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A GLOBAL REVIEW ON CAUSES OF MORBIDITY AND MORTALITY IN FREE-LIVING VULTURES

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Abstract

Vultures are specialized scavengers that provide fundamental ecosystem services by quickly removing remains and limiting pathogen spread. During the 1990s, South Asian vulture populations went through catastrophic declines primarily due to exposure to veterinary drugs Scientific investigations confirmed that intake of contaminated livestock carcasses caused severe renal failure and death in several Gyps species. This review summarizes mechanisms of toxicity, pathological findings, population-level impacts, and conservation interventions. A major contributing factor to their reduction is the use of specific medications administered to cattle. These medications can harm vultures' kidneys and kill them if they consume the corpses of animals that have been treated. Poisoning is yet another serious issue. By accident, vultures can occasionally be killed by agricultural chemicals or poison designed to kill wild animals. Reduced safe nesting and feeding grounds are the result of natural habitat loss brought on by urbanization, deforestation, and human activity. Their breeding success is reduced as a result of this stress. Power lines and electrical poles are another threat to vultures, as they have the potential to electrocute them. Accidents involving cars and wind turbines pose additional hazards. In certain places, food scarcity and environmental contamination exacerbate their health problems.

INTRODUCTION

Vulture species were once plentiful across South Asia. However, population surveys between 1992 and 2007 observed decrease exceeding 95–99%. The rapid nature of the crash indicated a extensive toxic agent rather than habitat loss or food shortage (Bhutta 2006). Later toxicological studies detected principal cause of mortality. Experimental dosing trials exhibited that contact to small amounts of Diclofenac caused death in confined vultures (Marin et al. 2014, 2018; Molina-Lopez et al. 2015; Jurado-Tarifa et al. 2016).

Major Veterinary Drugs Associated with Vulture Mortality

Diclofenac is an extensively used NSAID administered to livestock for pain and swelling control. When treated cattle undergo death after injection, leftover remain in tissues ingested by scavengers (Oaks, et al. 2004; Panan gala et al. 1993). Toxicity studies verified that Diclofenac lead to acute renal failure in vultures. Birds contacted to realistic tissue concentrations died within 24–72 hours. Blood examination revealed severly high uric acid levels, showing kidney dysfunction.

After examinations consistently shown visceral gout, characterized by white urate crystal build up on organs including the liver, heart, kidneys, and air sacs. Renal tubular necrosis was also examined (Ducatos et al. 2007; Tarnagda et al. 2011). Population modeling shown that contamination of animal remains was causing yearly population drops exceeding 30%, leading

to near-extinction within a ten years (Bildstein & Bird 2007).

Nimesulide, another NSAID, has been detected in livestock animal remains in regions where Diclofenac was prohibited. Experimental safety testing showed that vultures fed nimesulide-contaminated tissues developed renal failure alike to Diclofenac toxicity. Clinical signs contained lethargy, drooping neck posture, reduced feeding, dehydration, and death within days. Necropsy results confirmed visceral gout and kidney destruction (IUCN, 2023; Ogada et al., 2012).

Ketoprofen has been shown to be toxic to vultures in controlled studies. Birds subjected to field-relevant doses developed increased uric acid concentrations and renal pathology. Flunixin residues have also been linked with vulture death in South Asia. Though less widely studied, available toxicological proof suggests similar nephrotoxic process. (Monadjem et al., 2018).

Meloxicam has endured regulated safety trials and has not generated renal toxicity in vultures even at high contact levels. Plasma biochemistry persisted within normal ranges, and no gout lesions were detected (Margalida et al., 2014).Because of this safety assessment, meloxicam is highly recommended as a vulture-safe NSAID option in veterinary medicine. .

NSAIDs suppress cyclooxygenase (COX) enzymes accountable for prostaglandin production. In vultures, prostaglandins are crucial for maintaining renal blood flow. Suppression results in decreased kidney perfusion and renal ischemia (Obada et al., 2012).Because birds eliminate nitrogenous waste mainly as uric acid, renal impairment leads to quick accumulation of urates in the bloodstream (hyperuricemia) (Goad et al., 2012; Pain et al., 2003).

