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Factor influencing road kill mortality of birds: A review

Dupty Ram[1] and Naveen Tholia[2]

[1]Research Scholar, [2]Associate Professor

[1,2]Department of Zoology, School of Applied Sciences, Om Sterling Global University, Hisar, Haryana, India-125001

Email id- ramdupty@gmail.com

Mobile no. 9991116738

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ABSTRACT

Roads exert several negative and adverse effects on the survival of various animals and ecosystem health, including mortality, injury, habitat fragmentation, habitat isolation and enhancement of noise and chemical pollutants. These factors significantly affect wildlife survival, including that of avian species. Bird species such as scavenging raptors, corvids, and other insectivorous, granivorous and omnivorous species are attracted to roads for foraging and finding food resources. Birds drawn to roads are often startled by approaching vehicles, and such behavioral responses can result in bird fatalities. High speed and traffic volume also influence the mortality patterns of birds due to road vehicle collisions. Larger birds are more susceptible to vehicle collisions than smaller birds. Larger and heavier birds likely require more time to evade oncoming vehicles than smaller or lighter birds; thus, a longer flight distance does not necessarily extend the time before a vehicle reaches its position on the road. Furthermore, birds face an elevated risk of vehicle collisions when foraging, roosting or nesting near roads. Bird mortality is also influenced by seasonal variations in specific areas. During monsoon season, cloudier weather and reduced visibility increase the likelihood of road-vehicle collisions involving these bird species compared to other seasons. Factors such as temperature, rainfall, and photoperiod are associated with seasonality and affect the frequency and rate of road kill.

INTRODUCTION

Rapid development and expansion of road and highway networks have a large impact on the surrounding environment and various species residing near these areas. As the human population grows and their daily needs increase, due to fulfil the demand for transportation infrastructure also increases at all levels (Kazemi *et al.*, 2016; Bartonicka *et al.*, 2018; Saxena *et al.*, 2019). Development of road networks leads to considerable changes and degradation of the natural landscape at the global level (Kazemi *et al.*, 2016; Saxena *et al.*, 2019; Trombulak and Frissell, 2000). Construction of roads in steep and sensitive areas often negatively impacts environmental health, commonly resulting in roadside erosion, landslides, rockfalls, and other related issues (Bartonicka *et al.*, 2018; Jaboyedoff *et al.*, 2020; Losos *et al.*, 2019).

In addition to environmental damage, the establishment and development of road infrastructure also disrupt the movement of both wildlife and domestic animals (Chishty *et al.*, 2020; Choudhary and Chishty, 2022 & 2024b; Choudhary, 2024). Collisions of animals with vehicles along roads remain a significant problem (Da Rosa and Bager, 2012; Kazemi *et al.*, 2016; Bartonicka *et al.*, 2018; Abra *et al.*, 2019; Saxena *et al.*, 2019; Russo *et al.*, 2020). Animals must navigate these altered landscapes, facing the threat of being hit by vehicles on roads (Coffin, 2007; Da Rosa and Bager, 2012; Tayade *et al.*, 2019; Oddone Aquino and Nkomo, 2021; Choudhary and Chishty, 2024b). Roads have numerous adverse ecological effects, with bird collisions with vehicles being among the most significant (Forman and Alexander, 1998; Kociolek *et al.*, 2011; Sushanth *et al.*, 2025). Several studies have found that the indirect effects of roads have demonstrated a clear reduction in the local bird population in the vicinity of roads (Fahring and Rytwinski, 2009; Benitez-Lopezetal, 2010), although these responses may be partially influenced by other road-related stressors, including habitat loss and noise (Loss *et al.*, 2015). Therefore, the present review study aimed to analyse the factors affecting road-kill mortality patterns in birds.

Material and Methods

In preparing the manuscript, we conducted a comprehensive review of various databases, including Google Scholar, Web of Science, PubMed, and Academia, as well as other journals and websites pertinent to the factors affecting the road-killing mortality pattern of birds.

