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Population levels and productivity of the Himalayan Griffon (*Gyps himalayensis)* in Baitadi District, Nepal

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ABSTRACT

The Himalayan Griffon (*Gyps himalayensis)*, is a globally near threatened vulture species that nests in the cliffs of mid hills and Himalayas of Nepal. We studied the Himnalayan Griffon breeding population and productivity on its prominent nesting sites at Khodpe in Baitatdi district, Nepal from 2010 to 2020. In 2012, this district was declared free of veterinary diclofenac—a drug that caused precipitous population declines in Gyps vultures across south Asia during the late 1990s and early 2000s. We therefore expected an increase in the number of occupied nests during our study. However, the growth rates for the number of occupied nests, fledglings, and young fledged per nest during our study were negative with confidence limits overlapping zero. It is possible the population is limited by the availability of nest sites, although we also cannot discount carcass poisoning, electrocution, persecution, and forest fire as limiting factors. This colony is one of the few remaining known breeding sites within the Kailash Sacred Landscape, Nepal. We therefore recommend continued and enhanced monitoring of this species as well as continuation of conservation efforts.

1. Introduction

As obligate scavengers, vultures play an important ecological role in natural and anthropogenic systems by disposing of animal carcasses (Houston, 1979). Carcass removal is especially important in South Asian countries, like Nepal, where large numbers of cattle are kept for milk but not for meat, resulting in a large number of carcasses that require disposal (Prakash et al., 2003; Markandya et al., 2008). Vultures are also culturally important in different religious practices of the world such as the living practices of sky burial in the trans-Himalayan region (Acharya et al., 2009; Bhusal et al., 2020).

Vultures are the most threatened species among raptors (Buechley and Şekercioğlu, 2016; McClure et al., 2018). The Asian Vulture Crisis is mostly due to unintentional poisoning by veterinary use of non-steroidal anti-inflammatory drugs (NSAIDs), particularly diclofenac (Oaks et al., 2004). During the late 1990s, diclofenac caused catastrophic declines of three species of Gyps vultures across south Asia (Oaks et al., 2004; Prakash et al., 2003; Prakash et al., 2012).

In response to the Asian Vulture Crisis, the governments of India, Pakistan, and Nepal banned veterinary use of diclofenac in 2006 (Pain et al., 2008). The vulture-safe drug Meloxicam was also promoted as an alternative to diclofenac (Swan et al., 2006; Swarup et al., 2007). Conservationists further established Vulture Safe Zones, an integrated conservation approach where diclofenac-free carcasses were provisioned to vultures (Chaudhary et al., 2012). Some populations of Gyps vultures in south Asia seem to be recovering as a result of these actions (Chaudhary et al., 2012; Galligan et al., 2020; C.J.W. McClure et al., 2021; Prakash et al., 2012; Prakash et al., 2019).

The Himalayan Griffon (*Gyps himalayensis)* is an old world vulture native to the Himalayas and the adjoining Tibetan Plateau. This species was listed as Near Threatened due to the impacts of diclofenac use in livestock treatment as in the other three *Gyps* species namely White-rumped Vulture *Gyps bengalensis*, Slender-billed Vulture *G. tenuirostris* and Indian Vulture *G. indicus* that nearly went extinct (BirdLife International 2021). This species inhabits mountainous areas and in the winter season sub adult and juvenile moves to lower elevations while adults are busy on breeding in mountain (BirdLife International 2021). In summer, the species roam widely to the mountainous region in conjunction with the transhumance of livestock for the feeding purpose. Himalayan Griffons feed on carrion (Del Hoyo et al., 1994) and regularly visits carcass dumping sites. The species fact is details is in table below.

Table 1

In Nepal, the Himalayan Griffon is a widely distributed resident nesting in the cliffs and outcrops in the mountains and trans-Himalayan Tibetan steppe desert (Inskipp et al., 2016). Himalayan Griffons are monogamous and pairs return to the same nesting and roosting sites yearly. Stick nests are built on ledges or in small caves in a cliff (Fig. 1) making loose colony. Breeding is usually during winter from November

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Table 1
Himalayan Griffon Species Factsheet.

