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ARTICLE

Linear power infrastructure and vulture electrocution risk: mitigation through carcass dump relocation in Sudhauwala, Dehradun, India

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Abstract: Vultures are among the most threatened groups of birds globally, having undergone severe population declines across Asia and Africa due to multiple anthropogenic pressures, including poisoning, veterinary non-steroidal anti-inflammatory drugs (NSAIDs), food scarcity, belief-based use, and infrastructure-related mortality. Among these, electrocution from power infrastructure has emerged as an important but underreported threat. This study documents electrocution mortality of vultures in the Sudhauwala region of Dehradun, Uttarakhand, India, based on field observations conducted between May 2011 and February 2014. A total of 34 surveys recorded 743 individual vultures belonging to five species. During this period, 46 vulture carcasses attributable to electrocution were documented in proximity to high-tension power transmission structures. The highest proportion of mortality relative to observations was recorded for Himalayan Griffon *Gyps himalayensis*, followed by Eurasian Griffon *Gyps fulvus*, and Cinereous Vulture *Aegypius monachus*. Although surveys were conducted on a non-systematic basis, the number of mortality events observed suggests that electrocution may represent a significant localized threat, particularly for long-lived scavengers such as vultures. Based on these observations, the carcass dumping site that attracted vultures to the area was relocated approximately 2.4 km away from high-risk infrastructure in coordination with local authorities. Subsequent observations indicated continued use of the new site by vultures, with no mortality events recorded during limited post-relocation monitoring. This study highlights the risk posed by power infrastructure near feeding sites and demonstrates that relocation of carcass dumping sites can serve as a practical mitigation measure to reduce electrocution risk. The findings contribute to improving understanding of infrastructure-related threats to vultures and inform conservation planning in human-dominated landscapes.

Keywords: *Aegypius monachus*, anthropogenic mortality, carcass dumping site, conservation, electrocution, feeding site, *Gyps himalayensis*, *Gyps fulvus*, mitigation, population, power lines, scavengers, transmission infrastructure, uttarakhand.

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INTRODUCTION

Vultures are large avian obligatory scavengers (Campbell 2015). In total, there are 23 species of vultures found around the world ranging from the dense Amazon rainforest to the eastern African savannahs, the arid Sahara Desert, to the high-altitude areas of the Himalaya (Buechley et al. 2016).

Globally, the most significant threats to vultures include poisoning from veterinary non-steroidal anti-inflammatory drugs (NSAIDs) such as diclofenac, intentional and unintentional poisoning through poison-baited carcasses, and in Africa, belief-based use (Ogada et al. 2012; Botha et al. 2017). These factors have contributed to the alarming statistic that approximately 61% of vulture species are threatened with extinction, with the most severe declines recorded in Asia and Africa (Ogada et al. 2012). The African-Eurasian Vulture Multi-species Action Plan (MsAP) highlights the pressures as the primary drivers of population declines and emphasizes coordinated international conservation actions to mitigate them (Botha et al. 2017). In addition to these dominant threats, anthropogenic infrastructure such as power lines and electrical distribution systems has emerged as a significant and increasingly recognized cause of mortality in large soaring birds, including vultures. Electrocution and collision incidents have been documented across multiple continents, with records dating back to the early 1970s in South Africa and the United States (Markus 1972; Jarvis 1974; Ledger & Hobbs 1981). Subsequent studies have further demonstrated the risks posed by poorly designed electrical infrastructure, particularly where birds can simultaneously contact energized components, leading to fatal electrocution events (Kagan 2016).

Electrical infrastructure has become an increasingly important source of mortality for large soaring birds worldwide. Electrocution typically occurs when a bird simultaneously contacts two energized conductors, or an energized conductor and a grounded component of a pole or tower, thereby completing an electrical circuit. Large-bodied species with broad wingspans, such as vultures, eagles, and storks, are particularly susceptible because their wings or feet can bridge these components while perching, taking off, or landing (Ferrer & Janss 1999; Kagan 2016). In addition to electrocution, collisions with overhead wires also contribute to mortality, particularly where power infrastructure overlaps with important feeding, roosting, or migration areas (Smallie & Virani 2010).