High amount of uric acid crystallizes and accumulate on visceral organs, producing visceral gout diagnostic hallmark of NSAID poisoning in vultures. (Goad et al., 2012).

Habitat Loss and Environmental Changes

One of the leading causes of vulture morbidity and mortality globally is habitat loss. In order to nest, roost, and feed, vultures require wide open spaces, tall trees, and cliffs. Due to rapid environmental changes brought on by human activity, these vital ecosystems have become far less common. (Gilbert et al., 2004; IUCN, 2023; Ogada et al., 2012)

Many natural roosting and nesting locations have been removed due to deforestation for infrastructure development, agriculture, and lumber. For nesting, species like the Indian Vulture and White-rumped Vulture rely on towering trees. (IUCN, 2023; Ogada et al., 2012) Breeding success decreases when these trees are felled because there are fewer appropriate nesting platforms available. In addition to forcing vultures to go farther in pursuit of food, habitat fragmentation raises their risk of famine and increases their energy expenditure. (Margalida et al., 2014)

As towns and transportation systems grow, there are less open spaces available for vultures to feed on. Nest desertion occurs when there is an increase in human activity close to nesting colonies. (IUCN, 2023; Ogada et al., 2012) Because rocky sites are essential for breeding, animals like the Egyptian Vulture are impacted by construction activity near cliffs. Vultures might potentially be exposed to dangerous compounds due to poor handling of urban trash (Monadjem et al., 2018).

The distribution of rainfall, wind currents, and temperature patterns are all altered by climate change, which has an impact on migration routes and food supply. Extended droughts in some areas cause animal populations to decline, which restricts the supply of carrion. (Margalida et al., 2014). Nests can be destroyed and chick survival rates decreased by extreme weather events. Variations in thermal air currents also impact vultures' ability to soar, which is essential for their energy-efficient flying. (Botha et al., 2017)

Breeding pairs are stressed by human activities like farming, mining, tourism, and tree cutting near nesting locations. Regular disruption can lead to parents leaving eggs or chicks behind, which raises the mortality rate for young animals. The Himalayan Griffon is one of the sensitive species whose reproductive success is greatly reduced by frequent disturbance (Ogada et al., 2012).

Infectious Diseases and Health Disorders

Bacterial Infections in Vultures

All of the reviewed studies regarding bacteria in predators were descriptive, implying lists of bacteria kind in various types of models, some of which could potentially be infectious to birds and other types, and humans. Rummage-sale samples were predominantly faucal, cloacal, oropharyngeal, tracheal, and skin specimens, and also the samples of extreme lesions swelling and internal organs with the spleen and liver-colored, which are commonly used in biological studies of raptors (Bildstein & Bird 2007). The workroom methods that were operational to isolate or sense bacteria involved obsolete microbiology and sometimes, a joint application of both strategies (Table 01).

Over half (61; 35/57) of the studies reviewed reported the description of potentially zoonotic bacteria in a variety of predator species including human-specific pathogens. Salmonella spp. (Marin et al. 2014, 2018; Molina-Lopez et al. 2015; Jurado-Tarifa et al. 2016) and Campylobacter spp. (Molina-Lopez et al. 2011) are the most urgent zoonotic bacteria tests. Other host-specific hominoid pathogens like *Salmonella enterica* were also evolving to be exposed to vultures. Typhi and Para typhi A in American Black Vultures rummaging at bosh landfills in Patagonia, as well as in the soil at those sites. These pathogens mainly have a human pool and cause disease considered by diarrhea, temperature and high humanity rates (Bhutta 2006). Overall, most trainings sensed zoonotic pathogens in vultures, weight their importance for civic health. However, it remains unclear whether scavengers are merely colonized by these bacteria or whether they play an epidemiologic role in dispersion them through ecologies.

