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Review article

POPULATION DECLINE OF VULTURES AND THEIR CONSERVATION: SCENARIO IN INDIA AND HIMACHAL PRADESH

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ABSTRACT
World list of living species of Vultures stands at 23, comprising of seven species of New World and 16 Old World species. They are found on every continent except Antarctica, Australia and Oceania. They are scavenging birds, feeding mostly on the carcasses of dead animals. Vulture stomach acid is exceptionally corrosive, allowing them to safely digest putrid carcasses infected with *Botulinum* toxin, hog cholera, and anthrax bacteria that would be lethal to other scavengers. Six, out of nine species of vultures found in India have been facing problem of existence and therefore declared as threatened. The veterinary use of the non-steroidal anti-inflammatory drug (NSAID)-diclofenac-in livestock is the main, and perhaps the only, cause of the population declines Likewise, due to this chemical, vultures suffer from a disease called gout. Only a few studies have been conducted on the ecological aspects of these vultures which are crucially important in the ecosystem as efficient scavengers. Recent studies conducted with the financial help from Department of Science and Technology, New Delhi revealed the presence of 8 species of vultures from different areas of Himachal Pradesh. A total of 22 nesting colonies of Indian White-backed Vulture, supporting 77 nests have been reported from different areas of Himachal Pradesh during breeding season (October to March/April) in 2010-2011. A single nesting colony of Slender-billed Vulture *Gyps tenuirostris* has been recorded in Baroh area of Kangra with 2 nests. A total of 14 nesting colonies, supporting 64 breeding pairs of Himalayan Griffon (*Gyps himalayensis*) have been reported from Himachal Pradesh. No conservation measure could be efficient in protecting these threatened species from extinction if we do not have any reliable information on the current status, species richness, habitat-use pattern and ecology of these vultures. Identification and monitoring of the locations and number of remaining individuals of Vultures in the wild would be effective measure for conservation.

KEYWORDS: Vultures, Causes of Population Decline, Rate of Decline, Conservation Measures

INTRODUCTION

Vultures are classified into two groups: Old World vultures and New World vultures. World list of living species of Vultures stand at 23, comprising of seven species of New World and 16 Old World species (Tables 1, 2). The similarities between the two different groups are due to convergent evolution. The Old World vultures found in Africa, Asia, and Europe belong to the family Accipitridae, which also includes eagles, kites, buzzards, and hawks. Old World vultures find carcasses exclusively by sight. The New World vultures and condors found in warm and temperate areas of the Americas are not closely related to the superficially similar Accipitridae, but belong in the family Cathartidae, which was once considered to be related to the storks. However, recent DNA evidence suggests that they should be included among the Accipitriformes, along with other birds of prey. However, they are still not directly related to the other vultures. Several species have a good sense of smell, unusual for raptors, and are able to smell the dead they focus upon from great heights, up to a mile away (BirdLife International, 2011; Wikipedia, 2011).

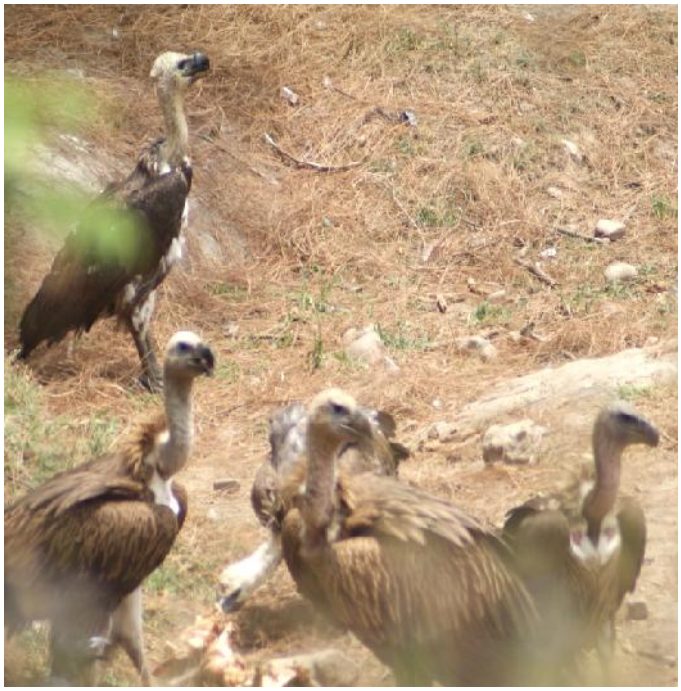
They are scavenging birds, feeding mostly on the carcasses of dead animals. They are found on every continent except Antarctica, Australia and Oceania. Vultures do not use their feet to kill their prey (the definition of a Raptor) and so have gone back and forth between being classified as a raptor or a non-raptor, and have gone through extensive DNA testing to test the relationships. A particular characteristic of many vultures is a bald head, devoid of feathers. This helps to keep the head clean when feeding. Research has shown that the bare skin may play an important role in thermoregulation (Ward *et al*., 2008).