Recent global assessments have identified power infrastructure as an important and expanding conservation threat to vultures. Infrastructure-related mortality has been documented across Africa, Europe, Asia, and North America, and is expected to increase as electricity networks expand into previously undeveloped landscapes (Ogada et al. 2012; Botha et al. 2017). The African-Eurasian Vulture Multi-species Action Plan (MsAP) recognizes electrocution and collision with power infrastructure as significant threats affecting numerous vulture populations throughout their range, particularly where poorly designed power structures occur close to feeding sites and communal roosts (Lehman et al. 2007; Botha et al. 2017).

Although most evidence has been reported from Africa and Europe, electrocution has also been documented in India. For example, Bohra & Vyas (2021) reported the electrocution of an Egyptian Vulture *Neophron percnopterus* in Rajasthan, highlighting that infrastructure-related mortality is an emerging conservation concern in the country. These observations suggest that localized mortality events may have disproportionate impacts on vulture populations because these species are long-lived, have low reproductive rates, and depend on high adult survival for population persistence (Dwyer 2004; Ogada et al. 2012).

This study aims to analyze the impact of electrocution on vulture populations in Dehradun, focusing on mortality events.

MATERIALS AND METHODS

Study Area

The study was conducted in the Sudhauwala region of Dehradun, Uttarakhand, India. The Sudhauwala is situated at the 30.3330° N, 77.9608° E, in the 15 km southwestern part of Dehradun district on the Dehradun to Chandigarh Highway. Jhajhara range is one of the forest ranges of Dehradun Forest Division. The terrain is characterized by valleys surrounded by human settlements, agricultural land, and infrastructure such as power lines (Kumar et al. 2017).

Data Collection and Survey Effort: The field observations were conducted from May 2011 to February 2014. The survey focused on a livestock carcass dumping site and the surrounding area within a 2–3 km radius, including nearby power transmission infrastructure frequently used by vultures for perching and roosting. A total of 34 surveys were conducted, distributed across multiple seasons-spring, autumn, and winter-with a minimum frequency of about one survey

