

# The collapse of vulture populations in South Asia

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**Abstract.** The catastrophic crash in Gyps vulture populations in South Asia has been caused by the non-steroidal anti-inflammatory drug diclofenac which results in renal failure. Sufficient diclofenac residues to cause death can be consumed by vultures feeding on a recently treated livestock carcass. Survival of at least three Gyps species depends on removing diclofenac from the vultures' primary food source, dead domestic livestock, by controlling its veterinary use. Survival of one or more of these species also depends on species restoration, most effectively achieved through captive breeding and release. Efforts on both fronts are in progress, but time available for remedial action is short and the probability of success will be greatly improved by the immediate collection of vultures for safe-keeping.

## INTRODUCTION

Populations of vultures on the Indian subcontinent were considered very abundant as recently as the late 1980s. Dramatic declines in populations were first measured in Keoladeo National Park (Rajasthan, India) in 1996 with reductions in excess of 96% recorded by 1999 (Prakash 1999). Three species of Gyps vulture have now been listed as Critically Endangered by the International Union for Conservation of Nature (BirdLife International 2000): *Gyps bengalensis* (Oriental White-backed Vulture), *Gyps indicus* (long-billed Vulture), and *Gyps tenuirostris* (Slender-billed Vulture).

## PEREGRINE FUND

The Peregrine Fund's studies, initiated in 2000 in Pakistan and Nepal, confirmed that populations have been similarly affected in these countries (Gilbert *et al.* 2002; Baral *et al.* in press). Between the 2000/01 and 2003/04 breeding seasons populations at three study colonies in Pakistan (*c.* 2,000 breeding pairs) declined



From top to bottom: Three Slender-billed Vultures, *Gyps tenuirostris* and one juvenile Griffon Vulture, *Gyps fulvus* (Photo by Rishad Naoroji, courtesy of the Peregrine Fund).

Long-billed Vulture, *Gyps indicus*. (Photo by Munir Virani/The Peregrine Fund).

Oriental White-backed Vulture, *Gyps bengalensis* (Photo by Munir Virani/The Peregrine Fund).

*Gyps bengalensis* in flight (Photo by Martin Gilbert/The Peregrine Fund)





Rows of dead vultures (top). (Photo by Pat Benson)

Lindsay Oaks and Munir Virani - necropsy on a vulture in Pakistan (bottom).

at an accelerating annual rate by 100%, 100%, and 67%, respectively. A very short window of opportunity, perhaps months rather than years, now exists to take remedial action to prevent species' extinctions.

These rapid declines were due to high rates of adult and sub-adult mortality (Gilbert *et al.* 2002). Over 1,600 dead vultures have been recovered from field sites in Pakistan, of which 259 were in an adequate state for gross post-mortem inspection. Among this sample, the single largest cause of mortality, accounting for 85% of vulture deaths, was a condition called visceral gout which was easily seen as a white, paste-like deposit on the surface of internal body organs. Avian visceral gout is a non-specific condition that follows renal failure in birds. Thus, renal failure was the largest single cause of mortality and therefore the single most important cause of the catastrophic population crash in vultures. Other causes of mortality, including gunshot, collision, intestinal foreign bodies, lead

poisoning, organophosphate poisoning, and identified diseases (Gilbert *et al.* 2002, Oaks *et al.* 2004), may have contributed to the species' decline but, by themselves, would not be responsible for the observed precipitous decline in numbers.

### THE CAUSE OF VULTURE DECLINE

Since the year 2000 The Peregrine Fund and its partners have conducted exhaustive testing of tissue samples from

freshly dead vultures. These tests have found no evidence of viral or bacterial infectious disease, pesticides, poisons, heavy metals, and nutritional deficiency as possible causes of renal failure observed in dead vultures (Oaks *et al.* 2004). In April 2003, we discovered a 100% correlation between renal failure in dead or dying vultures collected in the field in Pakistan and the presence of the pharmaceutical drug diclofenac. Subsequently, we demonstrated that very small doses of diclofenac (one tenth of the recommended dose for mammals) reproduced the same renal failure and diclofenac residues in vultures, and that fatal amounts of diclofenac can be ingested by vultures eating livestock that have died after recent treatment with recommended veterinary doses (Oaks *et al.* 2004). From these results, and almost identical evidence of renal failure and diclofenac residues reported for a smaller sample size of vultures collected in India and Nepal (Shultz *et al.* Submitted), it is clear that diclofenac has caused the recent catastrophic vulture population declines across South Asia. It is also clear that while diclofenac is used in veterinary treatment of livestock that die and become vulture food, vultures will continue to be poisoned to extinction and no amount of conservation effort will restore species in the wild while diclofenac occurs at current levels in the vulture's food source.

