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SPATIAL DISTRIBUTION AND POPULATION ESTIMATES OF THREE VULTURE SPECIES IN AND AROUND PIR LASURA NATIONAL PARK, NORTHEASTERN HIMALAYAN REGION, PAKISTAN

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ABSTRACT.—Vultures are crucial components of ecosystems as they perform important ecological and aesthetic functions. They provide sanitation services by feeding on carcasses, which would otherwise decay and possibly become a source of disease affecting the health of other animals. In the last few decades, populations have declined drastically, mainly due to the nonsteroidal anti-inflammatory drug diclofenac used in India, Pakistan, and Nepal. In the current study, we investigated the abundance of vultures inhabiting Pir Lasura National Park in Azad Jammu and Kashmir, Pakistan, from September 2015 to August 2016. We recorded three vulture species, including near-threatened Himalayan Griffons (*Gyps himalayensis*), endangered Egyptian Vultures (*Neophron percnopterus*) and critically endangered White-rumped Vultures (*Gyps bengalensis*), distributed across elevations ranging from 560–1530 masl. The Himalayan Griffons were the most common in the surveyed region ($n = 128$ individuals), followed by White-rumped Vultures ($n = 48$ individuals), and Egyptian Vultures ($n = 41$ individuals). Mean numbers of birds at roosts ranged from 7–20 for Himalayan Griffons, 14–26 for Egyptian Vultures, and 15–23 for White-rumped Vultures. We also identified a previously unknown roost of White-rumped Vultures that could be a potentially important area of conservation focus given the decline of this species in Pakistan. Due to declining populations in other parts of the world, the vulture populations we studied should be regularly monitored as a partial assessment of their conservation needs.

KEY WORDS: *Himalayan Griffon*; Gyps himalayensis; *Egyptian Vulture*; Neophron percnopterus; *White-rumped Vulture*; Gyps bengalensis; *abundance*; *distribution*; *Pakistan*; *population*; *vultures*.

DISTRIBUCIÓN ESPACIAL Y POBLACIONES DE TRES ESPECIES DE BUITRES EN Y EN LOS ALREDEDORES DEL PARQUE NACIONAL PIR LASURA, REGIÓN NORESTE DEL HIMALAYA, PAKISTÁN

RESUMEN.—Los buitres son componentes cruciales de los ecosistemas ya que cumplen importantes funciones ecológicas y estéticas. Ellos proporcionan servicios de saneamiento al alimentarse de los cadáveres que de otro modo se descompondrían y podrían servir como una fuente de patógenos para otros animales, afectando su salud. En las últimas décadas, las poblaciones de buitres han disminuido dramáticamente, principalmente debido al uso del medicamento antiinflamatorio no esteroide diclofenaco utilizado en India, Pakistán y Nepal. En este estudio, investigamos la abundancia de buitres que habitan el Parque Nacional Pir Lasura en Azad Jammu y Kashmir, Pakistán, desde septiembre 2015 hasta agosto 2016. Registramos tres especies de buitres, incluyendo la especie categorizada como casi amenazada *Gyps himalayensis*, la especie amenazada *Neophron percnopterus* y la especie críticamente amenazada *Gyps bengalensis*, distribuidas a través de altitudes que varían entre 560–1530 m snm. *G. himalayensis* fue la especie de buitre más común en la región censada ($n = 128$ individuos), seguida de *G. bengalensis* ($n = 48$ individuos) y *N. percnopterus* ($n = 41$ individuos). El número medio de aves en los dormideros varió entre 7–20 para *G. himalayensis*, 14–26 para *N. percnopterus* y 15–23 para *G. bengalensis*. También identificamos un dormidero previamente desconocido de *G. bengalensis* que podría ser un área potencialmente importante de conservación dada la disminución de esta especie en Pakistán. Debido a la disminución de las poblaciones en otras partes del mundo, las

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poblaciones de buitre que estudiamos deberían ser seguidas de modo regular como parte de una evaluación parcial de sus necesidades de conservación.

[Traducción del equipo editorial]

As scavengers, vultures eat carcasses, providing sanitation across a wide variety of landscapes and habitats. These actions benefit human populations and other wildlife populations by clearing carcasses which can spread disease (Pain et al. 2003, Prakash et al. 2003). In the absence of vultures, the time necessary for decomposition of carcasses is nearly three times longer, the number of carnivorous mammals scavenging carcasses increases threefold, the number of feral dogs and rats increases, at least in Asia (Pain et al. 2003), and the prevalence of human rabies increases (Markandya et al. 2008). Given these patterns, it is important that vulture species be monitored and conserved.

