Institution: University of Cambridge

Unit of Assessment: UoA5

Title of case study: The SAVE Programme: Saving Asia's Vultures from Extinction

1. Summary of the impact (indicative maximum 100 words)

Research from the Department of Zoology has been instrumental in identifying residues of the veterinary painkiller diclofenac in cattle carcasses as responsible for catastrophic declines in vulture populations across the Indian subcontinent. As a result, the drug has been banned for veterinary use in the relevant countries, and an international conservation effort (SAVE) to Save Asia's Vultures from Extinction has been set up. Declines have since slowed, captive breeding programmes have been introduced, and local people have been trained in monitoring work and advocacy. There has also been inter-government collaboration to support conservation efforts, the first example of such collaboration on the subcontinent.

2. Underpinning research (indicative maximum 500 words)

Professor Rhys Green is an RSPB Principal Research Biologist, fully embedded in the Conservation Science Group in the Department of Zoology where he is an Honorary Professor (since 1999). He spends 100% of his non-fieldwork time in the Department and was returned as Category C in the 2008 RAE. Since 2004, a substantial part of his research has focused on vulture conservation in the Indian subcontinent, in conjunction with other scientists and government and non-government conservation agencies in the region and in several other countries.

Since the early 1990s, populations of three vulture species in the Indian subcontinent have decreased by more than 97%, one of the most rapid and sustained declines of a bird species ever documented. In 2000, the World Conservation Union (IUCN) listed all three species as 'Critically Endangered', the highest category of endangerment, indicating a high risk of global extinction in the wild in the short term. These vultures, of the genus *Gyps*, are obligate scavengers on dead vertebrate carcasses, and in India their food is mostly domesticated ungulates. In 2004 a team of American and Pakistani researchers discovered that the widely-used veterinary anti-inflammatory drug diclofenac was the major cause of observed mortality in one of the three species in Pakistan. Diclofenac causes kidney failure, accumulation of uric acid (gout) and death when vultures eat the carcass of a recently-treated animal.

In the early 2000's, Green and co-workers found that a high proportion of dead vultures of two of the species across a large area of India, Pakistan and Nepal tested positive for diclofenac residues and had evidence of visceral gout[1]. This finding indicated that diclofenac was the likely cause of the rapid population declines in all three species of vultures across the entire subcontinent (the 2004 study mentioned above took place in a single province of Pakistan, and on one species only). Green then led work to develop a demographic model based on this data, which demonstrated that even very low rates of diclofenac contamination (0.13-0.76% of ungulate carcasses available to foraging vultures) would be sufficient to have caused observed population declines, given its high toxicity to vultures[2]. Data collected by the group validated the model and showed that diclofenac-caused mortality was theoretically sufficient to account for the observed vulture declines[2] across the affected areas.

Measurement of diclofenac concentration in tissues of treated cattle and an experiment on captive vultures enabled Green and colleagues to construct a model to define the period after treatment that cattle tissues remained toxic to vultures, which was found to be a few days[3]; this work had implications for conservation projects (both captive breeding and supplementary feeding programmes), as it demonstrated vultures should only be fed on carcasses of animals that had not been dosed with diclofenac in the week prior to death.

Green and colleagues also surveyed the concentrations of diclofenac in carcasses of domesticated ungulates in India, and determined that these were sufficient to have caused vulture declines at the observed rates without the involvement of any other factor[4], thus confirming the earlier model in

practice. In addition, the results provided a basis for estimating vulture population responses to changes in the prevalence of diclofenac in ungulate carcasses; the effectiveness of the Indian ban could therefore be monitored. Follow-up surveys showed a decline in diclofenac contamination of cattle carcasses after the ban[5]. Vulture population surveys in India and Nepal were carried out in 2011, finding that whilst numbers of vultures remained low, the decline had slowed, and may have reversed for one of the three species.

The very widespread veterinary use of diclofenac in the region meant that compliance with the ban, and subsequent impact on vulture numbers, would only occur if a comparative alternative (in terms of cost, effectiveness and availability) existed and this was non-toxic to vultures. In 2006, Green and colleagues in collaboration with the University of Pretoria and others in South Africa and Namibia determined that the alternative drug meloxicam, also out of patent, was non-toxic for related African vultures[6]; follow-up tests demonstrated it was also safe for the endangered Indian species.

