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Review Paper

Vultures in India: A review

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Abstract

Various papers published on studies related to the status of vultures in India were collected and assessed to acquire relevant information. In this paper, we reviewed and outlined the distribution, unique adaptations, habitat preferences, feeding behavior, breeding behavior, population status, threats, and impacts of the decline of vultures in India. Vultures are medium to large-sized scavenging birds that primarily feed on carrions. Being scavengers, they deliver an array of ecological, economic and cultural services. They feed on rotten carcasses and prevent the spread of deadly and contagious diseases like brucellosis, rabies, anthrax, plague, tuberculosis, etc. In the last two decades, drastic decline in the numbers of vulture populations have been observed. Many workers found the use of diclofenac; a non-steroidal anti-inflammatory drug in livestock is the main culprit for such decline. However, other factors of equal potential are also recognized, which include food scarcity, habitat loss, and others. The decline of these vultures poses serious threats to wildlife, livestock, and human health.

Keywords: Distribution, habitat preferences, threats, decline, vulture, Arunachal Pradesh.

Introduction

Vultures are large to medium-sized birds of prey and are nature's most efficient scavengers. They primarily feed on carrions of livestock and wild animals[1]. Unlike other birds of prey, vultures do not hunt rather they rely on carrions or carcasses. They consume large amount of carcasses, which could otherwise have caused adverse effect on human as well as the ecosystem since the unattended carcass can serve as a potential breeding ground for many pathogens and sources of diseases such as brucellosis, anthrax and tuberculosis to the livestock[2,3]. Being scavengers, vultures occupy unique niche and remain at the top of numerous food chains in the ecosystem. They also help in maintaining the ecological balance of the ecosystem. Thus, a drastic or abrupt decline in their population can have negative impact on the ecosystem.

Globally, there are 23 species of vultures categorized into two non-related groups, old world vulture (OWV) and new world vulture (NWV). These groups show functional similarities only because of convergent evolution. The OWVs belongs to order Accipitriformes and are more related to buzzards, kites, eagles and harriers[4]. Whereas the NWVs belongs to order Cathartiformes and are related to storks[5,6]. Out of 23, 16 species belong to OWVs and 7 species to NWVs[7] (Table-1). Of the total OWVs, 9 vulture species are found in India. These include Himalayan vulture (*Gyps himalayensis*), White-rumped vulture (*Gyps bengalensis*), Long-billed vulture (*Gyps indicus*), Slender-billed vulture (*Gyps tenuirostris*), Red-headed vulture (*Sarcogyps calvus*), Cinereous vulture (*Aegypius monachus*), Egyptian vulture (*Neophron percnopterus*), Bearded vulture (*Gypaetus barbatus*) and Eurasian Griffon (*Gyps fulvus*)[8]. Two species, Cinereous vulture and Eurasian Griffon are migratory species, and rest other 7 are resident species to India. However, Himalayan vulture is a regional migrant with different wintering and breeding sites within Indian states[9,10]. According to International Union for the Conservation of Nature (IUCN), White-rumped vulture (WRV), Long-billed vulture (LBV), Slender-billed vulture (SBV) and Red-headed vulture (RHV) are enlisted as critically endangered; Egyptian vulture (EV) as endangered; Bearded vulture (BV), Cinereous vulture (CV) and Himalayan vulture (HV) as near threatened; Griffon vulture (GV) as least concern[11] (Table-2).

Vultures have completely adapted morphologically and physiologically to a scavenging lifestyle. These adaptations include keen eyesight, soaring flight and extremely low pH levels in the stomach[12]. They have large wingspan, which helps them to fly with ease at great heights. They use the thermal and air currents to soar without compromising their intact energy to stay longer in the sky. OWVs have strong eyesight that helps them locate corpses (mainly large animals) even from many miles away while NWVs lack this adaptation but are equipped with a good sense of smell. Vultures have very low metabolic rates, which enables them to stay longer without any food and compensate the entire period. The vultures have high acidic gastric content that can easily kill almost any virus and bacteria present in the carcass[13] due to its high corrosive nature (pH: 1-2)[14].