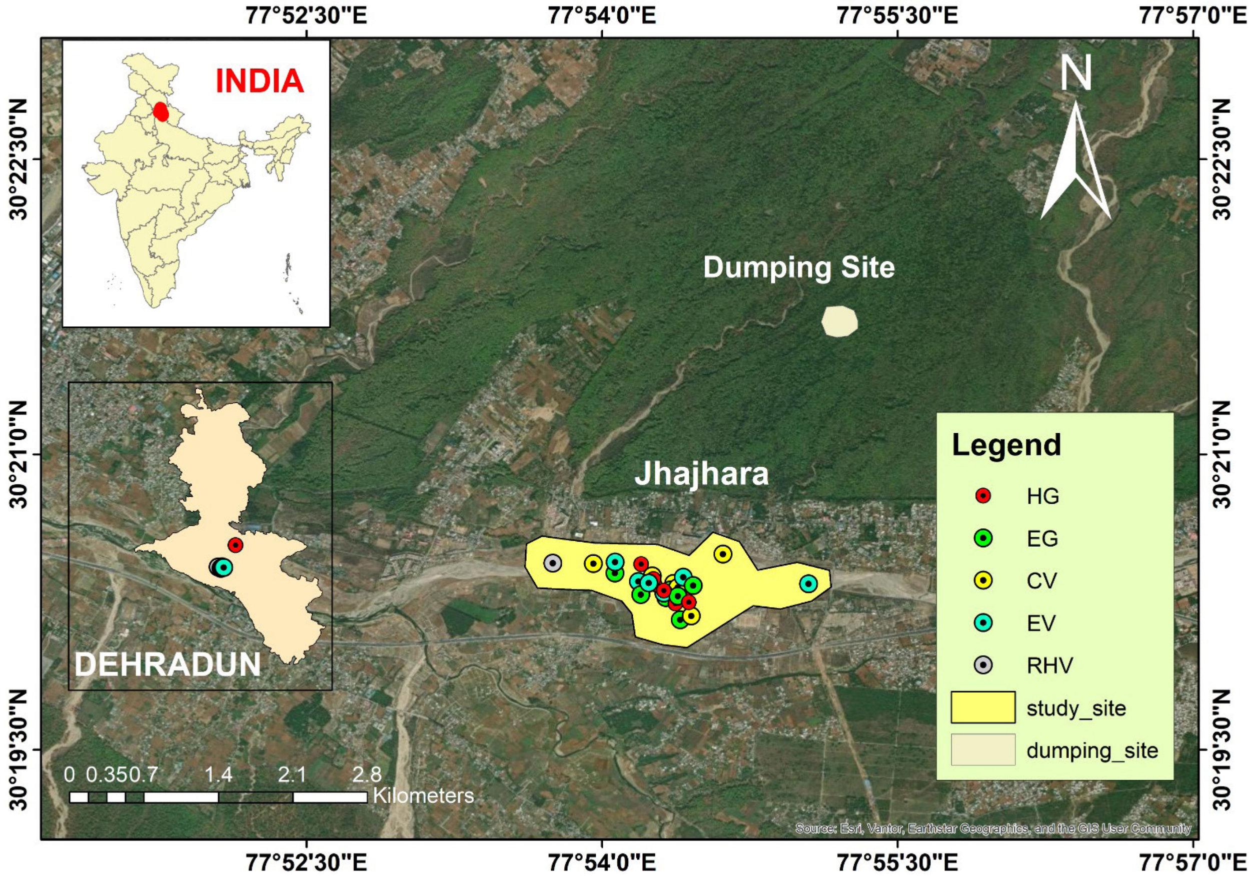

Image 1. Map of the study area highlighting the study area points and the Jhajhara range (new relocated site), the different colored points represent the different species of vultures reported during the study time: HG—Himalayan Griffon | EG—Eurasian Griffon | CV—Cinereous Vulture | EV—Egyptian Vulture | RHV—Red-headed Vulture. Source: Esri, Ventor, Earthstar Geographics, and the GIS User Community.

per month during active periods. The sampling effort was higher during winter months (October to February) when there was increased vulture abundance, resulting in approximately 6–10 visits per year. Each survey lasted 2.6–3.5 hours, mainly conducted in the morning (0630–1230). During each visit, direct counts of vultures present at the dumping site, and surrounding roosting locations were recorded using visual observation. Observations focused on feeding grounds and nearby powerline structures used for perching.

For each survey the following data were collected-

- Date and location
- Species identity (where possible)
- Number of individuals

Surveys were conducted on a non-systematic basis. Survey frequency varied across the study period, with an approximate minimum of 1–2 visits per month during active survey periods, and higher frequency during peak seasons. Overall, this corresponded to approximately 6–10 survey days per year, with 2–5 survey visits per season.

Mortality Recording

During each survey, the area surrounding the livestock carcass dumping site and nearby high-voltage power transmission structures within the 2–3 km survey area was searched on foot for vulture carcasses. Searches focused on the ground beneath transmission towers and powerlines that were frequently used by vultures as perching and roosting sites. The designated search area included the dumping site and adjacent powerline corridor, which were inspected systematically during each survey visit.

For each mortality event, the following information was recorded: (i) species identification, where possible; (ii) GPS location; (iii) photographic documentation; and (iv) visible evidence consistent with electrocution, such as burns or the carcass position beneath power infrastructure. Photographs were used to support species identification and confirm the cause of mortality.

Carcasses were not removed after documentation. To avoid duplicating records during subsequent surveys, each carcass was identified using its GPS location, photographs, species identity, and stage of decomposition. As carcass searches were conducted only during scheduled survey visits and not continuously, the mortality data presented represent minimum confirmed electrocution events, and the actual number of electrocution deaths may have been higher.

Survey Method

Field data were collected opportunistically during repeated surveys conducted between May 2011 and February 2014 at the livestock carcass dumping site in Sudhauwala and adjacent vulture loafing and roosting sites. The study area also included the surrounding high-voltage power transmission corridor, where vultures were frequently observed perching. A total of 34 surveys were undertaken, with greater sampling effort during the winter months (October–February) to coincide with the seasonal increase in vulture abundance. Surveys were conducted primarily between 0630 and 1230 h, with each survey lasting approximately 2.6–3.5 hours.