Vultures seldom attack healthy animals, but may kill the wounded or sick. When a carcass has too thick a hide for its beak to open, it waits for a larger scavenger to eat first. Vast numbers have been seen upon battlefields. They gorge themselves when prey is abundant, till their crop bulges, and

sit, sleepy or half torpid, to digest their food. They do not carry food to their young in their claws, but disgorge it from the crop. These birds are of great value as scavengers, especially in hot regions. Vulture stomach acid is exceptionally corrosive, allowing them to safely digest putrid carcasses infected with *Botulinum* toxin, hog cholera, and anthrax bacteria that would be lethal to other scavengers. This also enables them to use their reeking, corrosive vomit as a defensive projectile when threatened. Vultures urinate straight down their legs; the uric acid kills bacteria accumulated from walking through carcasses, and also acts as evaporative cooling (Wikipedia, 2011). The digestive acids are not the sole factor present that benefits vulture's carrion-eating lifestyle. Vultures must also have an ability to destroy toxins produced by bacteria that may be present long after the bacteria have been killed. Some potent toxins may well be absorbed by the oesophageal (food-pipe) epithelium before ever reaching the stomach. *Clostridium botulinum*, the causative agent of Botulism, produces five different toxins (named toxins A through F). Toxins A & E are principally found connected with human illness, and toxin C with animal illness. It is perhaps for this reason that Vultures have very high titres (amounts) of antibodies against this toxin, and also antibodies against the other Botulinum toxins. This is also observable in Coyotes and Crows who also have remarkable ways of preventing poisoning. The adaptive mechanism for life as carrion eaters may therefore be the presence of a substantial immune system, which may have a partly genetic basis, but also 'immune training' from the parent (i.e. in mammals-from breast milk) and from encountering microorganisms/toxins themselves (Ohishi *et al*., 1979). It is for the above reasons that the digestive system of vultures' has been the topic of research. The ability to disinfect rodent carcasses carrying Hantavirus is currently being tested and could prove to be of great significance to human medical research. There may also be vital information to be discovered for use in the event of biological warfare, acts of terrorism, or world-wide epidemics (Shriner, 1998).

Vultures are believed to have evolved in parallel with large herds of migratory ungulates, feeding on the remains of sick, injured and depredated individuals (Mundy *et al*., 1992). With the disappearance of these herds from most of the world range of vultures, the food supply formerly provided by wild ungulates was replaced by domesticated animals (Pain *et al*., 2008). *Gyps* vultures have large areas of bare skin on their body, and by changing their posture they can vary the extent to which these are covered by feathers. They have varying amounts of bare skin exposed and adopted in cold and hot conditions. Postural change can cause the proportion of body surface composed of bare skin areas to change from 32% to 7%, and in cold conditions these changes are sufficient to account for a 52% saving in heat loss from the body. These bare skin areas in *Gyps* vultures play an important role in thermoregulation (Ward *et al*., 2008).

Indian White-backed Vulture



Vultures feeding on a carcass in Kangra

ECOLOGICAL ROLE OF VULTURES

The ecological, social and cultural significance of vultures in India may be summed up as: scavenging on animal carcasses of animals and thereby helping keep the environment clean; and the disposal of dead bodies as per the religious practices of the Parsi community. Vultures are the primary removers of carrion in India and Africa. Removal of a major scavenger from the ecosystem will affect the equilibrium between

populations of other scavenging species and/or result in increase in putrefying carcasses. In the absence of carcass disposing mechanisms, vulture declines may lead to an increase in the number of putrefying animal carcasses in the country side. In some areas the population of feral dogs, being the main scavenging species in the absence of vultures, has been observed to have increased. Both increases in putrefying carcasses and changes in the scavenger populations have associated disease risks for wildlife, livestock and humans. In the absence of any alternative mode of disposal of animal carcasses, they continue to be disposed off in the open and with increasing numbers of feral dogs, there is increased risk of spread of rabies, and livestock borne diseases like anthrax (Prakash *et al*., 2003).

POPULATION DECLINE

Although *Gyps* vulture populations were probably declining slowly in many parts of the world during the 20th century, a very different situation existed in India, Nepal and Pakistan. Here, large populations of Indian White-backed Vulture and Long-billed Vulture remained until the 1990s. Large numbers of Slender-billed Vulture, which was not distinguished as a separate species from Long-billed Vulture until recently (Rasmussen and Parry, 2001), were also found in the northeastern parts of the subcontinent (Ali and Ripley, 1983; Prakash *et al*., 2007). Indeed, during the 1980s Indian White-backed Vulture was thought likely to be the commonest large bird of prey in the world (Houston, 1985). In India, *Gyps* vulture densities were so high in some areas that they were considered a hazard to aircraft (Grubh *et al*., 1990). This abundance was undoubtedly due to a plentiful food supply, in the form of the carcasses of domesticated ungulates (Pain *et al*., 2008). The era of abundant *Gyps* vultures in the Indian subcontinent came to a sudden end in the 1990s. This was firstly documented in Keoladeo National Park, Bharatpur in eastern Rajasthan (Prakash, 1999; Prakash *et al*., 2003). Subsequently, this population crash was documented throughout the Indian subcontinent (Samant *et al*., 1995; Prakash *et al*., 2003, 2005 a & b, 2007; Gilbert *et al*., 2004, 2006; Green *et al*., 2004; AVPP, 2007; Pain *et al*., 2008).