Seven vulture species occur in Pakistan; among those, the Red-headed Vulture (*Sarcogyps calvus*), White-rumped Vulture (*Gyps bengalensis*) and Long-billed or Indian Vulture (*Gyps indicus*) are listed as critically endangered, the Egyptian Vulture (*Neophron percnopterus*) is listed as endangered, the Himalayan Griffon (*Gyps himalayensis*) and Cinereous Vulture (*Aegypius monachus*) are listed as near threatened, and the Griffon Vulture (*Gyps fulvus*) is listed as least concern (BirdLife International 2017a, 2017b, 2017c, 2017d, 2017e, 2018a, 2018b). Many of these species were previously common in Southeast Asia (Roberts 1991, Gilbert et al. 2002), but very rapid declines have brought them to the brink of extinction (Collar et al. 2001).

The reasons for these declines appear to be due to interactions between vultures' inherently low productivity and their increasing mortality. Old World vultures have low baseline reproductive rates (Wynne-Edwards 1955, Amadon 1964, Piper et al. 1981) that can be reduced by slight changes in their environmental conditions (Houston 1985). Low reproduction has been exacerbated in the last few decades by exposure to the nonsteroidal anti-inflammatory drug (NSAID) diclofenac, which was used to treat inflammation and fever in domestic animals in India, Pakistan, and Nepal (Gilbert et al. 2002). When vultures fed on the carcasses of domestic animals treated with diclofenac, the vultures died due to kidney failure (Green et al. 2004, Oaks et al. 2004, Shultz et al. 2004). Other NSAIDs affect vultures similarly. For example, populations of Egyptian Vultures and Red-headed Vultures in India declined sharply following exposure to diclofenac and other NSAIDs (Cuthbert et al. 2006).

In light of concerns over declines in vulture populations, we monitored vulture abundance in and around Pir Lasura National Park (PLNP), Azad Jammu and Kashmir, Pakistan. In these areas, some colonies of vultures were believed to persist (Manzoor et al. 2013), and documentation of numbers is necessary as a first step toward conservation action.

METHODS

Study Area. We conducted this study in and around the subtropical pine forest of Pir Lasura National Park, Tehsil Nakyal of Kotli District, Azad Jammu and Kashmir (AJK), Pakistan (Fig. 1A). The study area was located in the southeastern part of the state of AJK, close to the Line of Control (LOC) between 33°25.92′–33°29.31′N and 74°05.64–74°03.02′E. PLNP encompassed >1580 ha, with elevations ranging from 1000–2000 masl, and mean annual rainfall of 1500 mm. Our study also included areas surrounding PLNP with minimum elevations of 560 masl. The area was characterized by permanent streams running through narrow valleys where residents cultivated crops and surrounded by hills and mountains of protected natural areas (Fig. 1B).

Field Methods. We conducted 12 field surveys per month from September 2015 to August 2016. Surveys included seven different sites selected for their high likelihood of allowing observations of vultures at roost sites (where vultures rest at night) and feeding sites (where vultures found carcasses to scavenge). During each field survey, two-person field crews recorded data in the mornings from 30 min before sunrise until all the vultures left the roost site, and in the evenings from 4 hr before sunset until 30 min after sunset. We also conducted field surveys at feeding sites, including dump sites and slaughter houses, to maximize our detection of vultures throughout our study area, and we included indirect signs of vulture presence such as accumulated vulture excreta, molted feathers, and scavenged carcasses. Each time we observed a vulture, we recorded geographic coordinates. At roost sites and at feeding sites, we used binoculars and spotting scopes to scan the valleys of the park to identify