Further, vultures have very high amount of antibodies, which can eliminate toxins produced by bacteria like *Clostridium Botulinum* that may be present inside even after the bacteria are killed[15]. They regurgitate the half-digested food when they perceive any threat from predator(s) or other animal(s). The vomit has very foul-smelling as well as high acidic content which drives away the predator(s). However, if the predators or other animals are close enough, the vomit can also cause burns to them[16]. Moreover, such regurgitation of recently ingested food helps vultures' to lessen their weight enabling them to take off easily and quickly.

Vultures have strong, long and hooked beaks that help them tear flesh from the carcass. The beak is operated by well-developed mandibular muscles. They can tear the carcass and clean it to the bone. Most of the vultures' diets contain flesh and other soft tissues. However with exception, 85% of the Bearded vulture diet is reported to be composed of bones[17]. Except for BV and EV, all the vulture species found in India have featherless head and neck; however, few down may be present on the neck. Since their heads and necks are bare, they can fully insert their heads into the carcass with a reduced risk of dirtying their bodies.

Unlike other raptors, vultures have weak and poorly padded toes with slightly curved talons. Such features make them insufficient to kill or hunt other animals like other raptors. The vultures have featherless toes and tarsi which help them to quick clean up after feeding. They excrete highly acidic and chemically potent urine on their own feet (a process called urohidrosis) to accomplish two functions. Firstly, to kill the bacteria and other parasites attached to the feet, and secondly, to regulate the body temperature[18].

In India, vulture populations have suffered a drastic declines in their numbers since the mid 1990s[19], with the decline in excess of 97% for three resident *Gyps* species (White-rumped vulture, Long-billed vulture and Slender billed vulture)[20]. From 1992 to 2007, the decline in numbers of WRV was 99.9% and combined total of LBV and SBV was 96.8%[21]. The RHV decline was estimated to be at least 90% by 2006[22]. These four vulture species are now listed as critically endangered species by IUCN[11], which is attributed to their severe and continuous decline. The causes for catastrophic change in population of vultures vary from region to region. However, the diclofenac theory and the alteration of the environment through anthropogenic activities are the most accepted one.

Table-1: Vulture species of the world[7].

Old world vulture (Africa, Asia and Europe)		New world vulture (North America and South America)	
1	Himalayan vulture (*Gyps himalayensis*)	1	Turkey vulture (*Cathartes aura*)
2	White-rumped vulture (*Gyps bengalensis*)	2	Lesser yellow-headed vulture (*Cathartes burrovianus*)
3	Long-billed vulture (*Gyps indicus*)	3	Greater yellow-headed vulture (*Cathartes melambrotus*)
4	Slender-billed vulture (*Gyps tenuirostris*)	4	Black vulture (*Coragyps atratus*)
5	Cinereous vulture (*Aegypius monachus*)	5	California condor (*Gymnogyps californianus*)
6	Red-headed vulture (*Sarcogyps calvus*)	6	King vulture (*Sarcoramphus papa*)
7	Egyptian vulture (*Neophron percnopterus*)	7	Andean condor (*Vultur gryphus*)
8	Eurasian griffon (*Gyps fulvus*)		
9	Bearded vulture (*Gypaetus barbatus*)		
10	Ruppell's vulture (*Gyps rueppelli*)		
11	Cape vulture (*Gyps coprotheres*)		
12	Hooded vulture (*Necrosyrtes monachus*)		
13	Lappet-faced vulture (*Torgos tracheliotos*)		
14	White-headed vulture (*Trignoceps occipitalis*)		
15	Palm-nut vulture (*Gypohieras angolensis*)		
16	White-backed vulture (*Gyps africanus*)		

Table-2: Vulture species in India[10,11]**.**

Vulture species		IUCN status	Resident/Migratory
1	White-rumped vulture	Critically endangered	Resident
2	Long-billed vulture	Critically endangered	Resident
3	Slender-billed vulture	Critically endangered	Resident
4	Red-headed vulture	Critically endangered	Resident
5	Cinereous vulture	Endangered	Migratory
6	Himalayan vulture	Near threatened	Resident, regional migratory
7	Egyptian vulture	Near threatened	Resident
8	Bearded vulture	Near threatened	Resident
9	Eurasian griffon	Least concern	Migratory