Of the nine species of vultures recorded from India, five belong to the genus *Gyps*. Three *Gyps* vultures viz., Indian White-backed Vulture (*Gyps bengalensis*), Long-billed Vulture (*Gyps indicus*) and Slender-billed Vulture (*Gyps tenuirostris*) are residents, and the remaining two, the Eurasian Griffon (*Gyps fulvus*) and Himalayan Griffon (*Gyps himalayensis*) are largely wintering species (Prakash, 1999; Prakash *et al*., 2003, 2007). In addition, Lammergeier (*Gypaetus barbatus*), Egyptian Vulture (*Neophron percnopterus*) and Red-headed Vulture (*Sarcogyps calvus*) are residents and Cinereous Vulture (*Aegypius monachus*) is wintering species (Grimmett *et al*., 1999).

Six, out of nine species of vultures found in India have been facing problem of existence and therefore declared as threatened. Of these, three species endemic to South Asia, the Indian White-backed Vulture *Gyps bengalensis,* Long-billed Vulture *Gyps indicus* and Slender-billed Vulture *Gyps tenuirostris* are at high risk of global extinction and are listed as critically endangered because of rapid population declines within the last decade in the Indian subcontinent. Further, Red-headed Vulture *Sarcogyps calvus* has been recently upgraded to critical category. Moreover, Egyptian Vulture *Neophron percnopterus* has been categorised as endangered and Cinereous Vulture *Aegypius monachus* has been placed under near threatened category (Prakash *et al*., 2003; Green *et al*., 2004; IUCN, 2007).

The minimum decline in White-backed vulture numbers in India during the period 1992-2003 was 99.7% and 97.4% for Long-billed/Slender-billed. This corresponds with a minimum estimated rate of decline of 34% per year for White-backed Vultures and 27% per year for the Long-billed/Slender-billed group. In the most recent census, there is evidence that the rate of declines may be increasing with a measured 81% decline between 2002 and 2003 in White-backed vultures, a 59% decline in Long-billed vultures, and a 47% decline for Slender-billed vultures (MoEF, 2006).

Himalayan Griffon on a carcass

CAUSES OF DECLINE AND REMEDIAL MEASURES

The veterinary use of the non-steroidal anti-inflammatory drug (NSAID)-diclofenac-in livestock is the main, and perhaps the only, cause of the population declines (Oaks *et al*., 2004; Shultz *et al*., 2004; Green *et al*., 2004, 2007). Vultures are exposed to toxic levels of diclofenac when they feed on carcasses of livestock which have died within a few days of treatment, and which contain residues of the drug (Oaks *et al*., 2004). Vultures that consume sufficient tissue from such carcasses die from the effects of diclofenac induced kidney failure. Shultz *et al*. (2004) found that a high proportion of Indian White-backed Vulture and Long-billed Vultures found dead in the wild had severe visceral gout, consistent with diclofenac poisoning being the main or sole cause of the population declines. Simulation modeling has indicated that less than 1% of the livestock carcasses available to vultures need to contain levels of diclofenac lethal to vultures to cause the recorded rates of decline across the country (Green *et al*., 2004).

Likewise, due to this chemical, vultures suffer from a disease called gout. Besides this, environmental changes have also produced adverse effects on the population of vultures as well. Food shortage, caused by the burial or burning of carcasses to reduce the nuisance and health risks have also contributed to their decline. Other reasons for the decline are anthropogenic (related with human population) like loss of nesting habitat, decreased breeding efficiency, infectious diseases, general environmental pollution etc. (Galushin, 2001; Virani *et al*., 2001; Pain *et al*., 2003; Prakash, 2004; Arun and Azeez, 2004; Oaks *et al*., 2004; Shultz *et al*., 2004; Green *et al*., 2004, 2006, 2007; Baral *et al*., 2005; Johnson *et al*., 2006; Prakash *et al*., 2007).

Diclofenac originated from Ciba-Geigy (now Novartis) in 1973. Diclofenac is marketed under many trade names like Anuva, Diclac, Dicloflex, Diclogem, Diclowin Plus, Diclon, Modifenac, Morbidic, Olfen, Naklofen, Rhumalgan, Sandoz, Topac, Voltaflam, Voveran etc. It is a non-steroidal anti-inflammatory drug (NSAID) taken to reduce inflammation and as an analgesic reducing pain in conditions such as arthritis or acute injury. It can also be used to reduce menstrual pain, dysmenorrhea. The name is derived from its chemical name: 2-(2, 6-dichloranilino) phenylacetic acid. In the United Kingdom, India, Brazil and the United States, it may be supplied as either the sodium or potassium salt, in China most often as the sodium salt, while in some other countries only as the potassium salt. Diclofenac is available as a generic drug in a number of formulations. Over the counter (OTC) use is approved in some countries for minor aches and pains and fever associated with common infections (http://www.novartis.com; Salmann, 1986).

The exact mechanism of action is not entirely known, but it is thought that the primary mechanism responsible for its anti-inflammatory, antipyretic, and analgesic action is inhibition of prostaglandin synthesis by inhibition of cyclooxygenase (COX), and it appears to inhibit DNA synthesis (Dutta *et al*., 2000). NSAIDs are associated with adverse renal [kidney] effects caused by the reduction in synthesis of renal prostaglandins in sensitive persons or animal species, and potentially during long term use in non-sensitive persons if resistance to side effects decreases with age. Unfortunately this side effect can't be avoided merely by using a COX-2 selective inhibitor because, "Both isoforms of COX, COX-1 and COX-2, are expressed in the kidney. Consequently, the same precautions regarding renal risk that are followed for nonselective NSAIDs should be used when selective COX-2 inhibitors are administered. However, diclofenac appears to have a different mechanism of renal toxicity (Brater, 2002; Naidoo and Swan, 2008).

