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Population trends of Critically Endangered *Gyps* vultures in the lowlands of Nepal

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Summary

Three species of resident *Gyps* vulture are threatened with extinction in South Asia due to the contamination of domestic ungulate carcasses with the drug diclofenac. Observed rates of population decrease are among the highest recorded for any bird species, leading to total declines in excess of 99.9% for the Oriental White-backed Vulture *Gyps bengalensis* in India between 1992 and 2007. Vultures have declined in Nepal, but quantitative information on the rate and scale of decreases is unavailable. Road transect surveys for vultures, following the same route, methodology and timing, were undertaken in lowland areas of Nepal for seven years from 2002 to 2011. The seven survey transects followed Nepal's East-West highway and covered 1,010 km in three years of the survey, and 638 km in the remaining four years. Slender-billed Vultures *G. tenuirostris* were very scarce, with a maximum of five individuals in 2002 and none recorded in 2010 and 2011. Oriental White-backed Vultures were most commonly recorded, but decreased from 205 to 68 birds over the survey period, with an estimated annual rate of decline of 14% a year. If population decreases commenced in Nepal in the same year as in India, then White-backed Vultures in Nepal have declined by 91% since the mid-1990s. Few resident *Gyps* vultures remained in Eastern and Central regions of Nepal, with just one, nine and six birds recorded in the three surveys that covered these regions. The majority of threatened *Gyps* vultures in lowland Nepal are now found in Western and Mid Western regions, where conservation efforts have been focused in the last six years. Removing veterinary diclofenac from across the country and continuing to manage effective "vulture safe zones" are essential to conserve Nepal's remaining vulture populations.

Introduction

The collapse in numbers of three resident species of *Gyps* vulture in South Asia has become one of the most urgent issues in bird conservation (Pain *et al.* 2008), with three of the eight vulture species recorded in Nepal now listed as 'Critically Endangered' (IUCN 2004). Widespread veterinary use of the non-steroidal anti-inflammatory drug (NSAID) diclofenac is now widely accepted as the main, if not the only, reason behind the decrease in vulture numbers in South Asia (Green *et al.* 2004, Oaks *et al.* 2004, Shultz *et al.* 2004, Gilbert *et al.* 2006). Diclofenac is known to be highly toxic to at least five of the eight species of vultures within the *Gyps* genus (Das *et al.* 2010), and dead birds recovered from the wild with measurable diclofenac residues reveal the same clinical signs as vultures experimentally dosed with diclofenac (Oaks *et al.* 2004, Swan *et al.* 2006, Naidoo *et al.* 2009). Dead vultures contaminated with diclofenac residues have been recovered across Pakistan, India and Nepal (Oaks *et al.* 2004, Shultz *et al.* 2004) and

large-scale surveys of domesticated ungulate carcasses (the principal food source of vultures in Asia) across India indicate that 10–11% of carcasses are contaminated with diclofenac. While other causes of mortality, e.g. deliberate and accidental poisoning of vultures (Margalida *et al.* 2008, Hernández and Margalida 2009) and changes in food availability (Margalida *et al.* 2010, 2011) are very important for vultures in Europe and Africa, there is no evidence that such factors play a key role in South Asia (Prakash *et al.* 2003, Pain *et al.* 2008) and population modelling indicates that diclofenac is the principal, if not the only cause, of vulture declines in South Asia (Green *et al.* 2004, 2007). As a consequence, the manufacture and importation of veterinary diclofenac was banned in India in May 2006, with bans in Nepal and Pakistan introduced in the same year.

Due to the veterinary use of diclofenac, vultures in South Asia have undergone one of the most rapid population declines every recorded. Road transect surveys across India indicate rates of population decrease for the Oriental White-backed Vulture *Gyps bengalensis* of 48% a year, and decline rates of around 22% a year for Long-billed *Gyps indicus* and Slender-billed Vulture *G. tenuirostris* (Prakash *et al.* 2007). Similar rates of population decrease are found in Pakistan, where monitoring of birds at breeding colonies indicates annual rates of decrease of 50% per year for Oriental White-backed Vulture and 25% per year for Long-billed Vulture (Gilbert *et al.* 2004, 2006, AVPP 2007). Such rapid rates of decline have had a catastrophic impact on the population, with road transects in India indicating that Oriental White-backed Vultures declined by 99.9% over the period 1992 to 2007, and Long-billed and Slender-billed Vultures decreasing by 96.8% over the same period (Prakash *et al.* 2007).