3. References to the research (indicative maximum of six references)

1. Susanne Shultz, Hem Sagar Baral, Sheonaidh Charman, Andrew A. Cunningham, Devojit Das, G. R. Ghalsasi, Mallikarjun S. Goudar, Rhys E. Green*, Ainsley Jones, Prashant Nighot, Deborah J. Pain and Vibhu Prakash (2004) Diclofenac poisoning is widespread in declining vulture populations across the Indian subcontinent. Proc. R. Soc. Lond. B vol. 271 no. Suppl 6 S458-S460. doi: 10.1098/rsbl.2004.0223

2. Green RE, Newton I, Schultz S, Cunningham AA, Gilbert M, Pain DJ and Prakash V (2004). Diclofenac poisoning as a cause of vulture population declines across the Indian subcontinent. J Appl Ecol 41, 793-800. doi: 10.1111/j.0021-8901.2004.00954.x

3. Green RE, Taggart MA, Das D, Pain DJ, Kumar S, Cunningham AC and Cuthbert R (2006). Collapse of Asian vulture populations: risk of mortality from residues of the veterinary drug diclofenac in carcasses of treated cattle. J Appl Ecol 43, 949-956. Doi: 10.1111/j.1365-2664.2006.01225.x

4. Green RE, Taggart MA, Senacha KR, Raghavan B, Pain DJ, et al (2007) Rate of Decline of the Oriental White-Backed Vulture Population in India Estimated from a Survey of Diclofenac Residues in Carcasses of Ungulates. PLoS ONE 2(8): e686. doi:10.1371/journal.pone.0000686

5. Cuthbert, R., Taggart, M.A., Prakash, V., Saini, M., Swarup, D., Upreti, S., Mateo, R., Chakraborty, S.S., Deori, P. & Green, R.E. (2011) Effectiveness of Action in India to Reduce Exposure of Gyps Vultures to the Toxic Veterinary Drug Diclofenac. PLoS ONE 6(5): e19069. doi:10.1371/journal.pone.0019069

6. Swan G.E., Cuthbert R, Quevedo, M., Green R.E., Pain, D.J., Bartels P., Cunningham, A.A., Duncan N., Meharg A.A., Oaks J.L., Parry-Jones J., Shultz S., Taggart M.A., Verdoorn G., Wolter, K.. (2006). Toxicity of diclofenac to *Gyps* vultures. Biology Letters 2, 279-28

4. Details of the impact (indicative maximum 750 words)

Impacts on public policy and services, impacts on international development

As a result of the research and allied studies, in 2006 the governments of India, Nepal and Pakistan banned the manufacture and importation of diclofenac for veterinary use, citing the toxicity of diclofenac to vultures and the evidence of its effect on their populations[7]. However, diclofenac came off patent in the 1990s, and by 2006 many companies in India were manufacturing the drug for human and veterinary use. The drug continues to be legal for human use and human diclofenac is also used illegally on animals. As a result, the immediate impact on the ban on levels of contamination of vulture food and vulture population trends was limited.

With the evidence from Green and colleagues that diclofenac was still being used for veterinary purposes up to 2008 (Ref 4, section 3), the Indian Government strengthened the ban by making it an imprisonable offence to import, manufacture, retail or use diclofenac for veterinary purposes. Human diclofenac also had to be labelled 'not for veterinary use'[8]. In 2010, the Government of Bangladesh banned veterinary formulations of diclofenac, bringing it into line with neighbouring countries.

In May 2012, the governments of Bangladesh, India, Nepal and Pakistan made a regional declaration on vulture conservation, with recommendations based upon the work of Saving Asian Vultures from Extinction (SAVE), which Green was instrumental in setting up (see below)[9]:

"Further commending the activities of SAVE and its members for their notable contribution to vulture conservation in the region…
…Removing diclofenic and other toxic NSAIDs completely from the vulture food chain, through measures including enhanced enforcement on the ban on veterinary use of diclofenic."

The International Union for the Conservation of Nature (IUCN) is co-ordinating collaboration among the governments through a Regional Steering Committee. Such inter-governmental collaborations on bird conservation are rare globally, and this is the first of its kind for the Indian subcontinent.

Impacts on the environment, impacts on animal health and welfare
Continued monitoring of vulture numbers across the region (which Green is involved in) has demonstrated that declines have slowed, and may even have reversed for one species[13]. As this result is based on changes to underlying survival rates and breeding success, it indicates that both of these have increased rapidly (Green's modelling work supports the partial removal of diclofenac from the birds' food supply as being the sole cause of any slowing in decline[5 above]).