Species	IUCN Status	National Status(Nepal)	Estimated Population (Global)	Estimated Population(Nepal)	Life Span	Weight	Length	Wing Span	Habitat	Occurrence
Himalayan Griffon	Near Threatened	Vulnerable	66,000–334,000	<10,000	18.3 Yrs	8–12 kg	95–130 cm	270–300 cm	1200–5500 m	175–6000 m

(source: BirdLife International 2021).

Fig. 1. Adult Himalayan Griffon taking care of its nestling in the nest at Khodpe, Baitadi.

to May. A single white egg is laid, usually in January, and the incubation period is about 50 days. Both sexes participate in incubation and take care of the nestling. The entire reproductive period is one of the longest recorded among *Gyps* vultures. The young bird stays with its parents until it is six to seven months old.

This species is poorly monitored (Joshi et al., 2015; BirdLife International 2021) and it is unclear whether Himalayan Griffons experienced declines owing to diclofenac (Virani et al., 2008; Acharya et al., 2009). Within the Mustang region of Nepal, Acharya et al. (Acharya et al., 2009) reported rapid population declines from 2002 – 2005 while Virani et al. (Virani et al., 2008) reported a stable population over a similar time period (2001 – 2006). Also within Mustang, Paudel et al. (Paudel et al., 2016) reported a decline from 2002 – 2005 and stabilization from 2008 – 2014. Here, we conducted long term monitoring of Himalayan Griffon nests in the Khodpe area of Joshi et al. (Joshi et al., 2015) and report trends in the number of occupied nests, fledglings, and overall productivity.

2. Study area

The focal Himalayan Griffon nesting cliffs ($n = 2$) are in the Khodpe area of Patan Municipality (29.4375°, 80.62278°) at an elevation of 2085 m in Baitadi District, Far-west Nepal (Fig. 2). The cliffs are in the Kailash Sacred Landscape, which is part of the Himalayas that includes western Nepal, northwestern India, and western Tibet. The Baitadi District has humid sub-temperate monsoon climate with relatively hot summer. Baitadi District is mostly between 700 and 3000 m and is densely populated by humans, with agriculture as the major livelihood (Joshi et al., 2015). South-East facing cliffs are used by Himalayan Griffons for nesting.

3. Methods

3.1. Colony monitoring

We monitored the colony of Himalayan Griffons on two cliffs within the Khodpe area of Baitadi district during the breeding season from 2010 to 2020. We visited the colony at least three times each breeding season and noted whether there were eggs or young in the nests. Nests were classified as occupied if they had eggs (Franke et al., 2017). In addition, we considered nest as productive or unproductive if the chicks fledged or not, respectively. We defined productivity as the number of young fledged per occupied nest (Franke et al., 2017).

3.2. Analysis

We used state-space models under a Bayesian framework to analyze the counts of breeding pairs, fledglings, and productivity (Benson and McClure, 2020). Our state-space models analyzed counts using the formula: $\log(N_t + 1) = \log(N_t) + r_t$, where N_t was abundance in a given year, $N_t + 1$ was abundance in the next year, and r_t was the growth rate from t to $t + 1$. For each year, the growth rate was a random variable (r) with a normally distributed mean. We modeled the number of pairs, the number of fledglings, and productivity separately using identical models following the code provided by Kéry and Schaub (Kéry and Schaub, 2012).

We implemented the models using Bayesian methods in JAGS (Plummer, 2003) from R (R Core Team 2019) by means of the R-package jagsUI (Kellner, 2016). We ran three chains at 50,000 iterations with a burn-in of 10,000 and thinning rate of one. We calculated the Gelman–Rubin statistic (Gelman and Rubin, 1992) and considered chains to have converged when parameters had an $\hat{R} < 1.1$. We also checked for convergence by visually assessing trace plots of parameter chains. We used vague priors for all parameters (Kéry and Schaub, 2012). We considered there to be trends in the number of breeding pairs, fledglings, or productivity if the 95% credible Interval (CRI) of their r parameters excluded zero (Benson and McClure, 2020).

4. Results

The greatest number of occupied nests recorded was 13 (in 2012) and the lowest was eight (in 2013 and 2019). Similarly, the years the most fledglings were observed were 2011 and 2012 (10 fledglings), with 2019 being the year with the fewest fledglings (five fledglings). Productivity varied from 60% (in 2018) to 90% (in 2011).