Far less information is available on the population trends of vultures in Nepal, as until relatively recently political instability in the country has prevented repeat surveys from being undertaken in lowland areas where resident Oriental White-backed and Slender-billed Vultures were formerly most abundant. It is known that diclofenac was widely available for sale and use as veterinary drug prior to the 2006 ban (Bird Conservation Nepal unpubl. data) and that carcasses of vultures were collected in Nepal with clinical signs of visceral gout and diclofenac residues indicative of diclofenac poisoning (Baral *et al.* 2004, Shultz *et al.* 2004). Vulture populations are known to have decreased at Koshi Tappu Wildlife Reserve in the east of Nepal, with 65 active nests recorded in 2000–2001, 14 nests in 2002–2003 and none in 2008 (Baral *et al.* 2004, Bird Conservation Nepal unpubl. data), and observations suggest further declines in other lowland areas (Baral *et al.* 2004).

In this study we provide the first quantitative assessment of the population decline rate of 'Critically Endangered' vultures in the lowlands of Nepal. The observed rate of decline, interspecific rates of decline and the total magnitude of the declines are compared with those found in India and Pakistan and we discuss whether diclofenac is likely to be only causal agent of the declines as is evident in neighbouring India. Lastly, the results of the road transects are used to identify the key lowland districts of Nepal where most vultures are remaining and where conservation efforts should be focused.

Methods

Rates of population change for resident Oriental White-backed and Slender-billed Vultures were estimated from road transect surveys that were undertaken along Nepal's East-West Highway within the lowland regions of Nepal (Fig. 1). The East-West highway runs through the Terai-Duar ecoregion which consists of a mosaic of tall riverside grasslands, savannas and evergreen and deciduous forest, and which runs along the southern edge of the Himalayas adjoining the Gangetic Plain (WWF 2010). Large areas of Nepal's Terai habitat have been settled and converted to agriculture and these areas formerly supported large populations of resident vultures due to high livestock numbers (Baral *et al.* 2004). Politically, Nepal is divided into five development regions (Fig. 1) and 75 districts. Surveys along the East-West highway were undertaken across all development regions and 20 lowland districts in 2002, 2003 and 2009. However, due to the very low numbers of vultures in the Central and Eastern regions of Nepal (Table 1) survey effort

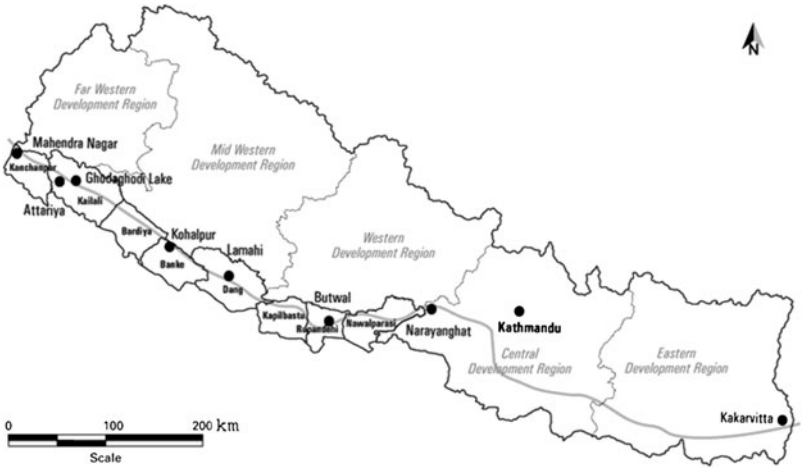

Figure 1. Map of Nepal with the route of the East-West Highway indicated by the grey line in the south of the country. Road transects were undertaken in the western half of Nepal (Far Western, Mid Western and Western development regions) in seven years from 2002 to 2011, but were only undertaken in the eastern half of Nepal (Central and Eastern development regions) in 2002, 2003 and 2009.

was concentrated in the Western, Mid Western and Far Western development regions (Figure 1), with these three regions and corresponding eight lowland districts surveyed in seven years from 2002 to 2011. The western half of the transect covered a total distance of 638 km, with the eastern half (surveyed in just three years) covering 372 km.

