; Chen et al., 2021; Zevgolis et al., 2023).

The literature review includes a number of islands and island complexes, that is still miniscule compared to the total SMI inhabited with road networks present worldwide. Therefore, the limited data extracted by the present study is insufficient to provide a complete extent of the phenomenon on islands, or to contribute to the design and implementation of SMI-specific mitigation measures.

Road network expansion will continue in the following decades globally, including on islands, with respective impacts on wildlife and ecosystems. Researchers have been aware of the importance of islands for safeguarding wildlife but have yet to bridge the knowledge gaps of the impacts resulting from roads. This literature review draws attention into the ways in which island ecosystems intertwine with, and are affected by, road networks, while highlighting the importance of further research followed by relevant mitigation actions.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Author contributions

MS: Data curation, Visualization, Conceptualization, Writing – review & editing, Methodology, Writing – original draft. SZ: Writing – review & editing. IV: Conceptualization, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcosc.2025.1656280/full#supplementary-material

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