Distribution and Habitat Preferences

Except for Antarctica and Australia, vultures are found on all other continents. NWVs are found only on continents of North America and South America, whereas OWVs are found on the three landmasses connected continents namely Asia, Europe and Africa[23]. Among the OWVs, only 4 species, Egyptian vulture (*Neophron percnopterus*), Cinereous vulture (*Aegypius monachus*), Bearded vulture (*Gypaetus barbatus*) and Griffon vulture (*Gyps fulvus*) are found on all the three continents[1]. 9 vulture species are found in India and these include HV, WRV, LBV, SBV, CV, RHV, EG, BV and GV[8]. These have been recorded from almost all regions of the Indian state and union territories which includes Gujrat in the west to Arunachal Pradesh in the east or north-east and Jammu & Kashmir in the north to Tamil Nadu in the south. However, their distributions are not evenly throughout the Indian states rather they are found in patches[24].

In India, vultures are found in almost all major habitat types and can be observed in the plains, foothills as well as in higher altitudinal regions, i.e., from sea-level to 4500 m asl. However, Griffon vultures were recorded from an altitude of 10,000 m and above. The WRV, LBV and SBV are usually observed below 2700 m asl[23]. Vultures can be found in or nearby human habitation, in areas with livestock and wildlife population, in carcass dumping grounds, in open forest, in dense deciduous woodland, in wooded savannah, in rocky cliffs, in crags, in precipices, in canyons and gorges[23,25]. From time immemorial, vultures have been seen living in close proximity to humans. Such an interaction has benefited the vultures a lot as they gain access to the easy meal (disposed carcasses of livestock). They are often observed at bone factory campuses[26], on rocks in gorges and valleys[27]. Rocky cliffs and hills provide favorable nesting sites for vultures[28]. WRVs are observed to nest on tall coconut trees and well-foliaged pine trees[29]. Large and tall trees are mostly preferred for roosting and building their nests. These include *Shorea robusta*, *Albizza procera*, *Pterygota alata*, *Bombax ceiba*, *Anthocephalus cadamba*, *Ficus religiosa*, *Ficus bengalensis*, *Cocos nucifera*, *Boswellia serrata*, *Phoenix sylvestris*, *Alstonia scholaris*, *Dalbergia sissoo*, *Prosopis cineraria*, *Anogeissus latifolia*, *Piper methysticum*, *Tectona grandis*[10,18,29-31], *Terminalia arjuna*[32], *Pinus roxburghiii*[33]. This indicates they have no preference over particular tree species for nest building. However, all the tree species chosen were tall and strong. This is to provide protection to the nest and nestling from predator(s). The nests are built at a considerable height, inaccessible to other animals and humans. In terms of forest types, thorn forests have the highest numbers of vultures, followed by dry deciduous, moist deciduous and riverine forests[34]. Vultures are generally observed in the area with permanent water source[18,25]. They need water for few important activities such as drinking and taking bath after feeding. The act of bathing keeps them clean, cool and protected from the pathogens clinging on the bloodstains of the carcass. Breeding colonies are most often observed near rivers, canals, ponds, or even dams[18]. Water may help in maintaining humidity for the egg to hatch[35]. Like for other species, vulture's distribution is also affected by the components of habitat and its utilisation. Therefore, understanding of the habitat preferences of vultures is a prerequisite and fundamental for the preparation of any management plan to conserve them.

Feeding and Breeding behaviour

Vultures are obligate scavengers and unlike other raptors, they do not go on hunt. A congregation of vultures can clean up a carcass of cattle in 30 to 40 minutes. The vulture's stomach contains high acidic content which can digests any infected carcass safely and kills any pathogens efficiently and quickly[13,14]. Cinereous vultures are the first individuals to be seen in the feeding site, and then the *Gyps* vultures arrive. Most of the vultures come up only after the day warms up.