Surveys were carried out during early to mid-May and followed the same route and methodology each year. The timing of the surveys is after the breeding season (October to March/April, Baral *et al.* 2005), when adults and young vultures will be independent of the nest.

Table 1. Numbers of vultures recorded from seven road transect surveys in the western regions of Nepal (Western, Mid-Western and Far Western development regions) and from three surveys in Central and Eastern development regions of Nepal. Species are the Oriental White-backed Vulture [OWBV], Slender-billed Vulture [SBV], Himalayan Griffon Vulture *Gyps himalayensis* [HGV], Eurasian Griffon Vulture *Gyps fulvus*) [EGV], Egyptian Vulture *Neophron percnopterus* [EV], Red-headed Vulture *Sarcoyps calvus* [RHV] and Cinereous Vulture *Aegypius monachus* [CV].

Year	OWBV	SBV	HGV	EGV	EV	RHV	CV
Western, Mid Western and Far Western development regions							
2002	205	5	9	1	1	1	0
2003	195	4	0	5	15	1	0
2006	141	4	-	-	-	-	-
2008	111	1	17	0	9	0	0
2009	52	1	0	0	3	2	1
2010	66	0	0	0	4	0	0
2011	68	0	0	0	2	0	0
Central and Eastern development regions							
2002	1	0	0	0	0	0	0
2003	9	0	0	0	0	0	0
2009	6	0	6	0	0	1	0

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Road transects followed the methods reported in (Prakash *et al.* 2003), and were driven at 20 km h^{-1} with all soaring or perching vultures sighted within 1,000 m of the road recorded and identified to species level. A fixed number of observers (two), facing opposite directions carried out the survey between 07h00 and 17h00. The driver did not participate in observations. All sightings of Oriental White-backed Vultures were assigned to adult, sub-adult and juvenile age classes in all surveys, other than in 2002 when this information was not recorded. In addition to the Critically Endangered *Gyps* species, all other vultures seen were identified and number recorded. Surveys over the western regions of Nepal were undertaken over 4–5 days, with the Central and Eastern regions driven over 2–3 days. Whenever possible, the transects were completed over consecutive days, however due to political unrest and frequent strikes and road blocks the duration of the surveys varied from 4 to 10 days, although the number of actual survey days remained constant.

Count data from the first two surveys (2002 and 2003) only recorded the total number of vultures for the eastern and the western sectors of the transect, whereas surveys from 2006-2011 recorded the number of vultures within each district along the East-West highway. Due to the way data were collected, two separate analyses were undertaken. The first was undertaken with ordinary least squares linear regression of vulture numbers against the natural logarithm of vulture numbers against year for the period 2002–2011 and this was only undertaken using data from the western sectors of Nepal (corresponding to the Western, Mid Western and Far Western development regions; Figure 1). This simple analysis was undertaken for both White-backed and Slender-billed Vultures, and for the latter regressions were fitted to $n + 1$ vulture numbers. A second analysis was undertaken for White-backed Vultures utilising all data from 2006 to 2011 by fitting Poisson regression (log-linear models) with site (corresponding to the eight districts surveyed in the western half of the survey) and year treated as factors, and was implemented using TRIM software (Pannekoek and Van Strien 2001). Three standard models were fitted corresponding to no time effects, linear trends, and effects for each time point (Pannekoek and Van Strien 2001). Due to the very low numbers of Slender-billed Vultures recorded Poisson regression models were not undertaken for this species. Five other vulture species (in addition to White-backed and Slender-billed Vultures) were also seen along transects, however the number of birds observed was too low and the variability too great to allow any meaningful assessment of trends (Table 1).