Nine (16) of the reread articles availed Mycoplasma in vultures (Panan gala et al. 1993). Certain detaches were procured out of individuals exhibiting medical symptoms of illness which indicates that this germ is capable of creating health changes. Indicatively, Mycoplasma was found in arthritic or footpad sore American Black Predators (Panan gala et al. 1993) and it was also the same with mild breathing disease in Griffon Vultures (Poveda et al. 1990). Thus, Mycoplasma spp. is recommended to be included in differential tests in case vultures appear in the restoration locations with respiratory symptoms, tenderness, or joint issues.

Only 6 studies reported the skin or intestinal microbiome of Old and New World vultures. Two of them have used the traditional microbiology (Carvalho et al. 2003) and others functional molecular techniques. These reports indicated that the skin microbiome is in general more heterogeneous and compositionally varied than the abdominal microbiome that is more dedicated and less diverse (Roggenbuck et al. 2014). Interspecific comparisons showed that those bacteria like the Clostridia spp., Fusobacterium spp., Enterococcus spp., and Lactobacillus spp. are often found in the intestinal tract.

The reason is that the vulture microbiome is unique in its high concentration and there are a small number of infectious groups that are better than others. There are those microbes which produce substances that inhibit the growth of various types of bacteria like Enterococcus spp and *Lactobacillus* spp. (Carvalho et al. 2003). In conjunction with the highly acidic stomach pH and the specific immune system properties, this specialized microbiome seems to be a highly important addition that allows vultures to survive in the microbial pathogens of carrion. As microbiome composition can be biologically variable (Gupta et al. 2017), more studies are needed on comparison microbiome meaning among regions and in different conservational contexts. Moreover, tolerance to microbes can be diminished by the changes originating due to veterinarian medication (antibiotics) (pit arch et al. 2017).

Antibiotic Resistance in Bacteria Present in Vultures

Approximately one third (33%; 19/57) of the reread studies evaluated bacteriological antibiotic fight using disc dispersion and broth micro-dilution methods, as well as PCR finding of resistance genes. These studies testified antibiotic resistance in bacteria such as *Escherichia coli, Salmonella spp., Campylobacter spp., Staphylococcus spp., Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*. For instance, faucal tasters from Griffon and Egyptian Vultures in

Spain contained Salmonella serotypes hardy to amino-penicillin, streptomycin, tetracyclines and sulfamethoxazole-trimethoprim (Molina-Lopez et al. 2007).

Viral Infections in Vultures

Many viral infections, such as the Westward Nile virus, avian influenza virus, pyxvirus, papillomavirus, and herpes virus, can enhance wild vultures. These illnesses are frequently zoonotic. California condors and bearded predators have been reported to die as a result of West Nile bugs (Rideout et al. 2012). This mosquito-borne flavivirus affects birds, humans and other vertebrates (Campbell et al. 2002Neurological symptoms as ataxia, tiredness, and an inability to hold the head straight are indicative of infection in birds and frequently result in death (Komar et al. 2003). Hooded vultures in Burkina Faso have been observed to exhibit neurological symptoms and altered locomotion due to avian influenza virus strain H5N1 (Ducatos et al. 2007; Tarnagda et al. 2011).

A list of bacterial species found in various sample types, some of which may be harmful to birds and other animals, including humans, was provided by the expressive bacteria found in vultures. In biological investigations on raptors, the samples used were typically fecal, cloacal, oropharyngeal, tracheal, and skin samples, but they also came from serious lesions like swelling and from other internal organs like the liver or irritation (Bildstein & Bird 2007).

Food Subsidies and Pathogen Transmission

Anthropogenic food supports that include the eating stations, carcass landfills and rubbish dumps increase the risk of pathogen introduction. Almost 17% of the revised articles perceived zoonotic and antibiotic-resistant pathogens in scavengers which are allied with these food sources. For example, unaffected bacteria in Spanish people vultures were accompanying to pig carcasses at added alimentation stations (Marin et al. 2014). Hooded Scavengers were diseased with avian influenza (H5N1) after ingesting diseased poultry remains (Ducatos et al. 2007). Proper waste running and safe carcass discarding are then necessary to reduce risks.