The number of occupied nests ($r = -0.02$; 95% CRI = −0.15, 0.11) and fledglings (−0.04; −0.17, 0.10), and productivity (−0.02, −0.09, 0.06) had negative r values (i.e. growth rates) over the course of the study, however the confidence intervals overlapped zero indicating great uncertainty (Fig. 3A). Indeed, the probability that the number of nests declined over the course of the study was 68%, and the probability that the number of fledglings and productivity declined were both 78% (based on the number of posterior draws of $r < 0$).

5. Discussion

Over a decade of monitoring Himalayan Griffons in the nesting area of the Baitadi district shows uncertain trends in population levels and

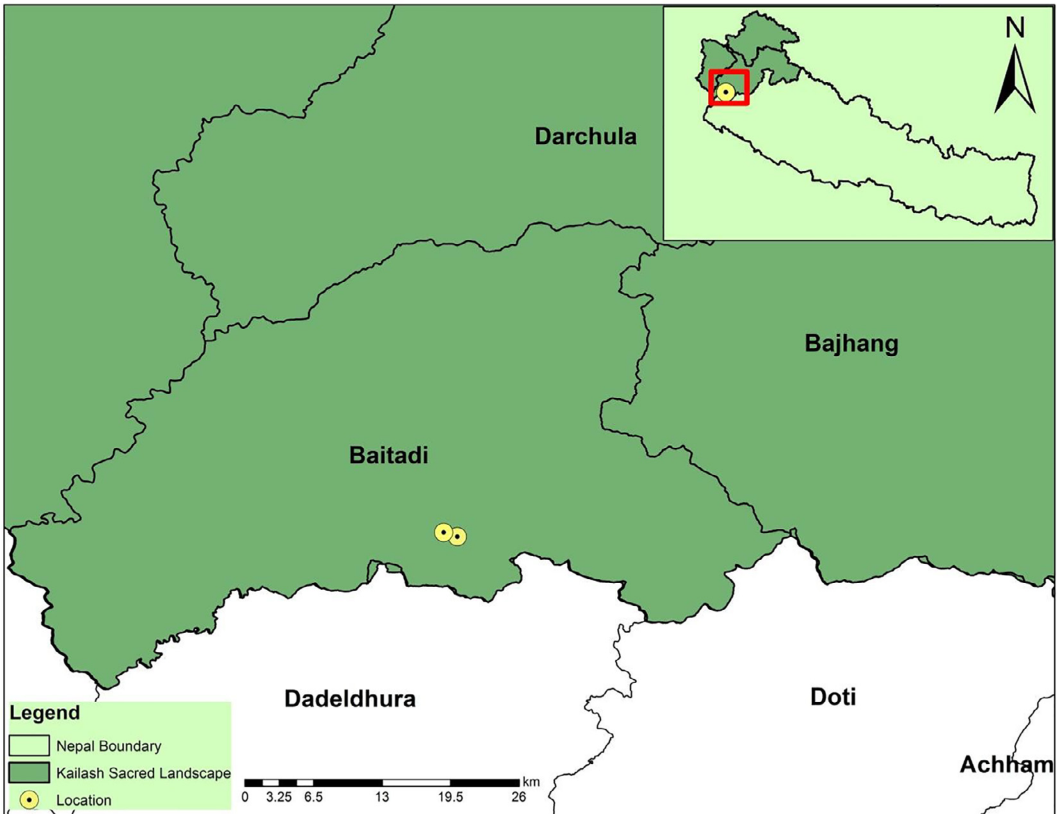

Fig. 2. Study area showing the nesting location, Khodpe, Baitadi District and Kailash Sacred Landscape.