Indian White-backed Vulture

India moved a IUCN motion in 2004 for vulture conservation, which was accepted in the form of the IUCN resolution which "called upon *Gyps* vulture range countries to begin action to prevent all uses of diclofenac in veterinary

applications that allow diclofenac to be present in carcasses of domestic livestock available as food for vultures; establishment of IUCN South Asian Task Force under the auspices of the IUCN; Range countries to develop and implement national vulture recovery plans, including conservation breeding and release". Recently, Government of India on May 11, 2006, through Drugs Controller General (F.No. 18-03/2006-DC) with approval of Health Ministry decided to withdraw all the licenses granted to manufacture diclofenac formulations for veterinary use and marketing of such formulations.

Currently, three captive breeding centers for Vultures, one in Haryana, second in West Bengal and third in Assam have been setup in India. Four more breeding centers are planned, in an attempt to create reservoirs of birds to be re-introduced once the environment is clear of diclofenac. The recovery programme in India is a joint project involving the Royal Society for Protection of Birds (RSPB), the Zoological Society of London, and the Bombay Natural History Society (BNHS, BirdLife in India), supported by Indian state and central governments. Also participating are Bird Conservation Nepal (BirdLife in Nepal), The Peregrine Fund, National Birds of Prey Trust and the Ornithological Society of Pakistan (BirdLife in Pakistan) (BirdLife International, 2008).

SCENARIO IN INDIA AND HIMACHAL PRADESH

The ecology and population dynamics of the Indian White-backed Vulture are poorly known, except a doctoral thesis (Grubh, 1974) and a few related publications reported from the Gir forest, Gujarat (Grubh, 1978 a & b, 1986). A few studies have been conducted on the ecological aspects of these vultures which are crucially important in the ecosystem as efficient scavengers. Most of this information is in the form of small articles. Many of such articles discuss various ecological and behavioral aspects of the different species such as feeding (Fox, 1913; Smith, 1915; Ezra, 1918; Gough, 1936; Livesey, 1937; Grubh, 1973), breeding (Jones, 1916; Gill, 1921; Sharma, 1970; Bhat, 1992; Kanoje, 1996) and inter-specific interactions (Grubh, 1978 a & b; Arun and Azeez, 2004).

In the recent years this group of scavenging birds has received the attention of the scientific community and various governments due to sharp decline in their population throughout their distributional range in the Indian subcontinent. Therefore, many programmes, including the captive breeding are being implemented for the betterment of Vultures in India. Recently, Chhangani (2002, 2003, 2004, 2005, 2007) has made some studies on the different aspects of vultures in Rajasthan, India.

Comprehensive studies on the status, abundance, population, etc. of vultures were conducted in Himachal Pradesh. Most of the literature available on the vulture life in the State was in the form of occasional short notes based upon opportunistic observations. A few sightings (Pandey, 1989; Mahabal and Sharma, 1992, 1993; Gaston *et al*., 1993; Mahabal, 1996, 2000, 2005; Thakur *et al*., 2002, 2003, 2010; Mattu and Thakur, 2006; Thakur, 2008) merely threw some light on the presence of different species of vultures in some small areas.

Indian White-backed Vulture at nest

Removal of skin of dead cattle in Kangra valley

Recent studies (October 2009 onwards) conducted with the financial help from Ministry of Science and Technology (Department of Science and Technology), New Delhi under FAST Track Scheme for young scientists revealed the presence of 8 species of vultures from different areas of Himachal Pradesh. A small breeding population of critically threatened Indian White-backed and Slender-billed Vultures has been found in very small patches in different areas explored. Indian White-backed Vulture *Gyps bengalensis* has been distributed in small patches in Bilaspur, Chamba, Hamirpur and Kangra. A total of 22 nesting colonies of this species, supporting 77 nests have been reported from these areas during breeding season (October to March/April) in 2010-2011. A single nesting colony of Slender-billed

Vulture *Gyps tenuirostris* has been recorded in Baroh area of Kangra with 2 nests. In addition, individuals of this species have been sighted feeding on carcasses at three sites i.e. one bird at Tarkhankad in Kangra, two birds with a juvenile at Sirmani in Kangra and three birds at Thulol near Sihunta in Chamba. A total of 14 nesting colonies, supporting 64 breeding pairs of Himalayan Griffon (*Gyps himalayensis*) have been reported from Himachal Pradesh.

Information on socio-cultural practices of disposal of carcasses and accessibility of Diclofenac to the vultures revealed that only 5% of the chemists in surroundings of nesting sites indicated towards the use of human diclofenac to the cattle, inspite of the fact that they were well aware about the story of vultures and diclofenac. Practice of removal of the skin and leaving the carcass for vulture consumption by locals has been a tradition of gone days in Himachal Pradesh. In the absence of this practice, dead bodies of domestic animals are usually buried. However, this social custom in Kangra valley is being practiced by some migrants from Punjab who unknowingly have been supporting a small breeding population of critically threatened Indian White-backed, Slender-billed and Red-headed Vultures. In addition, these immigrants were knowledgeable persons regarding the placement of carcass for vulture consumption as according to them vultures thoroughly clear the bones than other scavengers. Hides and bones of dead cattle have been an excellent source of money for them.