Result and Discussion

Roads have several adverse impacts on the survival of various vertebrates, such as causing death, injury, habitat fragmentation, habitat isolation and introducing noise and chemical pollution. These factors largely influence the survival of wildlife, including birds (Forman *et al.*, 2003; Jacobson 2005; Kociolek *et al.*, 2011). However, roads can offer some advantages to birds. For example, the heat retained by roads can lower the metabolic costs for birds resting on them (Whiteford, 1985), and the infrastructure associated with roads, such as light poles and bridges, can provide nesting opportunities for some bird species, such as pigeons, sparrows, and mynas (Forman, 2000; Choudhary and Chishty, 2024a; Yadav and Gaur, 2025). Several factors influencing the road-killing mortality

pattern of the avian community, including some prominent factors, are summarized in this review.

1. **Relationship among feeding guild and road kill mortality of birds:**

Numerous avian species, including scavenging raptors, corvids, and several insectivorous birds such as White Wagtails (*Motacilla alba*), Black drongos (*Dicrurus macrocercus*), and Green bee-eaters (*Merops orientalis*), are drawn to roads as a source of food (Mumme *et al.,* 2000; Dean and Milton, 2003; Husby and Husby, 2014; Choudhary and Chishty, 2024b). Some birds, such as the Red-backed Shrike (*Lanius collurio*) and Black Drongo (*Dicrurus macrocercus*), often utilize shrubs, trees, and power lines as vantage points for capturing prey from exposed soil, cultivated edges, and roadways, making these areas appealing for nesting (Ceresa *et al.,* 2012; Morelli, 2013; Choudhary and Chisthy, 2024b). Moreover, other factors, such as decreased predation risk, warmth of the road surface, which helps in energy conservation, and streetlights extending daytime activity, contribute to the allure of roads for certain birds (Morelli *et al.,* 2014). Birds attracted to roads are frequently startled by oncoming vehicles, and such behavioural movements can lead to death (Husby and Husby, 2014; Husby, 2016). Moreover, evaluating the patterns of bird-vehicle collisions is challenging because of their three-dimensional nature and the varying methods of crossing. Birds in the granivorous and omnivorous feeding guilds are more prone to car collisions because they search for food on roads and are drawn to the warmth of the pavement (Dhindsa *et al.,* 1988; Choudhary, 2024).

2. **Relationship among health condition of birds and road kill mortality:**

Avian species infected with blood parasites appear to have a higher likelihood of collision with roads and vehicles than healthy birds (Moller *et al.,* 2011). Additionally, some studies have indicated that birds killed on roads tend to be in better nutritional condition than those of the same species that fall prey to raptors (Bujoczek *et al.,* 2011). Furthermore, several studies suggest that birds found dead on roads are generally in good health prior to their deaths (Erritoze *et al.,* 2003).

3. **Effect of traffic volume and speed of vehicles on mortality of birds**

In most cases, the incidence of road kill tends to rise with increased traffic volumes and vehicle speed (Gunson *et al.,* 2011; Choudhary and Chishty, 2022 & 2024b), although this is not uniform pattern (Clevenger *et al.,* 2003). Additionally, there is a positive correlation between speed limits and bird road kill rates (Chambers *et al.*, 2010). Some studies have indicated that bird-related accidents are uncommon at vehicle speeds below 80 km/h (Nankinov and Todorov, 1983) and tend to occur only at speeds exceeding 100 km/h (Dhindsa *et al.,* 1988). During holiday periods, traffic volume often increases (Eloff and Van Niekerk, 2008). This surge in traffic leads to a greater number and frequency of road kills (Meza-Joya et al., 2019). A similar observation was made by Choudhary and Chishty (2024b) in Mount Abu, Rajasthan, where they noted a significant increase in bird mortality on weekends, particularly on Saturdays and Sundays, compared to other days due to the influx of tourist on weekends.