### SIGNIFICANCE OF THIS DISCOVERY

The discovery that the veterinary use of diclofenac has the capacity to have an acute toxic effect on wildlife and be responsible for the vulture population crash over such a huge area and in such a short time (about ten years) is unprecedented. This discovery is equivalent in significance to the discovery of the effects of DDT on raptors and other birds in the 1960s (Cade *et al.* 1988). Diclofenac, a non-steroidal anti-inflammatory drug (NSAID), represents a new environmental threat that has demonstrated capacity to decimate populations of formerly abundant birds in a very short period of time. Like Peregrine Falcons and DDT, vultures in this case are the "canary in the coal miner's cage" warning of a potentially dangerous environmental toxin. Vultures are sampling the environment and their deaths and population collapse have demonstrated a widespread toxic effect. These results are important to toxicologists and conservationists worldwide and should warn of the need for better scrutiny of drug contamination in the environment.

The extinction of vultures may have far reaching social, economic, ecological, and public health implications. Vultures may play a role in the control of important livestock diseases (e.g., anthrax, tuberculosis, brucellosis, foot-and-mouth disease, rinderpest, and contagious pleuropneumonia) by rapid disposal of infected animals and inactivation of pathogens. Vultures are efficient scavengers, able to dispose of carcasses rapidly (in minutes), before diseases such as anthrax have a chance to sporulate and spread. The niche occupied by vultures



Figure 5.  
Long-billed Vulture  
(*Gyps indicus*) in  
flight. (Photo by  
Munir Virani)

may be taken over by other animals, such as feral dogs, cats, and rats that, at higher density, may create a new threat to humans from attack and diseases such as rabies and plague. Vultures have been widely used in south Asia as a natural carcass disposal method and must now be replaced with more costly and labor intensive disposal methods. Vultures have also been an integral part of the Parsi (Zoroastrian) "sky burial" that has been devastated by the loss of vultures, especially in Mumbai and Karachi, and vultures have an important part in Hindu mythology.

Remedial action to prevent vulture extinctions is needed. There may be few or no protected areas where vultures are consistently safe from diclofenac exposure because vultures' capacity for flight allow them to forage and wander over large areas. Observed increasing rates of population decline are consistent with increasing probability of lethal diclofenac exposure to remaining birds and indicate that vulture numbers will decline to extinction at an accelerating rate. The time available to take remedial action can not be accurately predicted but may now be very short—perhaps a matter of months.

#### **POTENTIAL IMPACTS AND PROBLEMS FOR CONTROLLING DICLOFENAC**

Diclofenac was originally manufactured under patent for use in human therapy, especially arthritis and other inflammatory conditions. It continues to be among

several of the commonest non-steroidal anti-inflammatory drugs used in human medicine. However, Asian vultures are likely to be exposed to diclofenac mainly from livestock, rather than from human sources; therefore controlling diclofenac use in the veterinary market alone would be sufficient to remove diclofenac from the vultures' food source. Veterinary diclofenac is sold by at least 41 companies in India and five in Pakistan. Surveys of veterinarians in Pakistan show that diclofenac is used for therapy in a wide range of livestock ailments and injuries, the recommended use being the same as in human medicine (Todd & Sorkin 1988), i.e. for the reduction of inflammation, reduction of fever, and control of pain.

A veterinary course of diclofenac is very cheap in Pakistan and India at around \$0.50 US per course. Industry estimates are that 10 to 13 million animals are treated with the drug annually in India (statistics from a presentation by Vijay Teng, Sr. General Manager - Marketing, Intas Pharmaceuticals Ltd., at a vulture recovery strategy meeting in India during the last week of April 2004). There is no doubt that diclofenac use must be very popular over the entire sub-continent to have caused the effects we have measured. This conclusion is based upon our observation that vulture populations have plummeted all over the sub-continent, that 85% of all vulture mortality was due to one single cause, namely renal failure, 100% of which were due to diclofenac





Exhibiting a tagged bird.

residue contamination, and that the most (only?) likely source of such contamination is from treated livestock carcasses. This line of argument has since been bolstered with results (in press) from India that demonstrate the same 100% correlation between renal failure and diclofenac residues, and ~85% mortality due to renal failure, from many more sites in India and Nepal (Boelsterli 2003). Sales figures for diclofenac from the late 1990's indicate sales in the \$600

million USD range annually. Also, information at the Novartis website (<http://novartis.com/special/voltaren-shtml>) indicate that sales figures for Voltaren indicate a wide use of diclofenac. A survey in Pakistan found that of 84 veterinary pharmaceutical retailers, all 84 sold diclofenac and 77 reported selling it daily (Oaks *et al.* 2004).