CONSERVATION STRATEGIES

No conservation measure could be efficient in protecting these threatened species from extinction if we do not have any reliable information on the current status, species richness, habitat-use pattern and ecology of these vultures. Recently the state of Himachal Pradesh has come under a strong threshold of development. As a result, several animal species are under tremendous stress because of increasing human population, deforestation, pollution, construction of river valley projects, etc. Many natural habitats have been over-exploited, degraded and even destroyed. Most of large animals in the area are highly endangered and are protected under the Indian Wildlife (Protection) Act, 1972. Conservation of already depleted biological resources is perhaps the only option left to overcome this situation.

Identification and monitoring of the locations and number of remaining individuals of Vultures in the wild would be effective measure for conservation. Some of the parameters like terrain type, altitude, relief etc.; height, type, density and status of vegetation; nearby human settlements, source of water and food, mortality rate of cattle in nearby villages, socio-cultural practices of disposal of carcasses; vulture species type and richness, population dynamics, habitat-use pattern, breeding ecology and breeding success; human/animal interference in the light of some previous studies like Stendell (1967), US Fish and Wildlife Service (1980) and Hays *et al*. (1981) could be beneficial. Breeding colonies of vultures should be continuously monitored for any changes in the population size. These records, in the long run would help in the formulation of area/locality based, viable vulture conservation strategies. In addition, public awareness and public support programmes are the most important aspects of any effective conservation and management plan. Therefore, local people should be engaged in the whole process of conservation and management.

A Vulture with an egg in the nest

TABLE 1: New World Vultures and their Conservation Status (Family: Cathartidae)

S.No.	Species	Conservation Status
1.	Turkey Vulture *Cathartes aura* (Linnaeus, 1758)	LC
2.	Lesser Yellow-headed Vulture *Cathartes burrovianus* Cassin, 1845	LC
3.	Greater Yellow-headed Vulture *Cathartes melambrotus* Wetmore, 1964	LC
4.	Black Vulture *Coragyps atratus* (Bechstein, 1783)	LC
5.	King Vulture *Sarcoramphus papa* (Linnaeus, 1758)	LC
6.	California Condor *Gymnogyps californianus* (Shaw, 1797)	CR
7.	Andean Condor *Vultur gryphus* Linnaeus, 1758	NT

LC= Least Concern
CR= Critical
NT= Near Threatened
(Source: BirdLife International, 2011)

TABLE 2: Old World Vultures and their Conservation Status (Family: Accipitridae)

S.No.	Species	Conservation Status
1.	Palm-nut Vulture *Gypohierax angolensis* (Gmelin, 1788)	LC
2.	Lammergeier *Gypaetus barbatus* (Linnaeus, 1758)	LC
3.	Egyptian Vulture *Neophron percnopterus* (Linnaeus, 1758)	EN
4.	Hooded Vulture *Necrosyrtes monachus* (Temminck, 1823)	EN
5.	White-backed Vulture *Gyps africanus* Salvadori, 1865	NT
6.	White-rumped Vulture *Gyps bengalensis* (Gmelin, 1788)	CR
7.	Indian Vulture *Gyps indicus* (Scopoli, 1786)	CR
8.	Slender-billed Vulture *Gyps tenuirostris* Gray, 1844	CR
9.	Rueppell's Vulture *Gyps rueppellii* (Brehm, 1852)	NT
10.	Himalayan Vulture *Gyps himalayensis* Hume, 1869	LC
11.	Griffon Vulture *Gyps fulvus* (Hablizl, 1783)	LC
12.	Cape Vulture *Gyps coprotheres* (Forster, 1798)	VU
13.	Red-headed Vulture *Sarcogyps calvus* (Scopoli, 1786)	CR
14.	White-headed Vulture *Trigonoceps occipitalis* (Burchell, 1824)	VU
15.	Cinereous Vulture *Aegypius monachus* (Linnaeus, 1766)	NT
16.	Lappet-faced Vulture *Torgos tracheliotos* (Forster, 1791)	VU

LC= Least Concern
EN= Endangered
CR= Critical
NT= Near Threatened
VU= Vulnerable
(Source: BirdLife International, 2011)

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REFERENCES

Ali, S. and Ripley, S.D. 1968 (1983) *Handbook of the Birds of India and Pakistan*. Oxford University Press, New Delhi.

Arun, P.R. and Azeez, P.A. (2004) Vulture population decline, diclofenac and avian gout. *Current Science* 87 (5):565-568.

AVPP (2007) Asian vulture population project, February 2007. www.peregrinefund.org/vulture.

Baral, N.; Gautam, R. and Tamang, B. (2005) Population status and breeding ecology of White-rumped Vulture *Gyps bengalensis* in Rampur Valley, Nepal. *Forktail* 21: 87-91.

Bhat, S.D. (1992) Nesting by Indian Whitebacked Vulture. *Blackbuck* 8 (3): 85.

BirdLife International (2008) http://www.birdlife.org/ news/ news/2005/03/ vultures. Html

BirdLife International (2011) IUCN Red List for birds (www.birdlife.org downloaded on 26/12/2011)

Brater, D.C. (2002) Renal effects of cyclooxygyenase-2-selective inhibitors. *J. Pain Symptom Manage.* 23 (4 Suppl): S 15–20.