Vultures feed on carcasses that are 2-3 days old because, by this time, the flesh becomes tender and easy to open[36]. However, White-rumped vultures were observed to feed on the supplied carcass immediately, in captivity while other vulture species (LBV and SBV) feed almost after a day[37]. A vulture can eat up to 300-500 g of carrion per day in a single meal[18]. Although vultures feed mainly on carcasses; the EV can feed on tiger droppings, which is perhaps to collect hair for nest building[28]. Different species of vultures can be seen feeding together and also with other birds and mammals at the same feeding site[28,37]. This is because different species of vulture can exploit different portions of the carcass. In the feeding site, inter-specific and intra-specific competition can be observed[1]. Most of the vultures prefer soft tissues of the carcass. But with an exception, about 85% of the diet of the Bearded vulture consists of bones. A behavior of 'bone dropping' from height on the hard ground is observed in BV[17]. In Himalayan vultures, unusual behavior of feeding on tender needles of pine (*Pinus roxburghii*) is recorded. This vegetative matter may help in the procurement of nutrient supplement and roughage that aid in process of digestion[38]. After feeding on the carcass, vultures display an unusual act of bathing and sun-basking. The former helps the vultures to clean themselves, and the latter facilitate drying out of excess water from feathers. Basking continues for about an hour till the meal is partially or fully digested and thus by doing so, the sun's heat is used to kill the bacteria and other microorganisms attached to the body.

Vultures are slow breeders and reach maturity only when they are 4-6 years old. The clutch size is normally 1 and very rarely 2. Egyptian vulture, however, may lay 2 to 3 eggs a year[18]. They can re-lay if the previous one fails[39]. They are colonial breeders and usually use tall trees and rocky cliffs for nest building[10,40]. However, BV and SBV are solitary breeders and nest far away from their conspecific members and other vulture species[41]. The vulture's nest is a platform of sticks lined with green leaves[10]. Since vulture nests are large, nest building is an energy-intensive activity for them. Therefore, like other big raptors they build one strong nest at a time and continue to use it for the next few seasons until it is damaged[42]. Vultures are monogamous[43] and have almost no sexual dimorphism[44]. However, in Egyptian vulture extra-pair copulations are observed, where females sometimes associate with other males, providing extra help in raising the brood[45]. Nest building is a primary step in the process of breeding[46], followed by nest guarding, egg-laying and incubation, hatching, and then fledging. Both sexes of vultures are equally responsible for taking care of the nest and young ones. Breeding colonies are mostly observed near rivers, canals, ponds, or even dams[18]. Water helps in maintaining the humidity and thereby hatching of the egg[35]. Breeding season varies from species to species such as in case of WRV, it starts from January[47] while EV breeds in spring months[48]. Generally, the incubation period remains for approx. 35-42 days[48]. For different species, a complete breeding cycle varies from 7 to 8 months[18]. During the breeding season, the success of breeding is governed by the availability of food supply[10,49].

Population status and Threats

Vultures are among the most threatened raptor species[7,50,51]. Early accounts suggest vultures were once abundant across their distribution ranges. They were seen as annoyance and hindrance, particularly to aircraft, as they were frequently involved in bird strikes[52,53]. However, by the mid-1990s, drastic declines in vultures' population from their ranges have been observed, particularly in the regions of the Indian subcontinent. In India, the first report on vulture's population decline, which has also grabbed the global attention, came from the Keoladeo National Park in Bharatpur, Rajasthan[19]. Subsequently, population crashes were reported from other regions of their ranges[2,9,50,54-58] and is reflected in Table-3. The worst affected were the species of genus *Gyps*. In India, the total population decline of *Gyps* vultures was estimated to be 97% by 2005[20]. In another study, a decline in WRV's numbers during the period 1992-2003 was estimated at 99.7% and 97.4% for LBV plus SBV. This corresponds to a minimum estimated rate of decline of 34% per year for WRV and 27% per year for the LBV and SBV, collectively[59]. These *Gyps* vultures continue to decline, however by 2015 they have shown slight decrease in the decline rate. Moreover, WRV population had stabilized by 2010, but again continued to decline the subsequent years, at a slower rate. Based on regression model, the total population for WRV, LBV and SBV is estimated to be about 6,000 individuals, 12,000 individuals and 1000 individuals, respectively in India in 2015[60]. Decline in RHV population was also estimated at a rate of 41% per year in 1999 and 44% per year between 2000 and 2003 in India[22].