In 2011 an international consortium of conservation agencies, 'Saving Asia's Vultures from Extinction' (SAVE) was set up[10]. Green was one of the founders of SAVE and is chair of its Technical Advisory Committee. SAVE partners jointly manage a captive breeding programme in India, Nepal and Pakistan, with associated research into improving captive bird husbandry, and this programme is approved by the Government of India's Central Zoo Authority. All three vulture species have now been bred in captivity, with reintroductions of captive-bred birds scheduled to begin within five years. Husbandry guidelines[11] have also been produced to improve the welfare of captive birds and the success rates of breeding programmes; prior to the documented decline, no captive breeding programmes existed and most captive vultures were held only in zoos.

Impacts on society, culture and creativity
SAVE is developing 'vulture safe zones' in which local advocacy is combined with training of local people in monitoring vulture populations and the availability of veterinary drugs, and in undertaking studies of vulture ranging behaviour using GPS PTT tagging. In some cases, ecotourist projects have been linked with vulture safe zones[12], raising awareness, and providing additional income for local people.

Impacts on human health
Vultures provide a valuable ecosystem service: the breakdown of ungulate carcasses. Their loss provides more food for other scavengers, notably wild dogs, whose population in the region increased markedly with the decline in vulture population. This in turn increases the number of dog bites with the consequent possible transfer of rabies. An analysis by Markanda *et al*[16] estimates the monetised heath cost in India of the decline of vultures over the period 1992 to 2006 as approximately 1 trillion Rs (approx. £9 billion) with the cost more heavily felt at the end of the period. While the as yet small recovery in the vulture population has not yet eliminated this cost, it has slowed its increase (and may now be reversing it).

Impacts on commerce – companies are producing a new product
Carcass monitoring has shown that meloxicam is starting to replace diclofenac for veterinary use[5 above], and work is underway to improve the formulation of veterinary meloxicam used by Indian

companies to make it more acceptable to veterinarians and to assess the feasibility of a government subsidy to encourage its use. In 2004, only one Indian drug company was producing meloxicam. By 2011, this had increased to thirty companies[14].

Boehringer-Ingelheim (B-I), the company that developed meloxicam, have donated the expertise of a technical expert on drug formulation and manufacture to assist Indian companies to produce better formulations of the drug and have made details of an improved formulation freely available (meloxicam is out of patent, so B-I does not gain commercially from this). The company has also funded some of the advocacy work that underpins the vulture safe zones (see above)[15].

5. Sources to corroborate the impact (indicative maximum of 10 references)

7. Indian Government Directive: http://save-vultures.org/Documents/06_05__DCGI_Diclofenac_Order.pdf
8. Additions to the 2006 ban in India: http://save-vultures.org/save_solution_advocasyprgramme.html
9. Regional Declaration on the Conservation of South Asia's Critically Endangered Vulture species: www.save-vultures.org/Documents/12%2005%20Regional%20Declaration%20on%20Vulture%20Conservation%20(Delhi).pdf
10. Saving Asia's Vultures from Extinction (SAVE): www.save-vultures.org
11. Prakash, V., Bowden, C., Cuthbert, R., Lindsay, N., Prakash, N., Routh, A. & Parry-Jones, J. (2012). Husbandry Guidelines for 'in range' conservation breeding programmes of *Gyps bengalensis, Gyps indicus* and *Gyps tenuirostris.* Version 1.0 pp54. Royal Society for Protection of Birds, Sandy, UK: ISBN – 978-1-905601-34-9
12. http://www.aceculturaltours.co.uk/tourdetails/4021
13. Prakash V, Bishwakarma MC, Chaudhary A, Cuthbert R, Dave R, Kulkarni M, Kumar S, Paudel K, Ranade S, Shringarpure R, Green RE (2012). The population decline of *Gyps* vultures in India and Nepal has slowed since veterinary use of diclofenac was banned. PLoS ONE 7(11): e49118. doi:10.1371/journal.pone.0049118
14. Data on meloxicam producing companies in India – p10: http://save-vultures.org/Documents/SAVE_Report_Nov_11_Final.pdf
15. http://annualreport.boehringer-ingelheim.com/our-businesses/animal-health/a-future-for-vultures-in-india/
16. Markanda A., Taylor T., Longo A., Murty M.N., Murty S., Dhavala K. (2008) Counting the cost of vulture decline – an appraisal of the human health and other benefits of vultures in India. Ecological Economics 67 (2008) 194-204