Chhangani, A.K. (2002) Vultures the most eco-friendly bird. *Science Reporter* 39 (10): 56-59.

Chhangani, A.K. (2003) Predation on vultures, their eggs and chicks by different predators in and around Jodhpur. *Newsletter for Birdwatchers* 43 (3): 38-39.

Chhangani, A.K. (2004) Status of a breeding population of long-billed vulture (*Gyps indicus indicus*) in and around Jodhpur (Rajasthan), India. *Vulture News* 50: 15-22.

Chhangani, A.K. (2005) Population ecology of vultures in the western Rajasthan, India. *Indian Forester*. 131 (10): 1373-1382.

Chhangani, A.K. (2007) Sightings and nesting sites of Red-headed Vulture *Sarcogyps calvus* in Rajasthan, India. *Indian Birds* 3 (6): 218-221.

Dutta, N.K.; Annadurai, S.; Mazumdar, K.; Dastidar, S.G.; Kristiansen, J.E.; Molnar, J.; Martins, M. and Amaral, L. (2000) The anti-bacterial action of diclofenac shown by inhibition of DNA synthesis. *Int. J. Antimicrob. Agents* 14 (3): 249-251.

Ezra, A. (1918) Photos of vultures around carcasses in Assam. *Bulletin of British Ornithological Club* 38: 55.

Fox, E.B. (1913) Voracity of vultures in the Gir forest. *Journal of Bombay Natural History Society* 22: 395-396.

Galushin, V.M. (2001) Populations of vultures and other raptors in Delhi and neighboring areas from 1970s to 1990s. *Proc. 4th Eurasian Congress on Raptors*: 14-16.

Gaston, A.J.; Garson, P.J. and Pandey, S. (1993) Birds recorded in the Great Himalayan national park, Himachal Pradesh, India. *Forktail* 9: 45-57.

Gilbert, M.; Oaks, J.L.; Virani, M.Z.; Watson, R.T.; Ahmed, S.,; Chaudhry, M.J.I.; Arshad, M.; Mahmood, S.; Ali, A.; Khattak, R.M. and Khan, A.A. (2004) The status and decline of vultures in the provinces of Punjab and Sind, Pakistan: a 2003 update. In: *Raptors Worldwide* (Eds. R.C. Chancellor and B.U. Meyburg). *Proc. of the 6th world conference on birds of prey and owls,* Berlin and Budapest. pp. 221-234.

Gilbert, M.; Watson, R.T.; Virani, M.Z.; Oaks, J.L.; Ahmed, S.; Chaudhary, M.J.I.; Arshad, M.; Mahmood, S.; Ali, A.; Khattak, R.M. and Khan, A.A. (2006) Rapid population declines and mortality clusters in three Oriental white-backed vulture *Gyps bengalensis* colonies in Pakistan due to diclofenac poisoning. *Oryx* 40: 388-399.

Gill, E.H. (1921) Nidification of the Himalayan Longbilled Vulture tenuirostris. *Journal of Bombay Natural History Society* 27: 951-952.

Gough, W. (1936) Vultures feeding at night. *Journal of Bombay Natural History Society* 38: 624.

Green, R.E.; Newton, I.; Shultz, S.; Cunningham, A.A.; Gilbert, M.; Pain, D.J. and Prakash, V. (2004) Diclofenac poisoning as a cause of vulture population declines across the Indian subcontinent. *Journal of Applied Ecology* 41: 793–800.

Green, R.E.; Taggart, M.A.; Das, D.; Pain, D.J.; Kumar, C.S.; Cunningham A.A. & Cuthbert R. (2006) Collapse of Asian vulture populations: risk of mortality from residues of the veterinary drug diclofenac in carcasses of treated cattle. *Journal of Applied Ecology* 43: 949-956.

Green, R.E.; Taggart, M.A.; Senacha, K.R.; Pain, D.J.; Jhala, Y. and Cuthbert, R. (2007) Rate of decline of the Oriental White-backed Vulture *Gyps bengalensis* population in India estimated from measurements of diclofenac in carcasses of domesticated ungulates. *PloS One* 2 (8) e 686.

Grimmett, R.; Inskipp, C. and Inskipp, T. (2001) Pocket Guide to the Birds of the Indian Subcontinent. Oxford University Press, New Delhi. 384 pp.

Grubh, R.B. (1973) Calcium intake in vultures of the genus *Gyps*. *Journal of Bombay Natural History Society* 70: 199-200.

Grubh, R.B. (1974) The birds of Gir Forest (the ecology and behaviour in Gir forest). *Ph.D. thesis. University of Bombay, Bombay*.

Grubh, R.B. (1978 a) Competition and co-existence in Griffon Vultures: (*Gyps bengalensis*, *G. indicus* and *G. fulvus*) in Gir forest (Biology Behaviour; Biology Ecology; Gir National Park). *Journal of Bombay Natural History Society* 75: 810-814.

Grubh, R.B. (1978 b) The Griffon Vultures (*Gyps bengalensis, G. indicus* and *G. fulvus*) of Gir forest: Their feeding habits and the nature of association with the Asiatic Lion. *Journal of Bombay Natural History Society* 75: 1058-1068.