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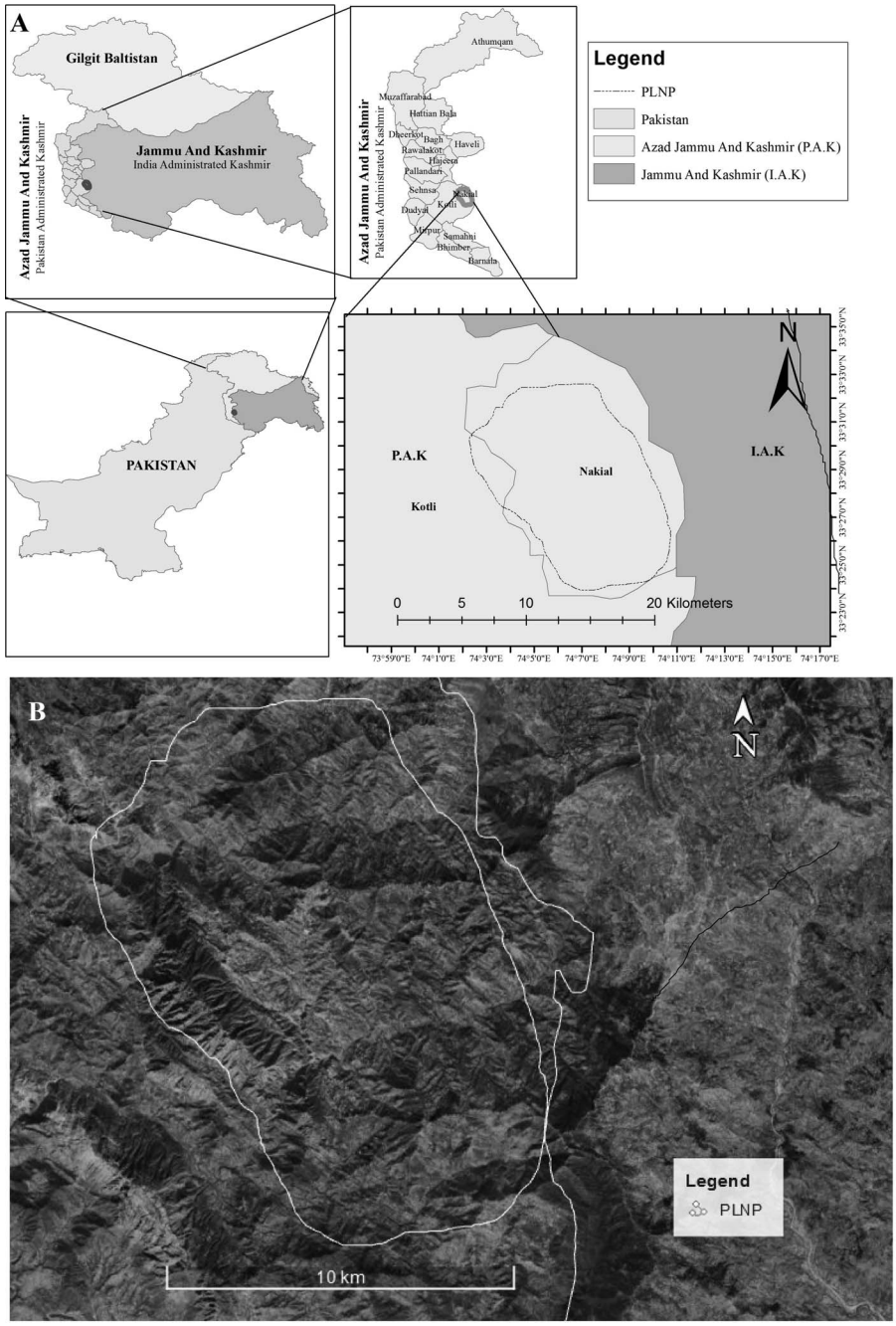


Figure 1. (A) Map of Pakistan showing location of study area, Pir Lasura National Park (PLNP), in the Azad Jammu and Kashmir area of Pakistan; (B) A Google Earth image showing the topography of the study area.

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Table 1. Occurrence of Himalayan Griffons (*Gyps himalayensis*), Egyptian Vultures (*Neophron percnopterus*) and White-rumped Vultures (*Gyps bengalensis*) in Pir Lasura National Park (PLNP), Azad Jammu and Kashmir, Pakistan, from September 2015 through August 2016. The symbol + indicates the presence of the species and – indicates absence.