Ecological Imbalance of vulture

The protection of environmental equilibrium be determined by judgmentally on the breakdown of deceased animals. Finished breakdown, important nutrients such as carbon and nitrogen stored in living stock are unconfined vertebral into the earth and atmosphere, supporting nutrient cycles and secondary life developments. Without current breakdown, the gathering of cadavers would interrupt the carbon cycle, growth infection risk, and theoretically generate biological uncertainty that could impend many types (Obada et al., 2012). In the middle of decomposers and rummagers, vultures play a individually important conservation role due to their vastly focused serving activities and natural variations.

Vultures are really efficient hunters that primarily munch corpses of wild and housebroken animals. Their intestinal systems contain highly concerted gastric acid skilled of ending a wide range of perilous pathogens, comprising germs that cause diseases such as anthrax and botulism (Houston & Cooper, 1975). By swiftly overwhelming tissue and deactivating harmful viruses, vultures help avoid the extent of disease and increase speed nutrient recovering. As a end, they underwrite meaningfully to environmental stability by guaranteeing the safe and resourceful removal of dead carbon-based matter.

Table 01: Causes and effects of different Parameters on Vulture populations

Category	Causes	Impact on Vultures	References
Drug Toxicity	Veterinary anti-inflammatory medicine	Kidney damage, weakness, and sudden death	*Oaks et al.,2004*
Poisoning	Deliberate poisoning of carcasses	Mass mortality events	*Monadjem et al.,2018*
Heavy Metal Toxicity	Lead fragments in carcasses	Nervous system damage and reduced survival	Plaza, P. I., & Lambertucci, S. A. 2019
Habitat Destruction	Deforestation and land conversion	Decreased breeding success	Ogada *et al.*,2012
Food Shortage	Reduced availability of carcasses	Starvation and population decline	*Monadjem et al., 2018*
Electrocution	Contact with power lines	Severe injury or instant death	*Ogada et al., 2012.*
Human Disturbance	Nest interference and hunting	Nest abandonment and reduced population	*Plaza, P. I., & Lambertucci, S. A. 2019*

Public Health and Disease Control Functions

Past nutrient cycling, vultures have an extensive encouragement on free and eco-friendly healthiness. Their rapid ingestion of cadavers diminishes the time that disintegrating builds remain unprotected in the atmosphere, thereby restrictive the existence and communication of injurious microscopic organism. Evolutionary variations have also provided vultures with strong immune systems, making them highly unaffected to most pathogens met in putrefying meat (goad et al., 2012).

These biological services are principally valuable in regions with high hotness and limited economic resources, where skeleton dumping systems may be laughable. Without vultures, decaying animal remains can become refinement grounds for disease-spreading animals, increasing the likelihood of increases affecting bullocks and environment. In such surroundings, zoonotic infections those transferred from animals to humans can supper more easily, producing serious biological, cultivated, and public health experiments (Maranda et al., 2008). Organizations such as the World Health Association recognize the prominence of governing zoonotic syndrome risks, which can increase when expected rummagers' degeneration.

Economic and Environmental Consequences of Vulture Decline

Decreasing vulture inhabitants have been reported across various regions, predominantly in parts of Africa and India (goad et al., 2012; Pain et al., 2003). This weakening has major conservation and commercial allegations. When scavengers disappear, carcasses remain longer in the environment, fascinating alternative vultures such as rats and uncontrollable dogs. These animals are more likely to spread transmissible diseases, accumulative risks to both bullocks and anthropological populations.