Grubh, R.B. (1986) A comparative study of ecology and distribution of Indian Whitebacked Vulture (*Gyps bengalensis*) Longbilled Vulture (*Gyps indicus*) in the Indian region. *Proc. 19th Int. Ornithology Congress* 2: 2763-2767.

Grubh, R.B.; Narayan, G. and Satheesan, S.M. (1990) Conservation of vultures in (developing) India. In: *Conservation in developing countries* (Eds: J.C. Daniel & J.S. Serrao). Bombay Natural History Society and Oxford University Press, Bombay. pp. 360-363.

Hays, R.L.; Summers, C.S. and Seitz, W. (1981) Estimating wildlife habitat variables. U.S. Fish Wildl. Serv., Washington, D.C. FWS/OBS-81/47. 111 pp.

Houston, D. (1985) Indian White-backed Vulture *Gyps bengalensis*. Pp. 465–466 In: *Conservation studies on raptors* (Eds. I. Newton and R.D. Chancellor). Cambridge: International Council for Bird Preservation, Technical Publication No. 5.

Indian Wildlife (Protection) Act (1972) Ministry of Environment and Forests, Govt. of India, Amendment 1991.

IUCN (2007) IUCN Red List of threatened species. http://www.iucn.org

Johnson, J.A.; Lerner, H.R.L.; Rasmussen, P.C. and Mindell, D.P. (2006) Systematics within *Gyps* vultures: a clade at risk. BMC *Evolutionary Biology* 6: 65.

Jones, A.E. (1916) *Pseudogyps bengalensis* White-backed Vulture breeding in immature plumage. *Journal of Bombay Natural History Society* 24: 369-370.

Kanoje, R. (1996) Nesting trees of Whiterumped Vulture. *Newsletter for Birdwatchers* 36: 14.

Livesey, T.R. (1937) The habits of vultures. *Journal of Bombay Natural History Society* 39: 398-399.

Mahabal, A. (1996) Bird survey in Shiwalik Himalaya of Himachal Pradesh. *Pavo* 34 (1&2): 7-16.

Mahabal, A. (2000) Birds of Talra wildlife sanctuary in lower Western Himalaya, Himachal Pradesh, with notes on their status and altitudinal movements. *Zoos' Print Journal* 15 (10): 334-338.

Mahabal, A. (2005) Aves. In: *Fauna of Western Himalaya*. (ed.: The Director) Zoological Survey of India, Kolkata, 275-339.

Mahabal, A. and Sharma, T.R. (1992) Distribution patterns of birds of Kangra Valley (Himachal Pradesh). *Himalayan Journal of Environment and Zoology* 6 (2): 85-96.

Mahabal, A. and Sharma, T.R. (1993) Birds in Nainadevi wildlife sanctuary in Shiwalik Himalayas. *Newsletter for Birdwatchers* 33 (3): 43-44.

Mattu, V.K. and Thakur, M.L. (2006) Bird diversity and status in Summer hill, Shimla (Himachal Pradesh). *Indian Forester* 132 (10): 1271-1281.

MoEF (2006) Action plan for vulture conservation in India. Ministry of Environment and Forests, Government of India, New Delhi.

Mundy, P.; Butchart, D.; Ledger, J. and Piper, S. (1992) *The vultures of Africa*. London: Academic Press.

Naidoo, V. and Swan, G.E. (2008) Diclofenac toxicity in Gyps vulture is associated with decreased uric acid excretion and not renal portal vasoconstriction. *Comp. Biochem. Physiol. C Toxicol. Pharmacol.* 149 (3): 269.

Oaks, J.L.; Gilbert, M.; Virani, M.Z.; Watson, R.T.; Meteyer, C.U.; Rideout, B.; Shivaprasad, H.L.; Ahmed, S.; Chaudhry, M.J.I.; Arshad, M.; Mahmood, S.; Ali, A. and Khan, A.A. (2004) Diclofenac residues as the cause of vulture population decline in Pakistan. *Nature* 427: 630–633.

Ohishi *et al*. (1979). *Journal of Wildlife Diseases* 15: 3-9.

Pain, D.J.; Bowden, C.G.R.; Cunningham, A.A.; Cuthbert, R.; Das, D.; Gilbert, M.; Jakati, R.D.; Jhala, Y.D.; Khan, A.A.; Naidoo, V.; Oaks, J.L.; Parry-Jones, J.; Prakash, V.; Rahmani, A.; Ranade, S.P.; Baral, H.S.; Senacha, K.R.; Saravanan, S.; Shah, N.; Swan, G.; Swarup, D.; Taggart, M.A.; Watson, R.T.; Virani, M.Z.; Wolter, K. and Green, R.E. (2008) The race to prevent the extinction of south Asian vultures. BirdLife International, United Kingdom.

Pain, D.J.; Cunningham, A.A.; Donald, P.F.; Duckworth, J.W.; Houston, D.C.; Katzner, T.; Parry-Jones, J.; Poole, C.; Prakash, V.; Round P. and Timmins, R. (2003) Causes and effects of temporospatial declines of *Gyps* vultures in Asia. *Conservation Biology* 17 (3): 661-671.

Pandey, S. (1989) The birds of Pong Dam lake bird sanctuary. *Tigerpaper* 16 (2): 20-26.

Prakash, V. (1999) Status of vultures in Keoladeo National Park, Bharatpur, Rajasthan, with special reference to population crash in *Gyps* species. *Journal of Bombay Natural History Society* 96: 365-378.