STUDY SITES	LATITUDE (N)	LONGITUDE (E)	ELEVATION (MASL)	HABITAT TYPE/SITE ATTRIBUTES	HIMALAYAN GRIFFON	EGYPTIAN VULTURE	WHITE-RUMPED VULTURE
Seri	33°28′29.36"	74°4′31.64"	1530	Protected area, Forest, Village	+	–	–
Topian	33°29′26.94"	74°3′45.53"	1500	Protected area, Forest	+	+	+
Karela	33°26′4.28"	74°8′12.25"	1480	Forest, Village	+	–	–
Pir Klinjar	33°28′45.41"	74°7′4.63"	1400	Forest, Village	+	–	–
Majhan	33°27′47.16"	74°8′5.00"	1270	River, Forest, Village	+	–	+
Datote	33°28′29.47"	74°9′58.53"	1270	Forest, Village	+	–	–
Banala	33°30′16.80"	74°6′40.06"	1250	Hills, Forest, Village	+	–	–
Kothiyan	33°29′47.06"	73°57′26.73"	1060	Hills, Forest, Village	+	–	+
Sarda	33°30′32.98"	73°55′56.65"	970	Hills, Forest, Village	+	+	–
Mandi	33°30′11.28"	73°53′23.36"	590	River, Village	+	+	–
Kotli Nala	33°28′36.73"	73°54′58.29"	560	River, Garbage dumping site	+	+	+

vultures not using the roosts (Kushwaha and Kanaujia 2011). We used a Canon (Tokyo, Japan) Power Shot SX520 digital camera with 16.0 MP and 42x optical zoom to photograph vultures to ensure that we correctly identified the species we observed, and followed Elosegi (1989) and Forsman (1999) in estimating the age of vultures as adult and preadult on the basis of body color, body length, and pattern of plumage.

Analytical Methods. We marked areas or locations having flocks of vultures as "positive" during field surveys, and merged those observations with expert knowledge from local communities and field staff of the Wildlife Department of AJK state to develop distribution maps of vultures in PLNP. We used Quantum GIS (Version 2.8) and ArcGIS Desktop (Version 10.1) to map the distributions of different vulture species in the study area. We used Kolmogorov–Smirnov tests to check whether our data were normally distributed. Because our data followed a normal distribution ($P > 0.05$), we used parametric tests to analyze our data.

We estimated the abundance of each vulture species in the park by using the "colonies count" method of Xirouchakis and Mylonas (2005) to establish a minimum estimate from our morning counts of vultures at roosts, and then we adjusted that estimate based on observations of vultures feeding and soaring in the area. We calculated a monthly abundance of vulture populations by the computing mean number of vultures during different months, and seasons at different sampling sites. We used Generalized Linear Mixed Models (GLMMs) to identify significant differences ($\alpha = 0.05$) in numbers of vultures across months and roosting sites. We evaluated monthly variation in the numbers of three vulture species (Himalayan Griffons, Egyptian Vultures, and White-rumped Vultures) by using Least Significant Difference (LSD) tests ($\alpha = 0.05$) for each vulture species separately.

RESULTS

From September 2015 to August 2016, we spent 504 hr observing vultures in and around PLNP. We documented Himalayan Griffons, Egyptian Vultures, and White-rumped Vultures during our observations. We found all three vulture species at elevations ranging from 560–1530 masl. We observed Himalayan Griffons at all 11 survey locations, Egyptian Vultures at four locations, and White-rumped Vultures at four locations (Table 1, Fig. 2). Overall, we found approximately three times as many Himalayan Griffons as Egyptian Vultures or White-rumped Vultures.

Species Abundance. We observed seven roost sites of Himalayan Griffons (Table 2). We estimated mean nightly roost site use as 18 per roost site (range 4–54). We estimated the total observed population as 128 individuals including 72 adults and 56 preadults. The largest roost of the Himalayan Griffons we observed was at Majhan Village (29 vultures) in October of 2015; the smallest roost was at Pir Klinjar Village (12 vultures) in May of 2016. The numbers of Himalayan Griffons did not differ significantly among different roosts or months (GLMM; $P > 0.05$), or across months (LSD; $P > 0.05$).