Results

Numbers of Oriental White-backed Vultures in central and eastern Nepal have shown significant decreases from 2002 until 2011 ($F_{1,6} = 30.09$, $P < 0.005$; Figure 2). The estimated exponential annual growth rate (r) was -0.147 (95% confidence intervals of -0.078 to -0.216), a multiplicative decline of 14% a year. Poisson regression models for this species for data from 2006 to 2011 indicated that a model with both time (year) and site (district) effects provided the best fit to the data. Wald tests showed no significant deviation of fit from a linear trend (Wald = 1.09, df = 3, $P = 0.781$), with an overall estimated multiplicative decline rate of 18.2 ± 10.3% a year (± SE) for the period 2006 to 2011, although this trend is not statistically significant at $P < 0.05$. Very few Slender-billed Vultures were observed, with a maximum of five birds recorded from western regions in 2002 and no birds in 2010 and 2011 (Table 1). Despite the limited numbers, linear regression for the period 2002 to 2011 showed a significant negative trend ($F_{1,6} = 37.59$, $P < 0.002$) with r estimated at -0.207 (95% C.I. -0.120 to -0.294), a multiplicative rate of decrease of 19% a year. Five other vulture species were recorded along the highway surveys, including the 'Critically Endangered' Red-headed Vulture *Sarcogyps calvus* and 'Endangered' Egyptian Vulture *Neophron percnopterus*. The age structure of Oriental White-backed Vultures was recorded on six surveys and linear regression analysis on the arcsine transformed proportions of each age class in each survey indicated no significant trend in the proportion of adult, sub-adult and juvenile birds over the period 2003 to 2011 (adults, regression slope = 0.569 ± 1.396

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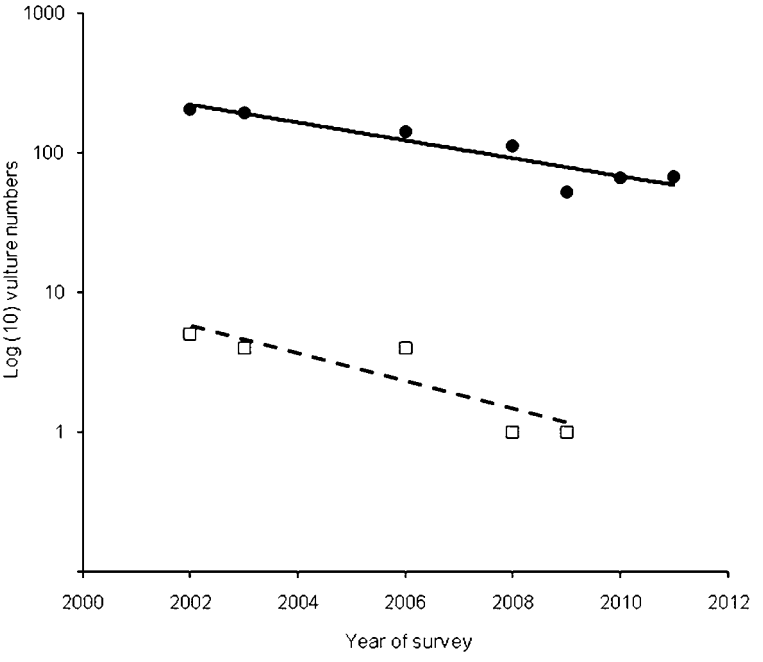

Figure 2. Numbers of Oriental White-backed Vultures (filled circles) and Slender-billed Vultures (unfilled squares) and fitted exponential declines for birds counted along road transects in western areas of lowland Nepal. No Slender-billed Vultures were recorded on the 2010 or 2011 surveys.

(± 1 SE), $F_{1,4} = 0.166$, $P < 0.704$; sub-adults, regression slope = 0.116 ± 1.304, $F_{1,4} = 0.1008$, $P < 0.933$; juveniles, regression slope = -1.419 ± 0.846, $F_{1,4} = 2.817$, $P < 0.169$). Over these six surveys adult birds comprised 77 ± 11% (mean ± 1 SD) of all sightings, with sub-adult and juvenile age-classes averaging 11 ± 9% and 10 ± 6% of the population, respectively.