Prakash, V. (2004) Diclofenac poisoning as cause of vulture population decline across the Indian subcontinent. *Journal of Applied Ecology* 41:793–823.

Prakash, V.; Green, R.E.; Pain, D.J.; Ranade, S.P.; Saravanan, S.; Prakash, N.; Venkitachalam, R.; Cuthbert, R.; Rahmani, A.R. and Cunningham, A.A. (2007) Recent changes in populations of resident *Gyps* vultures in India. *Journal of Bombay Natural History Society* 104: 129-135.

Prakash, V.; Pain, D.J.; Cunningham, A.A.; Donald, P.F.; Prakash, N.; Verma, A.; Gargi, R.; Sivakumar, S. and Rahmani, A.R. (2005 a) Corrigendum to ''Catastrophic collapse of Indian White-backed *Gyps bengalensis* and Long-billed *Gyps indicus* Vulture populations'' *Biological Conservation* 124: 559.

Prakash, V.; Green, R.E.; Rahmani, A.R.; Pain, D.J.; Virani, M.Z.; Khan, A.A.; Baral, H.S.; Jhala, Y.V.; Naoroji, R.; Shah, N.; Bowden, C.G.R.; Choudhury, B.C.; Narayan, G. and Gautam, P. (2005 b) Evidence to support that diclofenac caused catastrophic vulture population decline. *Current Science* 88: 2.

Prakash, V.; Pain, D.J.; Cunningham, A.A.; Donald, P.F.; Prakash, N.; Verma, A.; Gargi, R.; Sivakumar, S. and Rahmani, A.R. (2003) Catastrophic collapse of Indian White-backed *Gyps bengalensis* and Longbilled *Gyps indicus* Vulture populations. *Biological Conservation* 109: 381-390.

Rasmussen, P.C. and Parry, S.J. (2001) The taxonomic status of the 'Long-billed Vulture *Gyps indicus*. *Vulture News* 44: 18–21.

Salmann, A.R. (1986) The history of diclofenac. *American Journal of Medicine* 80 (4B): 29-33

Samant, J.S.; Prakash, V. and Naoroji, R. (1995) Ecology and behaviour of resident raptors with special reference to endangered species. Final Report to the U.S. Fish & Wildlife Service. Bombay Natural History Society, Mumbai.

Sharma, I.K. (1970) Breeding of the Indian Whitebacked Vulture at Jodhpur. *Ostrich* 41: 205-207.

Shriner, W. (1998) *The Turkey Vulture*. The Turkey Vulture Society

Shultz, S.; Baral, H.S.; Charman, S.; Cunningham, A.A.; Das, D.; Ghalsasi, D.R.; Goudar, M.S.; Green, R.E.; Jones, A.; Nighot, P.; Pain, D.J. and Prakash, V. (2004) Diclofenac poisoning is widespread in declining vulture populations across the Indian subcontinent. *Proc. Roy. Soc. Lond*. B (Supplement) 271 (Suppl 6): S 458–S 460.

Smith, O.A. (1915) Vultures feeding after sundown. *Journal of Bombay Natural History Society* 23: 579.

Stendell, R.C. and Myers, P. (1973) White-tailed kite predation on a fluctuating vole population. *Condor* 75: 359-360.

Thakur, M.L. (2008) Studies on status and diversity of avifauna in Himachal Pradesh. *Ph.D. thesis, Himachal Pradesh University, Shimla, India.* 306 pp.

Thakur, M.L.; Mattu, V.K.; Lal, H.; Sharma, V.N.; Raj, H., & Thakur, V. (2010) Avifauna of Arki Hills, Solan (Himachal Pradesh), India. *Indian Birds* 5 (6): 162–166.

Thakur, M.L.; Paliwal, R.; Tak, P.C. and Mattu, V.K. (2003) Birds of Balh valley, district Mandi, Himachal Pradesh, India. *Annals of Forestry* 11 (1): 113-126.

Thakur, M.L.; Paliwal, R.; Tak, P.C.; Mehta, H.S. and Mattu, V.K. (2002) Birds of Kalatop- Khajjiar wildlife sanctuary, Chamba (HP). *Cheetal* 41 (3 & 4): 29-36.

U.S. Fish and Wildlife Services (1980) Habitat evaluation procedures (HEP). ESM 102. U.S. Fish Wildl. Serv., Washington, D.C.

Virani, M.; Gilbert, M.; Watson, R.; Oaks, L.; Benson, P.; Kham, A.A.; Baral, H.S. and Giri, J.B. (2001) Asian vulture crisis project: Field results from Pakistan and Nepal for the 2000–2001 field seasons. In: Reports from the workshop on Indian *Gyps vultures* (Eds. T. Katzner and J. Parry-Jones). *Proc. 4th Eurasian congress on raptors,* Sevilla, Spain. pp. 7-9.

Ward, J.; McCafferty, D.J.; Houston, D.C. and Ruxton, G.D. (2008) Why do vultures have bald heads? The role of postural adjustment and bare skin areas in thermoregulation. *Journal of Thermal Biology* 33 (3): 168-173.

Wikipedia (2011) *Vulture*, http://en.wikipedia.org wiki/ Vulture (Dec. 26, 2011, 11:02 GMT).