4. **Relationship between abundance of birds and road kill mortality:**

Presence of birds in the surrounding areas was significantly associated with the number of birds observed on the road (Husby, 2016). However, the impact of mortality rates from birds resting on roads is more pronounced than the effect of their abundance in the surrounding areas (Husby, 2016). Several studies have indicated that the proportion of birds on the road accounts for a significant variation in road kill incidents (Moller *et al.,* 2011). According to Husby (2016), larger size birds tend to fly away from an approaching vehicle at a greater distance than smaller birds, and the distance at which they take flight significantly contributes to the variation in road kill occurrences and their vulnerability to becoming road kill. Furthermore, large sized birds may take greater risks because there is food on the road that other birds might take if they leave too soon (Husby, 2016).

Larger and heavier birds likely require more time to escape than smaller or lighter birds; therefore, a longer flight distance does not necessarily increase the time before the car reaches their position on the road. Speed of vehicles also affects the probability of birds choosing to fly away from the roads instead of trying to cross it (Husby and Husby, 2014), thus reducing the risk of being struck by a car (Husby, 2016). Birds often detect the sound of an approaching vehicle long before they see it approaching. Moreover, the noise generated by a car increases with its speed (Cai *et al.,* 2015). Curved road sections have been found to lead to more bird fatalities than straight roads (Hernandez, 1988), likely due to a combination of slower vehicle speeds (and less noise) and the fact that vehicles become visible at shorter distances. A care appears more menacing to a bird when it is moving directly towards it, which happens quickly on a curve (Husby and Husby, 2014). Many bird species may not have the cognitive ability to swiftly process all the information about a car's distance, direction, and speed, making them vulnerable in traffic (Husby, 2016; Choudhary and Chishty, 2022 & 2024b). This problem is likely worsened by higher vehicle speeds (DeVault *et al.,* 2015), especially if these speeds exceed those that birds are used to in their natural environment (DeVault *et al.,* 2014). Another reason is that vehicles passing at higher speeds strike birds with greater force, causing them to be thrown further from the road and out of sight (Husby, 2016). The presence of vegetation just a meter from the road can obscure road kill, making it more challenging to spot a dead bird when driving at higher speeds (Husby, 2016). Furthermore, the mortality rate from road kill might rise with increased vehicle speed, but these birds are less likely to be detected than those in areas with lower speed limits. Collisions involving vehicles can lead to non-fatal injuries to birds, which may subsequently increase their likelihood of dying from other factors, such as predation by other predators (Orlowski and Siembieda, 2005).

5. **Effect of road on the movement of birds:**

Road networks can interfere with movement of wildlife (Chen and Koprowski, 2016; Bischof *et al.,* 2017; Cayuela *et al.,* 2019) and affect gene flow between populations, resulting in fragmentation and isolation of populations, a reduction in genetic diversity, and even genetic differentiation among populations (Lesbarreres *et al.,* 2006; Clark *et al.,* 2010; Jackson and Fahring, 2011). Collision rates may either increase or decrease with an increase in roadside lighting (Hernandez, 1988; Jackson, 2003). Habitat presence around roadside trees and hedgerows, which prompt birds to fly at higher altitudes over roads, generally leads to a reduction in collision rates (Bard *et al.,* 2002; Clevenger *et al.,* 2003; Taylor and Goldingay, 2004; Orlowski, 2005), although they can sometimes cause an increase (Ramp *et al.,* 2006; Varga *et al.,* 2006). Birds exhibit varied responses to roads; some seem to learn to steer clear of vehicles (Mumme *et al.,* 2000), whereas others do not (Loos and Kerlinger, 1993; Jackson, 2003). Several bird species that inhabit forest habitats tend to avoid crossing forest gaps in regions primarily used for agriculture, logging, and urban development (Desrochers and Hannon, 1997; Awade and Metzger, 2008; Tremblay and St. Clair, 2009). Certain species even avoid crossing dirt roads that are 10–30 m wide (Develey and Stouffer, 2001). However, the barrier present due to roads might simply be due to the size of the gap they create in the habitat, unless these roads are also noisy or accompanied by larger structures such as powerlines (Clair, 2003).