During each survey, all vultures observed at the dumping site, nearby roosting locations, and associated power transmission structures were identified to species level, where possible, and counted using direct visual observations. Photographic and video records were obtained to support species identification, verify flock composition, estimate the number of individuals present, and document behavioral activities, including feeding, perching, and resting.

The livestock carcass dumping site was surveyed because it represented the primary foraging area for vultures in the region, whereas the adjacent power transmission structures functioned as the principal loafing and roosting sites. Repeated surveys of these locations enabled the documentation of species composition, relative abundance, behavioral observations, and electrocution-related mortality throughout the study period.

Following the relocation of the carcass disposal site, post-relocation monitoring was undertaken at the newly established disposal site at Sudhauwala to assess continued use by vultures and other raptors. Monitoring consisted of two field surveys, conducted on 15 November 2015 and 15 December 2015. During each survey, all raptors observed within and immediately surrounding the disposal site were identified to species level and counted using direct visual observations. For each species, behavioral observations (e.g., feeding, soaring, flying or perching) and associated habitat type were recorded. The same survey approach was used during both visits to facilitate comparison with pre-relocation observations. Because individuals may have been recorded on more than one survey visit, observations from separate visits were treated as independent sampling events and were not combined to estimate population size.

RESULTS

Observations

Across repeated surveys conducted between May 2011 and February 2014, 743 cumulative vulture observations representing five species were recorded. Because these totals represent repeated observations during multiple survey visits, they should not be interpreted as population estimates. The highest number of individuals recorded during a single survey visit was observed for the Eurasian Griffon (85 individuals), followed by the Himalayan Griffon (35 individuals), Egyptian Vulture (21 individuals), and Cinereous Vulture (20 individuals). A single Red-headed Vulture *Sarcogyps calvus* was recorded during the study. A total of 46 electrocution-related mortality events were documented beneath or adjacent to high-voltage power transmission structures.

The Vulture use of the Dumping Site

The number of vultures recorded at the Sudhauwala dumping site varied among survey periods throughout the study. The highest number of individuals recorded during a single survey visit was 161 vultures in March 2013, comprising 85 Eurasian Griffons, 35 Himalayan Griffons, 21 Egyptian Vultures, and 20 Cinereous Vultures *Aegypius monachus*. Lower numbers were recorded during other survey periods, indicating temporal variation in the use of the dumping site by vultures. As survey effort varied over the years, these observations

Table 1. The total observational table of different species of vultures.

Species	Total observations	Maximum count per survey	Range per survey	Electrocution deaths
Eurasian Griffon	404	85	24–85	19
Himalayan Griffon	176	35	10–35	24
Cinereous Vulture	89	20	4–20	3
Egyptian Vulture	72	21	4–21	0
Red-headed Vulture	1	1	1	0
Unknown	1	1	1	0

Table 2. The total observational data representing the seasonal visits to the survey site.

Month	Surveys	Total vultures counted	Temporal coverage (Years)	Seasonal classification	Total mortality events
January	5	84	2014	Winter	3
February	4	59	2014	Winter	6
March	8	264	2012, 2013	Spring	11
April	0	-	-	Summer (early)	-
May	1	1	2011	Summer (early)	1
June	0	-	-	Summer (peak)	-
July	0	-	-	Summer (peak)	-
August	0	-	-	Summer (late)	-
September	4	85	2012	Autumn	6
October	8	187	2011, 2013	Autumn	13
November	0	-	-	Autumn (late)	-
December	4	63	2013	Winter	6

Image 2. The linear infrastructure (electric pole profile- 220 KV power transmission station) images of power plant and power line, these images represent a suitable perching site for the large birds like Vulture, Eagle etc. © B.Sc. Forestry Students (D.I.B.N.S. Dehradun).

represent differences in site use rather than changes in the regional vulture population.

