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### COMMUNICATION

#### THE CRITICALLY ENDANGERED WHITE-RUMPED VULTURE *GYPES BENGALENSIS* IN SIGUR PLATEAU, WESTERN GHATS, INDIA: POPULATION, BREEDING ECOLOGY, AND THREATS

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## The Critically Endangered White-rumped Vulture *Gyps bengalensis* in Sigur Plateau, Western Ghats, India: Population, breeding ecology, and threats

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**Abstract:** The present study aimed to assess the population status, breeding ecology, and conservation threats of Critically Endangered White-rumped Vulture in Sigur Plateau, Tamil Nadu, India from June 2011 to May 2012. The population of White-rumped vulture was estimated in the roosting and nesting sites twice in a month. Nesting colonies were systematically visited four times in a month during the breeding season to study nesting and breeding ecology. Carcasses and vulture counting was done by opportunistic count method. Two sets of questionnaires namely 'precise and closed' and 'broad and open-ended' were developed to assess the people's perception on vulture conservation. The overall population of White-rumped Vultures was estimated about 70 to 115 individuals. In total, 68 nests were observed in two nesting colonies. Most of the nests (97%) were recorded on *Terminalia arjuna* and only 3% on *Spondias mangifera*. Among the 68 constructed nests, 34 were incubated and 30 chicks were fledged out from the nests with 88% breeding success. Feeding behavior was observed from 28 carcasses, Vultures were attended only 15 carcasses an average of 56.04±3.29 individuals of vultures were recorded. Interestingly, Elephant (61.8±5.1) and Indian Gaur (58.5±0.3) carcasses were attracted in greater numbers of vultures in subsequent days (3.5±0.2) than other carcasses. People's attitude to vulture conservation was positive and useful in 90.82% of the cases (n=99). Cattle carcass disposal method favored to vultures in these regions. The Sigur Plateau to be declared as "Vulture Sanctuary" in order to legally protect and conserve the country's southern-most wild and viable Critically Endangered White-rumped Vulture population in the landscape.

**Keywords:** Carcass, conservation, feeding behavior, Mudumalai Tiger Reserve, nest, Nilgiri Hills, population estimation, vulture sanctuary.

**Tamil abstract:** இந்த ஆய்வு கட்டுரை ஆனது மிக அருகிய (Critically Endangered) வெண்முதுகுக் கழுக்குகளின் எண்ணிக்கை இனப்பெருக்க தழுவியல் மற்றும் பாதுகாப்பு அச்சுறுத்தல்கள் மதிப்பிடுவதை நோக்கமாகக் கொண்டது ஜூன் மாதம் 2011 முதல் மே மாதம் 2012 வரை இந்தியாவின் தமிழ்நாட்டின் உள்ள சிசூர் பீடபூமி வன பகுதியில் இந்த ஆய்வு மேட்கொள்ளப்பட்டது வெண்முதுகுக் கழுக்குகளின் எண்ணிக்கையை கண்ணகிட ஒரு மாதத்தில் இரண்டு முறையும் மற்றும் இனப்பெருக்க தழுவியல் மற்றும் இனப்பெருக்க காலம் பற்றிய ஆய்வுக்கு ஒரு மாதத்தில் நான்கு முறையும் கூடு கட்டும் தளங்களில் ஆய்வு மேட்கொள்ளப்பட்டது மேலும் இறந்த விலங்குகளில் கழுகு எண்ணுதல் சந்தர்ப்பவாத எண்ணிக்கை முறையால் செய்யப்பட்டது மக்களின் கருத்தை மதிப்பிடுவதற்காக 'துல்லியமான மற்றும் மூடிய' மற்றும் 'பரந்த மற்றும் திறந்த-மூடியான' இரண்டு கேள்வித்தாள்கள் உருவாக்கப்பட்டன வெண்முதுகுக் கழுக்குகளின் ஒட்டுமொத்த எண்ணிக்கை சுமார் 70 முதல் 115 கழுக்குகள் என மதிப்பிடப்பட்டுள்ளது மொத்தத்தில் 68 கூடுகள் இரண்டு கூடு கட்டும் காலங்களில் காணப்பட்டன பெரும்பாலான கூடுகள் 97% டெர்மினியா அர்ஜுனாவிலும் 3% மட்டுமே ஸ்போண்டியாஸ் மங்கி:பொரா மரங்களில் பதிவு செய்யப்பட்டன கட்டப்பட்ட 68 கூடுகளில் 34 அடைகாத்தன 30 குஞ்சுகள் பொறித்து கூடுகளிலிருந்து 88% இனப்பெருக்க வெற்றியைப் பெற்றன உணவு உட்கொள்ளும் முறை 28 இறந்த விலங்குகளில் கண்காணிக்கப்பட்டது கழுக்குகள் 15 இறந்த விலங்குகளில் உண்ணுவதை 56.04±3.29 மட்டும் பதிவு செய்யப்பட்டன கவரஸ்யமாக யானை (61.8±5.1) மற்றும் கட்டுமாடு (58.5±0.3) சடலங்களில் அதிக எண்ணிக்கையிலான கழுக்குகள் கண்ணப்பட்டன மக்களின் மனநிலைமை கழுகு பாதுகாப்பு குறித்த மக்களின் அணுகுமுறை நேர்மறையாகவும் பயனுள்ளதாகவும் இருந்தது இந்த சிசூர் பீடபூமியில் கழுக்குகளுக்கு சாதகமாக கால்நடை சடலங்களை அகற்றும் முறை காணப்படுகிறது இந்த ஆய்வு சிசூர் பீடபூமியை "கழுகு சரணாலயம்" ஆக அறிவிக்குமாறு அரசுக்கு பரிந்துரை செய்கின்றது இதன் மூலம் மிக அருகிய வெண்முதுகுக் கழுக்குகளின் பாதுகாப்பு சிசூர் பீடபூமியில் சட்டப்பூர்வமான பாதுக்காப்பாக அமையும்.