Table-3: Summary on population size and trends of vultures[11]

Vulture species	Population size (mature individuals)	Population trend
White-rumped vulture	2500-9999	Decreasing
Long-billed vulture	30000	Decreasing
Slender-billed vulture	1000-2499	Decreasing
Red-headed vulture	2500-9999	Decreasing
Cinereous vulture	5600–21000	Decreasing
Himalayan vulture	66000-334000	Stable
Egyptian vulture	12000-38000	Decreasing
Bearded vulture	1300-6700	Decreasing
Eurasian griffon	500000-999999	Increasing

Numerous explanations and hypotheses have been proposed for the decline of vultures. These include food scarcity, habitat destruction, infectious diseases, poisoning, intentional hunting and diclofenac contamination[2,9,19,53,56,61-64]. However, the diclofenac theory gained wide acceptance as the main reason for the decline of vultures[55,56,65-67]. Moreover, food shortage and habitat destruction appear to be the most credible factors for the decline of *Gyps* vultures in Cambodia and Myanmar[68,69]. The intensities of all these threats are different throughout their distribution ranges. Therefore, it is very important to first identify the threats to consider any conservation initiatives to save these declining birds. Exposure of diclofenac, a non-steroidal anti-inflammatory drug (NSAID) has a worsening effect on vultures, even it cause death. Vultures get exposed to this after feeding on the carcasses of livestock treated with diclofenac few hours earlier to its death[70]. In India, the traces of diclofenac in livestock carcasses were first identified by Taggart and his colleagues. They collected 1848 liver samples from carcasses of dead livestock sampled at 67 sites in 12 states within India where they detected diclofenac residues in the sampled carcasses from all states except Odisha. The overall prevalence of detectable diclofenac ($\geq$10µg kg^{-1}) across all states was found to be 10.1% and varied significantly among states, with up to 22.3% prevalence determined in Bihar[70]. In another study, a captive WRV got died soon after feeding on carcass of animal that had received a normal veterinary dose of the diclofenac just before slaughter[66]. A median lethal dose (LD_{50}) of diclofenac is estimated at 98-225µg kg^{-1} vulture body weight for WRV[67]. Diclofenac contamination causes kidney failure in vultures followed by death[55,66]. A post-mortem study on vultures displayed visceral or renal gout[66]. In Assam, 99% of mortality of WRV, SBV, and LBV is associated to the use of diclofenac in livestock[71]. Besides, other NSAIDs, ketoprofen and aceclofenac, have been also reported with the same lethal effect on *Gyps* vultures as diclofenac[72-74]. Aceclofenac, diclofenac, and ketoprofen are related as are arylalkanoic acid derivatives. Another drug, nimesulide residues have been reported from the kidney tissues which are responsible for visceral gout in vultures in India[75]. In Cambodia, vultures are threatened by food shortage due to low population densities of wild and free-ranging domestic ungulates. Further, it is worsen by the improved management of livestock carcasses disposal[68]. The devastation of feeding sites through cutting and clearing of trees to build commercial buildings was found to be the crucial cause for the decline of the vulture population in Jorbeer, Rajasthan[76]. Construction high-tension electricity lines, uncontrolled mining activity, renovation of forts and deforestation for agricultural purposes, urbanization, and firewood collection are the serious threats to nesting sites of vulture in Jodhpur, Rajasthan[36]. A pesticide, strychnine has been identified as a major source of vulture mortality in India[62] and Thailand[77]. Strychnine has been deliberately used to poison the carcasses to kill the scavenging predatory mammals. Dichloro-diphenyl-trichloro ethane (DDT), an organochlorine was the reason for reproductive failure and high mortality rates in avian scavengers in many countries[78-80].

Vultures get killed unintentionally with poisoned carcasses which were meant to kill cattle-marauding predators[81]. 37 vultures were killed by poisoned cattle carcass in Assam[82]. Vultures are vulnerable to high-tension power-lines as they sometime get electrocuted with it, especially in desert or semi-desert areas without tall trees[83]. Though unusual, direct or intentional hunting of vultures also threatened the declining vulture populations. They are being killed for a mere belief that they are unclean. The chicks, eggs, and adults are captured and killed for food[83,84]. Even the climatic conditions affect the distribution and occurrence of vultures. Vultures that breed at high altitudes, such as the Bearded vulture in southern Africa, experience range contractions due to increase in temperatures[85]. Further, vulture's innate property of being long-lived, having low reproductive rates, low juvenile survival add additional stress with prevailing threats to the already dwindling population[86].