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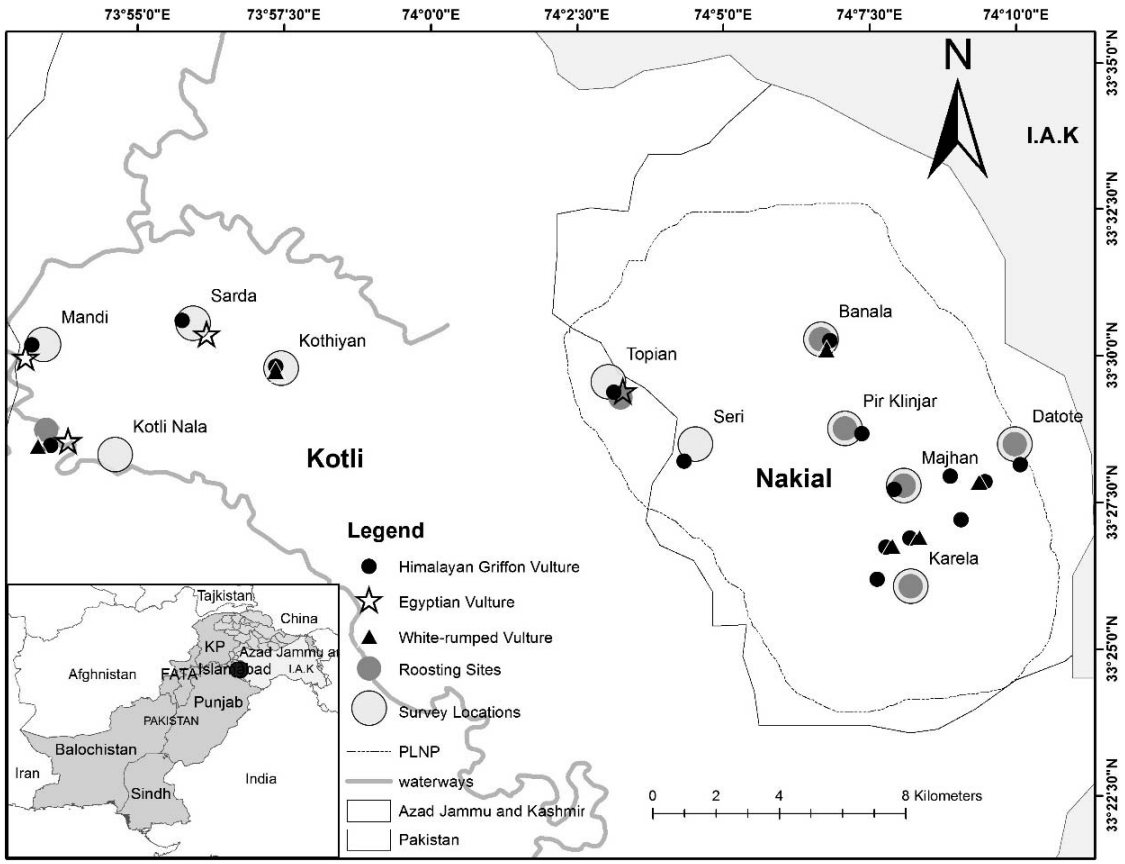


Figure 2. Roosting sites of Himalayan Griffons, Egyptian Vultures, and White-rumped Vultures at Pir Lasura National Park (PLNP), Azad Jammu and Kashmir, Pakistan, from September 2015 through August 2016.

We found two roosts of Egyptian Vultures. We estimated mean nightly roost use as 20 per roost site (range 6–26). We estimated the total observed population at 41 individuals, including 28 adults and 13 preadults. The numbers of Egyptian Vultures significantly differed between different roosts (GLMM; $F = 4.34$, df = 6, $P < 0.05$) but not between months ($F = 2.28$, df = 3, $P > 0.05$). However, the LSD test indicated that numbers of Egyptian Vultures differed significantly among different months of the year ($P = 0.019$), with the greatest numbers present in November, December, and January, and the fewest in March, April, and May.

We recorded three roosts of White-rumped Vultures, with a mean nightly roost size of 16 per roost site (range 6–23). We estimated the total observed population as 48 individuals, including 36 adults and 12 preadults. The largest group, 19 vultures (range 15–23), was recorded at Majhan; the smallest, 12 individuals (range 6–15), was at the Kotli Nala riparian site. The GLMM indicated that numbers of this vulture species did not differ significantly among roosts or months ($P > 0.05$), but the LSD test showed that the numbers of White-rumped Vultures differed significantly ($P = 0.012$) across months between August–November, September–November, May–November, June–November, and July–November.

DISCUSSION

We identified three vulture species, the Himalayan Griffon, Egyptian Vulture, and White-rumped Vulture, in and around PLNP, Pakistan. Previously, only the Egyptian Vulture had been reported from Kotli in this area (Manzoor et al. 2013), although four vulture species were reported from other parts of Azad Jammu and Kashmir. These included the White-rumped Vulture in Muzaffarabad (Awan et

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Table 2. Counts (range) of Himalayan Griffons (*Gyps himalayensis*), Egyptian Vultures (*Neophron percnopterus*), and White-rumped Vultures (*Gyps bengalensis*) at roost sites in Pir Lasura National Park (PLNP), Azad Jammu and Kashmir, Pakistan, September 2015 through August 2016.