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For **Author details** & **Author contribution** see end of this article.

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## INTRODUCTION

White-rumped Vulture *Gyps bengalensis* was once abundant in southern and southeastern Asia. Populations of the White-rumped Vulture and other resident *Gyps* vulture species have declined very rapidly since the mid-1990s across the Indian subcontinent (Prakash 1999; Gilbert et al. 2006; Prakash et al. 2007; Chaudhary et al. 2012). Declines in numbers of the White-rumped Vulture have exceeded 99.9% in India (Prakash et al. 2007) and the species is now classified as Critically Endangered (BirdLife International 2001, 2018). The cause of these declines has been due to the veterinary drug diclofenac (Green et al. 2004; Oaks et al. 2004), which was widely used to treat livestock in Asia. Vultures are exposed to diclofenac by feeding on livestock carcasses which contain residues of this drug. Efforts to achieve the voluntary withdrawal of diclofenac for veterinary use began in 2004. The license to manufacture veterinary formulations of diclofenac was withdrawn by the Drug Controller General of India via a letter dated 11 May 2006 addressed to all the state drug controllers. A similar ban on the veterinary use of diclofenac was also introduced in Nepal and Pakistan in 2006 and Bangladesh in 2010. Despite the ban of this drug in the veterinary sector since 2006, the spillover of human diclofenac multi-dose formulations into the veterinary sector has continued to be the major threat along with other vulture-toxic veterinary drugs (Cuthbert et al. 2016). Vultures play an important role in the ecosystem by scavenging dead animals (Moleón et al. 2014) and the sharp decline of vultures in India has impacted disposal of livestock carcass, sky burial of Zoroastrians and is implicated in increases in human-related diseases such as rabies (Pain et al. 2003).

In southern India there are six species of vultures, viz.: Egyptian Vulture *Neophron percnopterus*, Red-headed Vulture *Sarcogyps calvus*, White-rumped Vulture *Gyps bengalensis*, Long-billed Vulture *Gyps indicus* and two migrants namely, Cinereous vulture *Aegypius monachus*, and Himalayan Griffon Vulture *Gyps himalayensis* are found. Some short term and sporadic studies have been carried out in Tamil Nadu (Davidar & Davidar 2002; Davidar 2007; Ramakrishnan et al. 2010, 2012, 2014; Praveen et al. 2014; Samson et al. 2014a, 2015, 2016a,b,c, 2017, 2018, 2019; Samson & Ramakrishnan 2017a,b, 2018a,b,c; Ramakrishnan et al. 2018; Kalanithi et al. 2018; Sebastián-González et al. 2019), Karnataka (Subramanya & Naveen 2006; Thejaswi 2004; Samson et al. 2014b; Samson & Ramakrishnan 2016; Padma 2018; Rajkumar 2018)

and Kerala (Sashikumar 2001; Sashikumar & Vishnudas 2018). In Sigur Plateau, populations of the four resident species excluding Cinereous and Himalayan Griffon vultures mainly depend on wild carcasses (90%) (Ramakrishnan et al. 2010). Previous studies in the study area reported that the retaliatory killing of carnivores through poisoning the carcasses was one of the threats to the vulture population (Davidar & Davidar 2002). The present study was aimed to assess the population status, breeding ecology, and conservation threats of Critically Endangered White-rumped Vulture in Sigur Plateau, Tamil Nadu, India from June 2011 to May 2012.