6. **Effect of habitat types on mortality of wildlife with especial reference to avian community:**

Various habitat types and their arrangements have been found to affect the pattern of wildlife-vehicle collisions. For example, amphibians are often found as road kill near forested areas (Braz and Franca, 2016), whereas birds are more frequently impacted on roads adjacent to pasturelands and fragmented forests (Medrano-Vizcaino and Espinosa, 2021). Certain mammals, such as *Cerdocyon thous* and *Lepus europaeus*, are more susceptible near water bodies (DE Freitas *et al.,* 2014), and snake mortality is higher near pasturelands (Quintero-Angel *et al.,* 2012). Although habitat composition and structure are significant, they do not entirely account for patterns of wildlife mortality. Species inhabiting similar environments can show different

patterns of road-kill mortality. For instance, the crab-eating fox (*Cerdocyon thous*) and white-eared opossum (*Didelphis albiventris*) are generalist species that adapt to human-dominated areas (Cantor *et al.,* 2010; De Barros Ferraz *et al.,* 2010), yet they are impacted by roads differently; in a study in Misiones, Argentina, the white-eared opossum constituted 38.8% of road kill records, while *Cerdocyon thous* accounted for only 3.3% (Bauni *et al.,* 2017). Although differences in local abundance or density can partly explain the variation in road kill rates, even rare species can experience high mortality (Caceres, 2011; Delgado-V, 2007).

Construction of roads and highways has a direct impact on nearby habitats, leading to increased human encroachment and development. Roads affect ecosystems by disrupting habitats and wildlife, causing road-kill incidence, and creating barriers between two adjacent habitats for the movement of animals (Seiler, 2001; Choudhary and Chishty, 2022 & 2024b). Furthermore, the presence or absence of forest habitat and vegetation composition along roadside areas can influence road-kill mortality. According to Gunther *et al.* (1998), non-forest areas have more road kills than forests or other protected regions. Transitional zones between natural and developed areas are where road-kill occurrences are most likely. Wildlife is often fatally drawn to refuse and grains that fall from vehicles, leading to collisions with passing vehicles (Dhindsa *et al.,* 1988; Slater, 1994; Choudhary and Chishty, 2022). Moreover, the effects of road kill on animal populations vary based on the sensitivity of the species (Lin *et al.,* 2016). Furthermore, birds are at a higher risk of vehicle collisions when they forage, roost, or nest close to roads (Erritzoe *et al.,* 2003; Huijser *et al.,* 2007). The likelihood of collisions tends to increase near watercourses and residential areas (Erritzoe *et al.,* 2003; Ascensao and Mira, 2007). Additionally, road-kill mortality is more frequent at lower altitudes and in open areas than in forest habitats and at higher altitudes (Clevenger *et al.,* 2003; Ascensao and Mira, 2007; Ramp *et al.,* 2006; Choudhary, 2024).

7. Effect of climatic variable on road kills mortality of birds:

Kazemi *et al.* (2016) found that weather conditions affect visibility and animal behavior on roads. Adverse weather conditions often impair the ability to drive and animals to see each other in time to prevent road-vehicle collisions of wild animals, including birds (Choudhary and Chishty, 2022 & 2024b). Although road infrastructure contributes to fatalities, it plays a crucial role in the interactions between various factors (Colino-Rabanal *et al.,* 2011). For example, roads modify the natural environment and lead to habitat fragmentation. Animals living in these fragmented areas often lack access to essential resources for survival within the immediate area they inhabit (Meza-Joya *et al.,* 2019). Consequently, species that require specific food or water resources in areas separated by roads often have to cross these roads to meet their biological requirements (Orlowski and Nowak, 2006; Guthrie, 2012).