The geographic distribution of birds indicates that for the most recent four counts (from 2008 to 2011) most remaining Oriental White-backed Vultures in the lowlands of Nepal are now found in western regions of the country, with important populations remaining in Kapilvastu, Dang, Nawalparasi and Rupandehi districts (Figure 3). No vultures were recorded in Kanchanpur or Bardiya districts in western Nepal during the transects, with relatively low and very low numbers found in Kailali and Banke districts, respectively (Figure 3). As already reported, vultures appear to be almost completely absent from the central and eastern regions of Nepal, with count data indicating that vultures had already declined to very low levels by 2002 (Table 1).

Discussion

The surveys undertaken in this study provide the first quantitative estimate of the rate and scale of population decreases for threatened *Gyps* vultures in Nepal, supporting previous qualitative information for lowland areas of the country (Baral *et al.* 2004). Comparison of rates of decrease of Oriental White-backed Vultures in Nepal with rates from India and Pakistan indicate that at 14% a year decline rates are around one third the rate for this species in comparison to the rates found in these two countries (Table 2). Results suggest no difference in the rate of decrease of Oriental White-backed versus Slender-billed Vultures in Nepal, in contrast to the pattern

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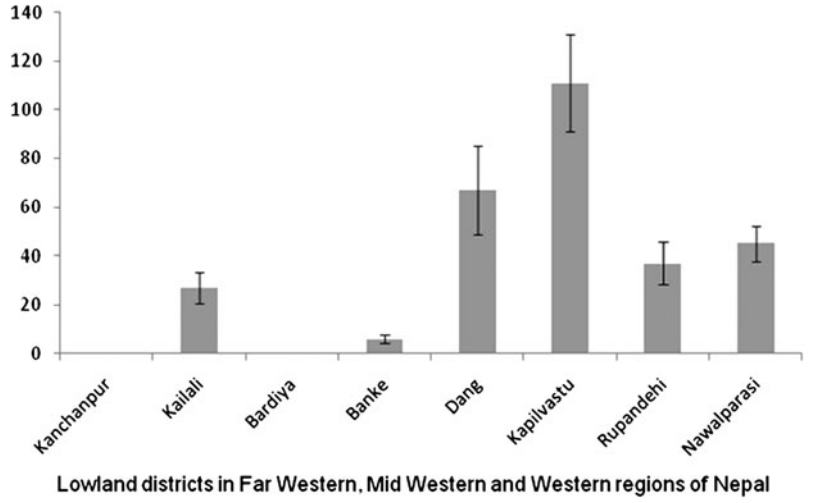

Figure 3. Average numbers (± 1 SD) of Oriental White-backed Vultures recorded along road transects for the period 2008–2011 in the eight lowland districts within western areas of Nepal (see Figure 1).

observed for India and Pakistan, where rates of decline are higher for Oriental White-backed Vultures in comparison to Long-billed/Slender-billed Vultures (Table 2). An explanation for these varying decline rates is currently lacking. However, given the overwhelming evidence that diclofenac is the principal factor behind the vulture declines (Green *et al.* 2004, 2007), and that diclofenac is toxic to all species of *Gyps* vultures (Swan *et al.* 2006, Das *et al.* 2010), then it is most likely that differences in the rates of decline correspond to differences in diclofenac prevalence. In India, numbers of resident *Gyps* vultures are estimated to have started decreasing in around 1995 (Pain *et al.* 2008), following the introduction of diclofenac in the early to mid-1990s. If vulture declines began in Nepal at the same time and at the same rate as observed from the road transects, then for the period 1995–2011 numbers of Oriental White-backed Vultures are estimated to have decreased by around 91%. While such a decrease is severe, it is less than the decreases found in India and Pakistan, where this species declined by 99.9% from

Table 2. Annual decline rates for the Oriental White-backed Vulture (OWBV), Slender-billed Vulture (SBV) and Long-billed Vulture (LBV) estimated for Nepal (this study), India (Prakash *et al.* 2007) and Pakistan (Gilbert *et al.* 2006, Pain *et al.* 2008), along with estimated decline rates for the period 1995–2007 (all countries) and 1995–2011 (Nepal).