## STUDY AREA

The Sigur Plateau is located in Mudumalai Tiger Reserve and its strategically situated between the Nilgiri Hills and the Eastern Ghats landscape (Figure 1). It covers an area of 778.80km<sup>2</sup> at an average elevation of 280m above mean sea level. The boundaries of the Sigur Plateau are Bandipur National Park (Karnataka) in the north, Wayanad Wildlife Scantuary to the west, and Sathyamangalam Tiger Reserve to the south and east. It harbors a diverse range of wild animals including Asian Elephant *Elephas maximus*, Tiger *Panthera tigris*, Leopard *Panthera pardus*, Indian Gaur *Bos gaurus*, Chital *Axis axis*, Sambar *Rusa unicolor*, and numerous other important mammal and bird species. The Critically Endangered *Gyps* vultures such as Long-billed, White-rumped, & Red-headed vultures and Endangered Egyptian vultures are also known to occur in this plateau (Ramakrishnan et al. 2012; Samson et al. 2016). The five major streams in the Sigur Plateau are the Moyar River, the Sigur River, the Avarahalla River, the Kedarhalla River, and the Gundattihalla River crisscrosses the Moyar Valley and finally end up into the Bhavanisagar reservoir.

## MATERIALS AND METHODS

### Nest site count

A preliminary survey was conducted in June 2011 to identify the nesting and roosting sites of White-rumped Vulture in the Sigur Plateau (Image 1). Information was also gathered from past literature and questionnaire survey was conducted to the local and tribal people (n=60) in six villages viz. cattle grazers (n=25), NTFP collectors (n=40) and forest field staff (n=35) to locate roosting and nesting colonies of White-rumped Vultures

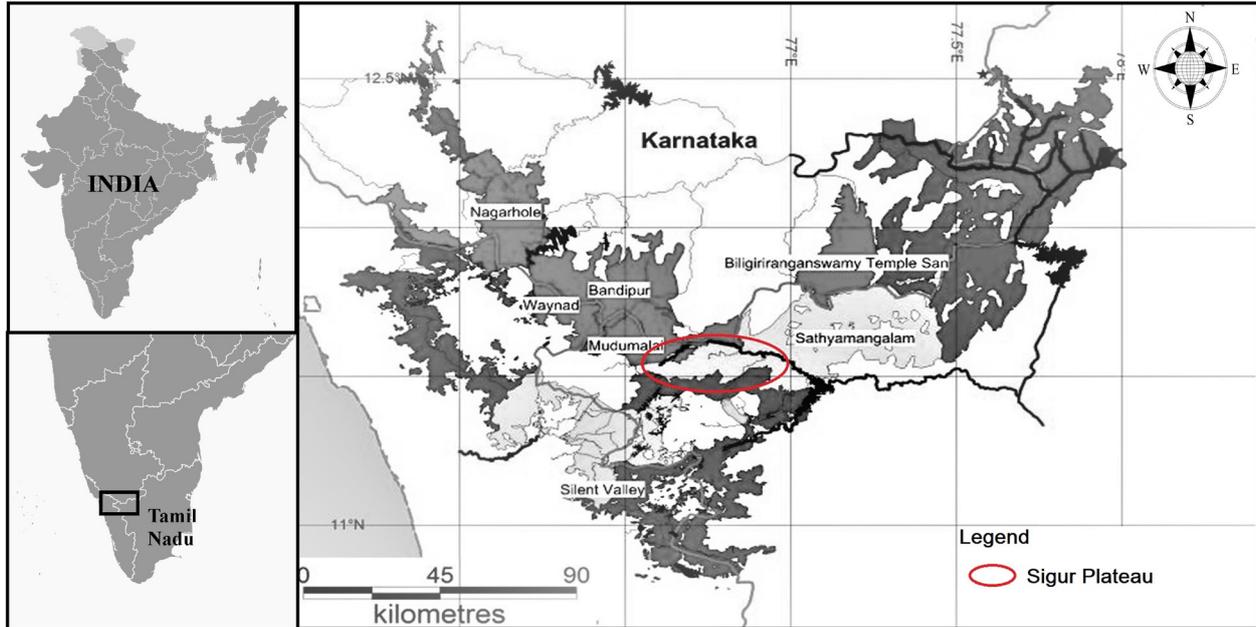


Figure 1. Map showing the study area Sigur Plateau located on the Nilgiris Eastern Ghats Landscape.