### SHARING RESULTS

The discovery of diclofenac poisoning as the major cause of vulture mortality and population decline first occurred in April 2003. The scientific community was first informed of the discovery in May 2003 (6<sup>th</sup> World Conference on Birds of Prey, Budapest, Hungary). The publication in *Nature* (Oaks *et al.* 2004) presented this discovery with appropriate additional experimentation and peer review.

The approval of scientific peers after critical review of our results was important before taking them to appropriate government organizations and non-governmental organizations (NGOs). However, in the interest of immediate remedial action, and to expedite the transfer of knowledge and responsibility to governments and NGO representatives, The Peregrine Fund and partner, Bird Conservation Nepal, hosted the Kathmandu Summit Meeting (5-6 February, 2004) entitled: "Veterinary use of the drug *diclofenac*: A new environmental threat exposed by the collapse of vulture populations in South Asia." This meeting was endorsed by the United States Department of State and the Assistant Secretary of State, John F. Turner, and urged national governments of the region to participate with senior

government representation. The meeting provided a briefing on the scientific evidence of the role of the drug diclofenac in the catastrophic collapse of *Gyps* vulture populations in South Asia and offered potential solutions to mitigate the effects of diclofenac. It concluded with an opportunity for government representatives to participate in a forum that resulted in a resolution to control the veterinary use of diclofenac and help restore these Critically Endangered species. It also resulted in an offer by the Environmental Research and Wildlife Development Agency (ERWDA) from the United Arab Emirates to house up to 75 vultures of each species for safe-keeping in existing facilities until expertise and facilities could be developed within the range states. The Peregrine Fund offered to assist in the collection and transport of these birds from Pakistan and Nepal, so that the immediate financial costs to the range states would be nil.

### ELIMINATION OF DICLOFENAC THE CAUSE OF VULTURE DECLINE

No amount of conservation effort will succeed while the cause of the decline is left intact. Diclofenac was introduced into the veterinary market as recently as 1993-94. It appears to have become popular because it has therapeutic value in the treatment of symptoms in a broad range of ailments and injuries, causing immediate but short-term relief for the treated animal which quickly shows improvement. However, the drug has no specific curative value, has many potential substitutes, and is therefore non-essential.

An immediate, outright ban of diclofenac in veterinary use in all range states may be the simplest, most effective way to eliminate the drug from vultures' food, and would quickly reduce the unsustainably high rates of vulture mortality that occurred over the past 10 years or more. Alternate actions are much more complex and potentially controversial, and by themselves perhaps less likely to succeed.

### VULTURE SPECIES RECOVERY

Based on the rate of decline of vulture populations, all three species could become extinct in the wild within five years and functionally extinct as populations much sooner. The 2003/2004 or 2004/2005 breeding seasons may be the last in which colonies of more than 50 pairs of birds will exist and enough vultures could be collected in a single season to establish captive populations of *G. bengalensis* and *G. indicus*. It will be already difficult to collect sufficient numbers of *G. tenuirostris* in a single breeding season. If these species are to have any future hope of survival, captive flocks should be established immediately to allow for future restoration programs. Vulture recovery efforts are being implemented in Pakistan, India, and Nepal, but success will depend on the ability to move quickly to bring birds into safe-keeping in captivity. Agreement

in a timely manner by governments to collaborate on species restoration and issue permits for collection and translocation of vultures will have a big impact on the likelihood of success. So far, this collaboration has been disappointingly slow.

### FURTHER STUDIES

One priority for further study is to answer those skeptics who do not believe that sufficient numbers of contaminated carcasses could be available to vultures to have caused the catastrophic decline in vulture populations. We are measuring the proportion of contaminated carcasses randomly located on road and trail transects, and comparing results with proportions predicted to be necessary by mathematical models based on rates of mortality measured in the field.

We aim to determine if provisioning can reduce vulture foraging range and mortality due to diclofenac exposure. Six vultures from a single colony in Pakistan are being tracked with global positioning system precision using satellite technology during periods with and without food provisioning at the colony.

Justification for species restoration currently depends on the proportional extent (>96% decline) and rate of loss (>30% annually) of vultures over time. Monitoring numbers of pairs, breeding success, and mortality at colonies studied since 2000 (Gilbert *et al.* 2002) is ongoing and will continue to provide valuable information. However, empirical data on how many vultures remain and where they occur would help justify the need and cost of species restoration. The Peregrine Fund has implemented the Asian Vulture Population Project (AVPP) to provide these data. The AVPP uses the power of the internet to recruit volunteers across the sub-continent to locate and count vulture breeding colonies annually. Results are shared immediately on the AVPP website (<http://www.peregrinefund.org/vulture/>) and are available to anyone with internet access.

Studies to determine whether alternative drugs exist that are effective on livestock and safe for vultures are in progress by other researchers.


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