Seasonal and Spatial Patterns

Electrocution incidents and vulture abundance exhibited strong seasonal patterns, with peak values recorded during March and October across multiple years. These periods consistently showed the highest counts of Gyps vultures (e.g., up to 85 individuals in March 2013 and 65 individuals in October 2011), along with the highest number of electrocution events. In contrast, vulture abundance declined sharply outside these peak periods. The only available record from the early summer period (May 2011) documented a single individual, indicating a substantial reduction in local vulture presence following the peak seasons. Although no surveys were conducted during peak summer months (June–July), the observed decline from spring to early summer, combined with the absence of records in subsequent months, suggests a strong seasonal reduction in vulture abundance during this period. This pattern is consistent with the known migratory and dispersal behavior of Gyps vultures, which move away from the region during warmer months.

Table 3. The post relocation data of the new dumping site with the total species observed.

Species	IUCN Red List status	Maximum count recorded during a single post-relocation survey	Survey month of maximum count
Egyptian Vulture *Neophron percnopterus*	Endangered	8	December 2015
Himalayan Griffon *Gyps himalayensis*	Near Threatened	4	November 2015
Eurasian Griffon *Gyps fulvus*	Least Concern	6	December 2015
Black Kite *Milvus migrans*	Least Concern	7	November 2015
Crested Serpent Eagle *Spilornis cheela*	Least Concern	7	December 2015

Image 3. A group of Egyptian Vultures (Endangered) species was reported from the new dumping site. © Ravi Kiran.

DISCUSSION

Electrocution

Electrocution can occur when a bird perches on a cross-arm and completes an electrical circuit with two or more body parts (Shobrak 2012). The lack of roosting trees in the dumping site area and presence of the large amount of tall electric poles attracts the birds to rest, particularly those of the Himalayan Griffon and Eurasian Griffon, make them highly susceptible to contact with overhead power lines. The data from the present study shows a significant effect on the vulture's population, below are the notable effects recorded from the Dehradun.

Electrocution as a Key Mortality Factor

The data clearly indicate that electrocution is a major source of mortality for the different species of vultures in the Dehradun region. These findings are consistent with global studies that identify power lines as a significant hazard for large avian species.

Conservation Concerns

The presence of human settlements and infrastructure in close proximity to key vulture habitats exacerbates the risk. The loss of vultures has broader

Image 4. A decomposing body of vulture was found underneath the power line. © Javed Anver.

Image 5. The Eurasian Griffon *Gyps fulvus* dead bodies under the high-tension electric pole (below picture) and another decomposed caracass was photographed during the survey. © Javed Anver.

ecological consequences, as these scavengers play an essential role in preventing the spread of disease by removing carcasses from the environment.

Electrocution and Conservation Implications

The present study demonstrates that electrocution associated with power transmission infrastructure represents an important source of mortality for vultures in the Sudhauwala region. The majority of electrocution deaths involved Himalayan Griffons and Eurasian Griffons, suggesting that these large-bodied species are particularly vulnerable because they frequently perch and roost on high-voltage transmission structures located adjacent to the carcass dumping site. Similar patterns have been reported elsewhere, where large soaring birds are at increased risk of electrocution due to their body size, wingspan, and use of electrical infrastructure as perching sites (Ferrer & Janss 1999; Biasotto et al. 2022).

The concentration of feeding resources close to power infrastructure is likely to increase the exposure of vultures to electrocution risk. These findings support the implementation of targeted mitigation measures, including relocation of carcass dumping sites away from hazardous electrical infrastructure and modification of high-risk power structures in areas that are regularly used by vultures. Such interventions have the potential to substantially reduce infrastructure-related mortality while maintaining access to important feeding resources.

Although electrocution was the primary focus of this study, vultures in the Indian subcontinent continue to face multiple anthropogenic threats, including poisoning, habitat degradation, and loss of suitable nesting and roosting sites (Prakash et al. 2012; Biju & Mize 2021). Consequently, reducing electrocution mortality should

Image 6. The vultures were photographed sitting on the power line. © Javed Anver.

Image 7. A group of vultures were seen sitting on the electric pole, on the below a Red-headed Vulture can be seen from the Sudhauwala area. © Javed Anver.

Image 8. Two partially decomposed body of the Himalayan Griffon *Gyps himalayensis* were photographed close to a high-tension pole. © Javed Anver.

be considered as one component of an integrated conservation strategy for these threatened scavengers.