Image 1. White-rumped Vulture *Gyps bengalensis* roosting on the tree in Sigur Plateau.

in Sigur Plateau. Once the roosting and nesting locations were confirmed. Population estimation was done twice (15 days interval) in a month. The rivers and nullas (streams) were thoroughly searched for nesting sites' shreds of evidence of White-rumped Vulture to monitor the population. We divided the age-class of White-rumped Vultures into two categories namely Adult (Fully matures after five years) and Immature (1–4 years). The population size of White-rumped vultures was estimated by counting the individuals in the roosting and nesting sites during the early morning (06.30–09.30 h) and late evening (17.30–19.30 h) hours. We assumed fidelity of nesting sites, fixed time of roosting and geographic closure, no movement into (immigration), or out of (emigration) sites to estimate population size as described by Baral et al. (2005).

### Breeding ecology

To study the nesting and breeding ecology of White-rumped Vulture, each nesting colony was systematically visited four times (Seven days interval) in a month during the breeding season (September-2011 to May-2012) to check the status and number of vultures present in each nest. All nesting colonies' observations were done using binoculars (Nikon 52×10) from an appropriate distance (100–300m). The focal animal sampling method (Altmann 1972) was used to monitor the status and behavior of the White-rumped Vulture in nesting colonies (Postupalsky 1974; Acharya et al. 2009). Every visit, five to 10 minutes were spent to check the breeding status of each nest. All observations were made between 07.00h and 12.00h. Nests were identified by the presence of fresh nesting materials and whitewash (excreta) below the nesting tree or by the presence of the incubating vulture in the nest. All the nests were identified and nesting trees were tagged for future monitoring (Postupalsky 1974). The nesting variables such as tree height, Diameter at Breast Height (DBH), trunk size, primary branch, branch start, branch end, nest height, number of nests in a tree, nest dimension, nest position, and nest location were recorded. Tree height was measured using a rangefinder (Bushnell) and diameter at breast height (DBH) was measured using a measuring tape. All nesting trees were tagged (using a metal plate by numbering the nesting trees). The direction of nests on the nesting trees was determined by compass. Nest locations on trees were determined by visual estimation, viz., top of the crown, and limb (offshoot growing directly out of a tree trunk). Confirmation of active (occupied) and abandoned (unoccupied) nests was done based on the criteria laid down by Postupalsky (1974). An active breeding pair

was defined as that laid an egg, and non-breeding pair was confirmed that occupied the nest at least for three weeks but did not lay an egg. Breeding success was calculated based on the number of fledglings divided by the number of breeding pairs (that laid eggs). On each visit, an active nest was considered occupied by a pair by only when a single or two adult vultures were observed at the nest, one standing and one incubating or one incubating adult was present or one adult with a chick or a young chick alone was presented in the nest. A colony was considered as active, only if it contained at least one active nest with egg (Xirouchakis & Mylonas 2005).

### Counts at carcasses

In this, we counted the number of carcasses found by the opportunistic count method (Information gathered by forest officials and local people) as well as the number vultures intake the carcasses. Similarly, other scavenger animals were also noted. Besides the type of carcass, the cause of death, type of habitat, domestic or wild, and locations were recorded.

### People's on vulture conservation

Questionnaire survey was carried out between the months of April and May 2012 in the villages and settlements located in the vicinity of vulture colonies to understand inhabitant's perceptions about vulture population, carcass disposal methods, livestock holdings, livestock depredation by wild animals, veterinary practice, forest resource use, and conservation attitudes. A total of 109 persons were interviewed (87 cattle holders, six veterinary doctors, and 12 quacks, and four medical shops keepers). Two sets of questionnaires were developed for this study. One was 'precise and closed' and the other one was 'broad and open-ended'. Most of the people in this plateau are illiterate, so the questions were asked in local language for easy communication., Questions were asked concerning diclofenac usage and knowledge about diclofenac and their perceived effect on vulture populations and sale of diclofenac in drug stores. Mode of veterinary practice and treatment to injured livestock was interviewed to the veterinary doctors and veterinary assistants (quacks).