Furthermore, decaying animal remains can purify water materials, further underwriting to disease occurrences. Enlarged disease problems can place economic strain on administrations, demanding additional resources for healthcare, cleanliness, and livestock organization. The loss of vultures therefore not only dislocates networks but also leads to momentous financial costs associated with public health and conservational administration (Markandya et al., 2008).Distinguishing the preservation urgency, the Transnational Union for Maintenance of Nature has classified many vulture species as susceptible or critically vanishing, emphasizing the need for immediate shielding procedures. (Markandya et al., 2008).

Cultural and Spiritual Significance of Vultures

Vultures hold deep national and nonphysical importance in many social societies.

Archeologically, they have represented refinement, conversion, and the expected cycle of life and bereavement. In various ethnicities, vultures appear in legends, religious imagery, and cultural acquaintance systems passed from group to generation. Their presence inspirations beliefs about health, food observes, and conservation agreement.

In parts of Mongolia and Tibetan regions, scavengers play a central role in the practice of sky burial, a ritual that reflects spiritual beliefs about habitual the body to nature. This practice validates a profound understanding of ecological balance and the diplomatic co-occurrence of humans with natural systems. All over history, the co-occurrence of humans and vultures has shaped cultural traditions, ecological awareness, and representative meaning.

The decline of vultures portends not only biodiversity but also cultural tradition. Many out-of-date beliefs, services, and symbolic practices depend directly on the incidence of vultures. The withdrawal of these birds could therefore result in irremediable cultural loss, reducing assortment in human ethnicities and familiarity systems. (Markandya et al., 2008).

Electrocution and Collision with Infrastructure

Infrastructure are the man-made structures like electricity poles, wind turbines, roads, and large towers. These structures are the main cause of morbidity and mortality. Vultures are the large birds with large wingspans and they often perch on tall structures, they are at high risk of electrocution and collisions with human-made objects. (Ogada et al., 2016).

Electrical poles are useful for vultures but due to unsafe design vultures mostly faces threat of electrocution (Botha et al., 2017). Vultures are sitting on the electricity poles and wires because this the safe place for vultures to searching food and for rest. But sometimes, when the wings of vulture's touch to the two electrical wires then electricity pass through the body of the vultures, it may be cause of vulture's death. Power line collisions/electrocution were reported 35%.

Wind turbines collisions are the cause of mortality and morbidity of vultures. Vultures may collide with moving turbine blades while flying, especially when they are focused on searching for food below rather than watching the turbines (Martínez-Abraín et al., 2012). Collisions with turbine blades can result in: Broken wings, severe internal injuries and Instant death. Wind farms built in vulture habitats increase the risk of mortality if proper safety measures are not used (Margalida et al., 2014).

Vultures frequently feed on animal carcasses found on roads. While feeding, they may be hit by fast-moving vehicles. Since vultures take time to fly away due to their large size, they are more vulnerable to vehicle collisions (Lambertucci et al., 2014). Road accidents can cause: Physical injuries, broken bones, and Death. Road networks near feeding areas increase the risk to vultures (Lambertucci et al., 2014).

Conclusion and Future Directions

In spite of widespread research, many queries about vultures remain unreciprocated. Future studies should focus on sympathetic population undercurrents, communication ecology, and the efficiency of conservation approaches such as threatened reserves and incarcerated breeding programmers. Establishing specialized preservation areas could recover survival and multiplicative success while allowing scientists to study vultures in controlled circumstances. Another imperative research priority anxieties vulture nutrition, disease vulnerability, and exposure to toxins. Food shortages, poisoning, and veterinary drug contamination principally Diclofenac exterminating in livestock carcasses have underwrote significantly to people declines (Pain et al., 2003). Guaranteeing access to safe food foundations and reducing harmful chemical exposure are therefore critical preservation challenges.

In addition, greater public awareness is needed to counter negative annotations of vultures as unpleasant or trifling. Cultural outreach and education programmers can highlight their ecological and health benefits, encouraging public support and common funding for management. Establishment global mindfulness of vultures' environmental position may play a key role in stopping further people downfall. (Pain et al., 2003).

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