Diclofenac Poisoning

Historically, the vulture population in India has suffered dramatic declines due to poisoning from diclofenac, a non-steroidal anti-inflammatory drug used in veterinary medicine. Although diclofenac has been banned, its impact lingers, making vultures more vulnerable to threats such as electrocution.

Mitigation

Given the significance of electrocution as a threat to vultures in Dehradun, we propose the following mitigation measures:

1. Shifting the dumping site: Based on field observations and documented instances of vulture mortality due to electrocution, the authors formally recommended the relocation of the carcass dumping site to reduce exposure to nearby power infrastructure. This recommendation was developed as part of the present study and communicated to the Divisional Forest Office (DFO), Dehradun Forest Division, and the Municipality of Sudhauwala through a written technical report submitted in the year 2014. The report included spatial analysis of mortality locations, photographic evidence of electrocution incidents, and an assessment of the proximity of the existing dumping site to high-risk electrical infrastructure.

2. The recommendation emphasized that the existing dumping site, located near expanding power infrastructure, posed a continued risk to scavenging vultures. A proposed alternative site, approximately 2.4 km from the original location and within a relatively undisturbed area, was identified to minimize disruption to vulture movement patterns while reducing electrocution risk.

3. Involving the local Administration/Municipality: The authors were engaged with relevant local authorities, including the Forest Department and the Municipality of Sudhauwala Dehradun, to address the issue. Detailed

Image 9. On the above picture, two dead vultures were photographed by the team near the high-tension electric pole in Dhalwala and on the below picture two dead vultures were reported under the electric pole. © Javed Anver.

reports and necessary documentation were submitted, highlighting the urgency of relocating the dumping site, which is in close proximity to expanding power infrastructure. In response, the authorities acted promptly, facilitating the relocation of the dumping site to a safer location, thereby reducing the risk of further electrocution-related vulture mortality. This coordinated effort demonstrates the potential for effective conservation action through collaboration between research institutions and local government bodies.

4. Relocation: The relocation was done on 04 April 2015 by notifying the local community with a notice, to those who actively participate in the dumping of their livestock. A warning board from the forest department was installed to ensure the prevention of dumping the caraccas on the site. A new site was allotted to the villagers and local community to dump their carcasses and safeguarding it to prevent any further death in vulture species.

5. Post-relocation: Vultures were observed feeding at the relocated carcass disposal site during both post-relocation surveys, demonstrating continued use of the new feeding area. The relocation was intended to reduce the risk of interactions with nearby power infrastructure, although the limited post-relocation monitoring did not allow a quantitative assessment of changes in activity at the former site. In addition to vultures, other raptor species, including the Black Kite *Milvus migrans* and Crested Serpent Eagle *Spilornis cheela*, were also recorded at the relocated site.

Image 10. The dumping ground surrounding with power line and vultures can be seen in the background, a stray dog can also be observe in this photograph. © Javed Anver.

CONCLUSION

This study documents electrocution as an important source of mortality for vultures using a livestock carcass dumping site located adjacent to high-voltage power transmission infrastructure in the Sudhauwala region of Dehradun, India. During 34 surveys conducted between 2011 and 2014, 46 confirmed electrocution-related mortality events were recorded, with Himalayan Griffons and Eurasian Griffons accounting for most documented deaths. These findings indicate that the proximity of predictable food resources to electrical infrastructure can create localized mortality hotspots for large scavenging birds.

The relocation of the carcass dumping site was done on 04 April 2015, approximately 2.4 km from the original location was implemented as a management intervention to reduce this risk. Limited post-relocation monitoring demonstrated that vultures continued to use the relocated feeding site, suggesting that relocation can maintain access to food resources while potentially reducing exposure to hazardous infrastructure. However, because post-relocation monitoring consisted of only two surveys, the effectiveness of this intervention in reducing long-term electrocution mortality could not be quantitatively evaluated.

The study highlights the importance of incorporating power infrastructure into vulture conservation planning. Locating carcass disposal sites away from hazardous transmission structures, together with retrofitting high-risk power poles and implementing long-term monitoring, should be considered practical conservation measures to reduce infrastructure-related mortality of vultures and other large soaring birds.