### Statistics and mapping

Statistical analyses were done using past3 statistical software and mapping on nest locations was done using Quantum GIS 1.7.1walcrow version computer software with the help of GPS field data.

**RESULT**

**Population status**

Although three colonies namely Anaikatty, Jagalikaladvu, and Siriyur were found during our study, the Anaikatty nesting colony was abandoned by the White-rumped vultures. Monthly two visits (once in a fortnight) were carried out in two colonies namely, Jagalikaladvu and Siriyur from June 2011 to May 2012. The numbers recorded are presented in Table 1. There is a significant variation was found in the numbers of White-rumped Vultures observed between breeding  $108.75 \pm 2.91$  (October–May) and non-breeding  $79.25 \pm 2.06$  (June–September) seasons in both the vulture nesting colonies ( $t=4.74$ ;  $P<0.0000$ ).

**Nesting behavior**

The breeding season of White-rumped Vulture was observed from September 2011 to May 2012. The nesting colonies were located in the riparian ecosystem of Sigur and Gundattihalla rivers (Figure 2). Two tree species namely *Terminalia arjuna* and *Spondias mangifera* were utilized for nesting by White-rumped Vultures in the study area. A total of 31 trees with 51 nests were recorded in the Jagalikaladvu nesting colony

(49 nests in *Terminalia arjuna* and 2 nests in *Spondias mangifera*). On the other hand, 17 nests were seen in 10 *Terminalia arjuna* trees at the Siriyur nesting colony. The mean height of the nesting tree was  $26.73 \pm 0.76$  and the DBH was  $478.43 \pm 36.27$  irrespective of the tree species in both the nesting colonies. The maximum height of the nesting tree was 36m and a minimum height was 17m in the Jagalikaladvu nesting colony. The average trunk size of the nesting trees was  $10.15 \pm 0.54$  m irrespective of the tree species in both the nesting colonies. Similarly, the branch start and branch end of the nesting trees showed that  $9.92 \pm 0.54$  m and  $23.80 \pm 0.75$  m respectively. The primary branch was  $4.39 \pm 0.21$  m and the canopy size shows much higher values on length  $16.82 \pm 0.68$  and width  $28.63 \pm 0.75$  the nest height from the ground level shows  $24.72 \pm 0.62$ . The height of the nest location was ranged from 14m to 36m. White-rumped Vultures construct cup type nests and the nest dimension was approximately 1m length and 40cm width and 15cm depth. Most of the nests (34%) were positioned towards north-east direction (NE) ( $n=23$ ) followed by south-west (SW) (29%;  $n=20$ ), south-east (SE) (25%;  $n=17$ ) and north-west (NW) (12%;  $n=8$ ) (Figure 3). Most of the nests were located on the tree crown ( $n=51$ ) and a considerable number of nests were located on the limb