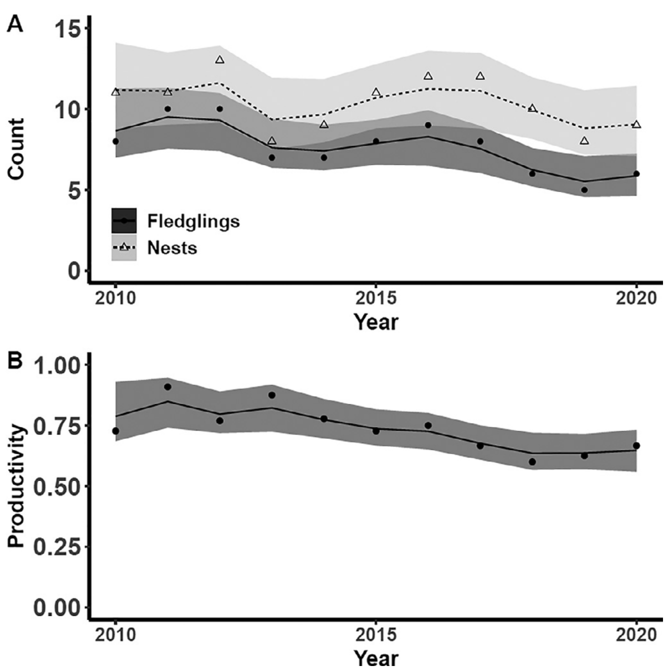

Fig. 3. A) Observed (points) and estimated (lines, shaded areas = 95% credible interval (CRI)) counts of occupied nests and fledglings of Himalayan Griffons. B) Observed (points) and estimated (line, shaded area = 95% CRI) number of fledglings per nest (productivity) of Himalayan Griffons.

reproduction. Indeed, the 95% credible interval for the growth rate in the number of pairs (−0.15, 0.11) substantially overlaps zero and ranges from marked increases to precipitous declines. Previous work within the Annapurna region of Nepal suggested either stable or declining populations of Himalayan Griffons (Acharya et al., 2009; Virani et al., 2008; Paudel et al., 2016). A study conducted within the same time period as ours and in the country's largest nesting colony (Arghakhanchi) suggested increases in both population and productivity (C.J.W. McClure et al., 2021). One of the limiting factors for the breeding population at our study site may be the size of cliffs and availability of favorable nesting caves, but this hypothesis remains untested.

Immigration is an important process in the stabilization of raptor populations (Paudel et al., 2016; Brown and Collopy, 2013; C.J.W. McClure et al., 2021), and might be acting to bolster our focal population. However, the productivity we observed was greater than was reported from the Arghakhanchi colony, which increased in population over the same time period as our study (C.J.W. McClure et al., 2021).

There are several disparate and uncoordinated studies examining the population dynamics of Himalayan Griffons across Nepal (Acharya et al., 2009; C.J.W. McClure et al., 2021; Virani et al., 2008; Paudel et al., 2016). Results of these studies should be combined into a composite population index (Benson and McClure, 2020; Ogada et al., 2016) that estimates the population trend across the global range of the species. Further, researchers should attempt to survey Himalayan Griffons outside of established study areas. The Global Raptor Impact Network [www.globalraptors.org; (Markandya et al., 2008)] could serve as the main platform for collaboration on a range wide program to monitor Himalayan Griffons.

With the aim to conserve the remaining vultures; Baitadi District was declared as diclofenac free district in December 2012 and a community and school awareness program around the nesting site continues. However, the population of Himalayan Griffons at our focal colony has not increased as expected, and is most likely declining. As mentioned earlier, it might be a lack of nesting sites hampering population growth in our study site. However, carcass poisoning, electrocution, persecution, and forest fire are observed threats to vultures in the area—perhaps limiting the recovery of the species. This colony is one of the few remaining known breeding sites of Himalayan Griffons in Nepal within the Kailash Sacred Landscape. In addition to enhanced monitoring, future work should determine the processes and threats that limit the populations of this near threatened species.

Conclusion

The decade long monitoring of Himalayan Griffon breeding population and productivity in the nesting site of far west Nepal shows uncertain trends in population levels and productivity. The number of occupied nests, fledglings, and young fledged per nest were variably fluctuating in the each breeding season. However, the overall scenario indicates the population at this colony is most likely declining, as is productivity.

Author contributions

KPB: designed the study, data collected, and wrote original draft; HLD: field data collected, review, and editing the draft; and CJWM: data analyzed, review, and editing the draft.

Declaration of Competing Interest

The authors declare no competing interests.

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