SITE NO.	ROOST SITE	HIMALAYAN GRIFFONS	EGYPTIAN VULTURE	WHITE-RUMPED VULTURE
1	Topian	16 (12–25)	21 (14–26)	17 (14–21)
2	Karela	21 (11–21)	0	0
3	Pirklinjar	12 (4–12)	0	0
4	Majhan	29 (16–54)	0	19 (15–23)
5	Datote	17 (10–24)	0	0
6	Banala	20 (6–20)	0	0
7	Kotli Nala	13 (12–15)	20 (6–23)	12 (6–15)
	Mean ± SE	**18 ± 2.17**	**20.5 ± 0.5**	**16 ± 2.33**

al. 2009) and Toli Pir National Park, Rawalakot (Faiz et al. 2015), the Egyptian Vulture in Toli Pir National Park, Rawalakot (Faiz et al. 2015) and PLNP, Kotli (Manzoor et al. 2013), and the Himalayan Griffon in Ghamot National Park, Neelam, in Musk Deer Gurez National Park, Neelam, and in Machiara National Park, Muzaffarabad (Awan et al. 2004).

The Himalayan Griffon is listed as near threatened on the basis of rapid population decline (BirdLife International 2018b). Previously, studies in other parts of the northeastern Himalayan region of Pakistan (Siddique and Khan 2016) estimated the mean population of Himalayan Griffons in Muzaffarabad as 51.6 ± 7.6 (SE) and 46 ± 7.6 individuals using nesting-site counts and transect counts, respectively. In our study, we estimated a slightly larger population of Himalayan Griffons, 128 individuals. This difference could be due to the surveys' coverage of slightly different areas, or to the fact that we counted both adults and preadults, and preadults would not be expected to be present at a breeding colony, such as that studied by Siddique and Khan (2016). Thus, we do not infer a change in abundance in our study area. Future research should continue monitoring so that assessments of population changes are possible.

The Egyptian Vulture is listed as endangered due to an extremely rapid population decline in India (>90% in the last decade), declines in Europe and West Africa (50–79% in 42 yr), and continuing declines throughout its African range (BirdLife International 2017d), including western, eastern, and southern African populations, which appear to have declined significantly, as have Arabian populations (Jennings 2010). We estimated the population size of this species in our study area as 41 individuals. Gilbert et al. (2003) had previously reported very few Egyptian Vultures (only two individuals) in the Punjab province, Pakistan (the nearest observation to our study area, to our knowledge). Given the precipitous declines of this species, we recommend that the Egyptian Vultures in PLNP should be monitored, so population changes can be identified and any declines reversed.

The White-rumped Vulture is listed as critically endangered (BirdLife International 2017a). We estimated 48 individuals in our study area at only three roosts. Of these three roosts, one also held roosting Egyptian Vultures and the other two had Himalayan Griffons. The mixed-species roosts could be facilitated by the diverse landscapes surrounding these roosts and food resources. Previously, the population of the entire state of Azad Jammu and Kashmir was estimated to be 50 birds, with a declining population trend (WWF Pakistan 2015). Considering this, our estimate of 48 White-rumped Vultures in our study area may suggest a positive trend, but this will need to be monitored in the future. Conversely, White-rumped Vultures apparently vanished recently from two other nearby roosts (Dholewala and Changa Manga), and declined 54% at a third (Toawala; Gilbert et al. 2006). This emphasizes the need for conservation efforts to protect the remaining vulture roosts and colonies, and for tracking the number of vultures region-wide.

The White-rumped Vulture was once widely distributed, occurring in southern Vietnam, Cambodia, Myanmar (Burma), Bangladesh, Pakistan, India, Afghanistan, Bhutan, and Nepal. In Pakistan, the White-rumped Vulture occurs in the Indus region and from the Himalayas to Assam Valley, and in some parts of the southern Assam Hills (Brown and Amadon 1968, Rasmussen and Anderton 2005). In 1985, the White-rumped Vulture was reported as most abundant vulture species in the world (Houston 1985). But in the early 20th century this species

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vanished from most of Southeast Asia, and now survives there only in Cambodia and Myanmar (Eames 2007, Hance 2009). This underscores the importance of conserving the White-rumped Vulture wherever it now occurs.

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