Impact of decline

Vultures provide many services to the human society and natural environment, most notably carcass disposal. These services directly or indirectly affect human health, economic activity, and environmental quality. Considering the gradual decline in the vulture population, if the numbers drop abruptly or even if they become extinct, two consequences are going to happen, first, there will be an upsurge in the numbers of carcasses and secondly, there will be an increase in the numbers of facultative scavengers (vulture's substitute).

Ecological impact: The rise in the number of unattended carcasses directly affects human health. The carcass can serve as a potential breeding ground for many pathogens that will lead to the likelihood of direct and indirect infections such as anthrax, rabies, etc[2,9]. Diseases affecting livestock such as brucellosis, tuberculosis increases with increase in pathogens and vectors, associated with putrefying carrion[19]. Unattended rotten carrions or carcasses will pollute the environment (air, soil, and water), which may result in the increased incidence of anthrax and water-borne diseases to human[87]. Also, the decline in vulture populations leads to a rise in numbers of alternative scavengers such as feral dogs[9], other canine species and rodents. This situation increases the chance of spread of zoonotic diseases, such as rabies and bubonic plague[2]. In India, a remarkable increase in dog numbers was observed in the year 1997 and was estimated to be 29 million[87]. Cases of human rabies are prevalent in India and is estimated that over 95% of human deaths from rabies are due to dog bites[88].

Economic impact: The decline in vultures has had a significant impact on the lives of locals, especially in rural areas. In the absence of vultures, the locals are only left with two options, either they have to bury or burn the livestock if it dies, and for such they have to incur the cost[10].

In absence of natural carcass disposal mechanism performed by vultures, humans are compelled to adopt more sophisticated carcass disposal mechanisms. The decline in vultures has resulted in increase in carcass numbers, which in turn increases the incidence of diseases. Inevitably, a large amount of money has to be spent to control such a situation. With the vultures decline, the total cost of healthcare in India between the periods of 1993 to 2006 is estimated to be Rs.1046 billion[89]. The Parsee community of India had been known to depend on vultures for the corpses' disposal as they consider that the burial or burning of human remains defile the elements of earth[90]. In addition, the corpses are left in open for the vultures to feed as a religious custom for some community in Central Tibet and Nepal[90]. The declining vulture population has deprived the Parsee community to continue their traditional way of disposing the corpse. This has prompted the Parsee people to opt alternative means for corpse disposal such as the installation of 'solar concentrator' which hasten the decay of corpses and the construction of 'vulture centers'. In one report, the loss of vultures in Mumbai has cost the Parsee community with Rs.1.6 million[87]. Also, the vultures decline has adversely impacted the bone collectors and fertilizer industries in India in two ways. First, there is a loss of supply due to the disposal of carcasses by burial or incineration. Secondly, there is the unavailability of properly clean bones due to incomplete removal of flesh by alternative scavengers.

Conclusion

This paper outlined the distribution, unique adaptations, habitat preferences, feeding behavior, breeding behavior, population status, threats, and impacts of the decline of vultures in India. The paper indicates that significant amount of work related to the status of vultures has been carried out in India. However, more detailed and intensive research on species level is needed to provide complete information on the vultures of India. Over the last 20 years, declines in vulture populations have been reported by many authors, especially in the Indian subcontinent. Various studies have been carried out to determine the causal factor of the decline. Most of the study suggested that the diclofenac, a non-steroidal anti-inflammatory drug, was the main culprit for the decline. To tackle down this threat, the Ministry of Environment and Forest, India has issued a ban on diclofenac use and production by the year 2006. Other major possible threats suggested are the food scarcity and habitat loss. Therefore, it is evident and necessary to identify and understand the threats, habitat preferences, habitat utilization of vultures before the inception of any management plan to conserve these birds. The paper reveals that the decline in vultures is driven by both, natural environmental changes and human-induced threats. Also, the hygienic management of carcasses to prevent its adverse consequences has affected the vultures with, shortage of carcass. Taking into account the continuing decline in vulture, the paper recommends regular monitoring of vultures throughout India to track the population trends and to identify the potential threats or causal factors so that immediate and accurate conservative action can be implemented.

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