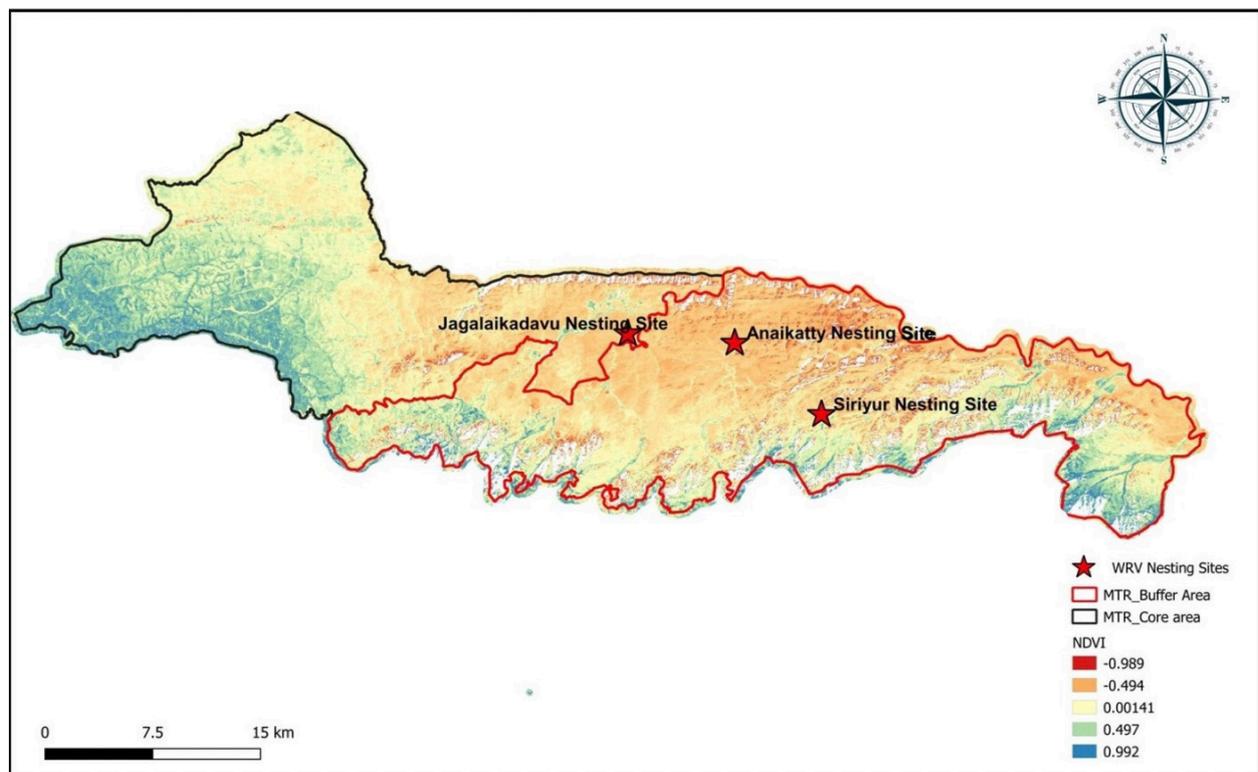


Figure 2. The nesting colonies of White-rumped Vulture in Sigur Plateau, Mudumalai Tiger Reserve, Tamil Nadu, India.

**Table 1. Population estimation of White-rumped Vulture in Sigur Plateau, Western Ghats, India.**

Colonies	Seasons	Adult		Immature		Total	
		Maximum Minimum	M±SE	Maximum Minimum	M±SE	Maximum Minimum	M±SE
Jagalikadavu + Sิริyur Overall	Non-breeding (June–September)	62–50	58±1.5	28–12	21.25±2.04	86–70	79.25±2.06
	Breeding (October–May)	84–69	77.37±1.15	56–20	31.37±2.47	138–97	108.75±2.91
Jagalikadavu (June 2011–May 2012)		61–34	48.75±1.69	40–06	18.56±1.56	98–44	67.04±2.78
Siriyyur (June 2011–May 2012)		28–10	22.16±0.75	17–06	9.70±0.55	41–22	31.87±0.91
Overall			70.91±2.10		28±2.02		98.91±3.54

**Table 2. Nesting trees and nest variables details of White-rumped Vulture in the Sigur Plateau, Western Ghats, India.**

Variables	Nesting trees		Overall
	<i>Terminalia arjuna</i> (N=39)	<i>Spondias mangifera</i> (N=2)	
Height	27.07±0.75	20±1	26.73±0.76
DBH	478.43±36.27	478±41.5	478.43±34.51
Trunk Size	10.15±0.54	5.5±0.5	9.92±0.54
Branch Start	10.15±0.54	5.5±0.5	9.92±0.54
Branch End	24.12±0.76	17.5±0.5	23.80±0.75
Main Branches	4.41±0.21	4±1	4.39±0.21
Canopy size	16.92±0.71	15±1	16.82±0.68
Nest Height	24.92±0.63 (n=66)	18±1 (n=2)	24.72±0.62

**Table 3. Nesting success details of White-rumped Vulture nesting colonies from the Sigur Plateau, Western Ghats, India.**

Nesting colonies	No of trees	No of nest constructed	Nests with eggs	Nests with hatched chicks	Confirmed fledged	Breeding success	Abandoned or failed nests
Jagalikadavu	31	51	26	22	22	85%	29
Siriyyur	10	17	8	8	8	100%	9
Total	39	68	34	30	30	88%	38

(n=15) portion of the tree. The percentage of canopy cover was classified into four categories (0% to 25%, 25% to 50%, 50% to 75% and 75% to 100%). The result showed that the most nesting trees (n=15) were in the 25%–50% canopy cover, followed by 50%–75% (n=12), 75%–100% (n=9) and 0%–25% (n=5) (Table 2).