According to Choudhary and Chishty (2024b), bird mortality is also affected by seasonal variations in particular areas. They observed maximum avian mortality in the monsoon season followed by summer, and minimum mortality was observed in winter on Mount Abu, Rajasthan, India. One of the major reasons for the high mortality rate of birds due to collisions with road vehicles is heavy traffic. Mount Abu, is the only single hill station of Rajasthan state, attracts a significant number of domestic tourists each month or seasons. The influx of tourists to Mount Abu is higher during the monsoon and summer seasons than in winter. This increased tourist activity is likely a major factor in the higher incidence of road-vehicle collisions and bird deaths during the monsoon and summer seasons compared to winter. Furthermore, various factors, such as the characteristics of the environment, changes in seasons, and availability of resources, have a significant impact on the diversity and abundance of wild animals, including birds, in a particular area (Katuwal *et al.,* 2016; Adhikari *et al.,* 2020; Pandey *et al.,* 2020; Choudhary and Chishty, 2022, 2023 & 2024b). In the monsoon season, the weather becomes cloudier, and visibility is very low. Consequently, these bird species are frequently killed by road-vehicle collisions during the monsoon season compared to other seasons (Choudhary and Chishty, 2024b).

Seasonal fluctuations are often linked to the timing of road-kill occurrences (Oddone Aquino and Nkomo, 2021). Impact of different seasons on the frequency and rate of road kills varies by location. In the study by Da Rosa and Bager (2012), avian road-kill patterns in southern Brazil were predominantly observed in summer and autumn, with 265 and 202 fatalities, respectively, out of a total of 671. Kazemi *et al.* (2016) found that road kill numbers were notably high during the spring and summer in Golestan National Park. During summer, these species are particularly abundant in seasonal wetlands. Consequently, landscape features, ecological niches, animal behavior, and seasonal factors affect road-kill numbers. Factors such as temperature, rainfall, and photoperiod are associated with seasonality and influence the frequency and rate of road kills (Both *et al.,* 2008; Coelho *et al.,* 2012; Choudhary and Chishty, 2024b). Other factors that impact driving visibility will also influence the likelihood of animal vehicle collisions (Oddone Aquino and Nkomo, 2021). Position of the road play a significant role in how far ahead drive can spot an animal before potential collisions (Romin and Bissonette, 1996). For example, road segments with hills or curves can limit visibility and heighten the risk of frequently collision of animals with vehicles (Romin and Dalton, 1992). Lack of appropriate lighting and absence of warning or signs board advising drive to slow down and stay alert on roads prone to road vehicle collisions of animals can lead to more accidents (Tayade *et al.,* 2019; Wilkins *et al.,* 2019). Additionally, adverse climatic conditions can diminish the effectiveness of road signs and lighting (Kazemi *et al.,* 2016). Conditions such as heavy rainfall, mist and fog can reduce visibility on roads and leading to more road kill of animals including the birds (Oddone Aquino and Nkomo, 2021; Choudhary and Chishty, 2022, 2024b).

CONCLUSION

Rapid expansion of road networks exerts profound and long-term impacts on the environment and ecosystem health. Road construction not only directly degrades habitats but also introduces several negative effects such as habitat fragmentation and isolation. Fragmentation of habitat due to roads prevents wildlife movement and increases the risk of wildlife collisions with vehicles, disrupting local and regional migration patterns of animals. The impact of roads on avian populations is particularly severe, with millions of birds dying annually due to collisions with vehicles. In addition to the direct mortality of birds, there are several indirect effects, such as a reduction in breeding success and altered behavior patterns, which contribute to the overall decline in bird populations. These multifaceted effects underscore the urgent need for comprehensive ecological evaluations and mitigation strategies when planning and implementing road and highway development projects.

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