Country/Species	Annual decline rate	Decline 1995–2007	Decline 1995–2011
Nepal			
OWBV	13.7% (8–19%)	83%	91%
SBV	18.7% (11–25%)	92%	96%
India			
OWBV	43.9% (33–56%)	99.9%	-
SBV/LBV	16.1% (6–30%)	88%	-
Pakistan			
OWBV	48–50%	> 99%	-
LBV	25%	97%	-

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1992 to 2007 (Table 2). With the decimation of vulture populations in Nepal, other factors such as accidental poisoning, human persecution, electrocution, localised shortage of food due to alternative disposal mechanisms of carcasses could also affect the remaining vulture populations. These factors are known to be significant agents of decline for vulture populations in Europe (e.g. Margalida *et al.* 2008, Hernández and Margalida 2009) and vulture deaths from deliberate poisoning of carcasses in response to predation by wildlife and deaths from electrocution have both been recorded in Nepal (BCN unpubl. data). While these additional sources of mortality are of great concern, the rate and the wide geographic scale of the declines along with knowledge of the widespread availability and use of diclofenac by veterinarians and farmers in Nepal (Bird Conservation Nepal unpubl. data) indicate that diclofenac has been and remains the key threat to vultures in Nepal. The lower rates of decline observed by this study in comparison to India and Pakistan suggest that diclofenac use was less prevalent in Nepal, nonetheless declines of $> 90\%$ are estimated to have occurred for both the 'Critically Endangered' Oriental White-backed and Slender-billed Vulture over the last 16 years.

The majority of Oriental White-backed Vultures in lowland Terai-Duar regions of Nepal (which formerly supported good populations of vultures; Baral *et al.* 2004) are now found in the Western and Mid Western regions of Nepal. Kapilvastu, Dang, Nawalparasi and Rupandehi districts appear to be key areas supporting remaining birds and these lowland districts are now crucial for vulture conservation in Nepal. Until recently (a vulture conservation breeding centre was established in Nepal in 2008; Anon 2009), vulture conservation efforts in Nepal have focused on first banning the veterinary use of diclofenac and secondly on *in situ* conservation initiatives around remaining breeding colonies. *In situ* conservation has aimed to establish "Vulture Safe Zones" in areas surrounding colonies. This has been undertaken by working with local communities to remove stocks of diclofenac from the surrounding areas, advocacy programmes and monitoring of potential diclofenac users (farmers, veterinarians and pharmacists), and provisioning safe diclofenac-free food (by herding old cattle until they die a natural death) close to the breeding sites. Vulture numbers have shown localised increases at these Vulture Safe Zones, with breeding numbers at one site increasing from 17 nests in 2006 to 65 nests in the 2009 season (Chaudhary *et al.* 2010). While some of these increases are likely to be due to immigration of vultures from neighbouring areas these sites also show high breeding success and year-round observations of juvenile and immature birds at these sites suggests recruitment is also occurring. The locations of four of the first six Vulture Safe Zone sites are within the same areas where most vultures were recorded on the four most recent road transect surveys (2008 to 2011). While it is too early to assess the longer-term benefits of this approach, as the observed increases are likely to be a combination of recruitment and immigration, it is encouraging that most birds are now found in areas where *in situ* vulture conservation efforts have been established.

In summary, the results of these road transect surveys indicate that both threatened *Gyps* vulture species in Nepal have undergone major population decreases, and that the Slender-billed Vulture is now extremely rare in the country. Annual rates of decrease for Oriental White-backed Vultures in Nepal are one third the rate observed for this species in India and Pakistan, suggesting that diclofenac usage in Nepal has been lower than in other areas of South Asia. Repeated monitoring of vulture numbers along road transects over the next 5–10 years will help determine the effectiveness of *in situ* and other conservation measures at reversing the population decreases in vulture numbers in Nepal.

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