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Hindi: गिद्ध (Vultures) विश्व स्तर पर सबसे अधिक संकटग्रस्त पक्षी समूहों में से एक हैं। एशिया और अफ्रीका में उनकी आबादी में मानवजनित (Anthropogenic) कारणों से अत्यधिक गिरावट आई है। इसके प्रमुख कारणों में विषाक्तता (Poisoning), पशु-चिकित्सा में प्रयुक्त नॉन-स्टेरॉयडल एंटी-इन्फ्लेमेटरी दवाओं (NSAIDs) का उपयोग, भोजन की कमी, पारंपरिक मान्यताओं के कारण उनका उपयोग तथा विद्युत अवसंरचना (Power Infrastructure) से होने वाली मृत्यु शामिल हैं (Ogada et al. 2012; Botha et al. 2017)। इन सभी कारणों में से विद्युत अवसंरचना से करंट लगने (Electrocution) के कारण होने वाली मृत्यु एक महत्वपूर्ण, किन्तु अपेक्षाकृत कम रिपोर्ट की गई समस्या के रूप में उभरकर सामने आई है।. यह अध्ययन भारत के उत्तराखंड राज्य के देहरादून जनपद के सुधौवाला (Sudhauwala) क्षेत्र में गिद्धों की करंट लगने से हुई मृत्यु का दस्तावेजीकरण प्रस्तुत करता है। यह अध्ययन मई 2011 से फरवरी 2014 के बीच किए गए क्षेत्रीय सर्वेक्षणों पर आधारित है। कुल 34 सर्वेक्षणों के दौरान पाँच प्रजातियों के 743 गिद्धों का अवलोकन किया गया। इसी अवधि में उच्च वोल्टेज (High-Tension) विद्युत संचरण लाइनों एवं उनके टावरों के निकट करंट लगने के कारण मृत पाए गए गिद्धों के कुल 46 शव दर्ज किए गए। अवलोकित गिद्धों की संख्या की तुलना में सबसे अधिक मृत्यु अनुपात हिमालयी ग्रिफॉन (Gyps himalayensis) में दर्ज किया गया, इसके बाद यूरेशियन ग्रिफॉन (Gyps fulvus) तथा सिनेरियस गिद्ध (Aegypius monachus) का स्थान रहा। यद्यपि सर्वेक्षण नियमित एवं व्यवस्थित पद्धति से नहीं किए गए थे, फिर भी दर्ज की गई मृत्यु घटनाओं की संख्या यह संकेत देती है कि करंट लगने की समस्या गिद्ध जैसे दीर्घायु मृतभक्षी पक्षियों के लिए स्थानीय स्तर पर एक गंभीर खतरा हो सकती है।. इन अवलोकनों के आधार पर, स्थानीय प्रशासन के सहयोग से उस मृत पशु निस्तारण स्थल (Carcass Dumping Site), जो गिद्धों को इस क्षेत्र की ओर आकर्षित करता था, को उच्च जोखिम वाली विद्युत अवसंरचना से लगभग 2.4 किलोमीटर दूर स्थानांतरित किया गया। स्थानांतरण के बाद किए गए सीमित अनुवर्ती (Post-relocation) अवलोकनों से यह पता चला कि गिद्ध नए निस्तारण स्थल का उपयोग करते रहे तथा इस अवधि में करंट लगने से किसी भी गिद्ध की मृत्यु दर्ज नहीं की गई।. यह अध्ययन दर्शाता है कि भोजन स्थलों के समीप स्थित विद्युत अवसंरचना गिद्धों के लिए गंभीर जोखिम उत्पन्न करती है। साथ ही, यह भी प्रदर्शित करता है कि मृत पशु निस्तारण स्थलों का सुरक्षित स्थान पर स्थानांतरण करंट लगने से होने वाली मृत्यु के जोखिम को कम करने के लिए एक प्रभावी एवं व्यावहारिक संरक्षण उपाय हो सकता है। इस अध्ययन के निष्कर्ष गिद्धों के लिए अवसंरचना-जनित खतरों की समझ को बेहतर बनाने में योगदान देते हैं तथा मानव-प्रभावित परिदृश्यों (Human-dominated Landscapes) में उनके संरक्षण की योजना बनाने के लिए उपयोगी जानकारी प्रदान करते हैं।

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