**Breeding success**

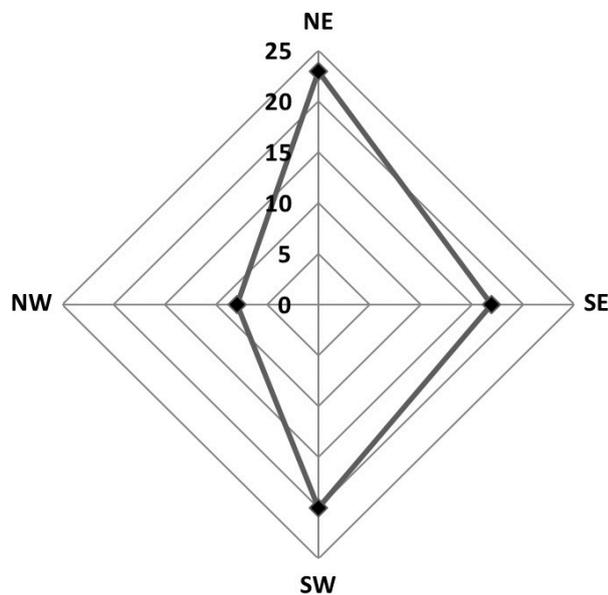
Although nest-building activity of White-rumped Vultures started from September–October, the intensive nest construction was observed in October (n=48) and nest attendance by parent birds was until the end of chicks fledged out from the nests (May). The nests (n=68) were classified as occupied and abandoned. It was unfortunate to note that the proportion of

abandoned nests were gradually increased during the breeding i.e in the month of October 52% (n=20), in November 38% (n=14), and in even in December it was 10% (n=4) during nest construction and egg-laying stages. Among the 68 constructed nests, 50% (n=34) completed incubation. Of which, 88% (n=30) of nests had successfully hatched, and all hatched young ones were successfully fledged out. The incubation took place from November to January (55 to 60 days). Hatchlings were seen from the first week to the second week of January 2012 (30 chicks). The breeding success has differed between the nesting colonies. Siriyyur nesting colony (100%) had higher breeding success than the Jagalikadavu colony (85%) (Table 3). The nesting success in the nesting trees was also measured in which 56.41%

**Table 4. Preference of carcasses by vultures in Sigur Plateau, Tamil Nadu, India.**

	Name of the carcasses	Number of Individuals	Avg. No of days Observed	WRV	LBV	RHV	Total	WB	SD
1	Buffalo	1	2	62±4	3±1	2.5±0.5	67.5 2.5	6±2	8
2	Cow	3	2.5	36.6±5.7	1.6±0.2	0.8±0.1	39.9±5.6	8.1±1.3	6.2±2.4
3	Elephant	2	4	56.5±5.4	2.1±0.4	3.1±0.6	61.8±5.1	16.6±2.5	3±1.4
4	Indian Gaur	3	3.3	53±7.7	2.5±0.6	3±0.3	58.5±0.3	5.4±6.95	0
5	Sambar Deer	3	1	35.3±3.1	1±0.5	1±0.5	37.3±4.1	4.2±1.8	0
6	Spotted Deer	3	1	29.3±5.6	1.3±0.3	1.3±0.3	32.3±6.1	2.1±0.6	0
7	Buffalo	1	6	0	0	0	0	18.7±3.4	6.21±2.1
8	Buffalo calf	11	2.5	0	0	0	0	12.3±3.8	4.2±1.9
9	Indian Gaur calf	1	1	0	0	0	0	8	0

WRV—White-rumped Vulture | LBV—Long-billed Vulture | RHV—Red-headed Vulture | WB—Wild Boar | SD—stray dogs



**Figure 3. Nest orientation of White-rumped Vultures within nesting tree.**

(n=22) was observed from *T.arjuna* trees. On the other hand, 100% of the failure of nesting was recorded in *S.mangifera* trees (n=2). The overall breeding success of both the nesting trees was 41.07% in *T.arjuna* followed by 0% in *S.mangifera*.

A total of 24 visits, we had observed 30.12±5.36 individuals of both Tufted Grey Langur *Semnopithecus priama* and Bonnet Macaque *Macaca radiata* were disturbed on the nesting trees. Four broken eggs and eight destroyed nests were recorded during our fieldwork envisaged that there was a severe disturbance by these primates.

**Observation of carcasses**

A total of 28 ungulate carcasses were observed during the study period, which included 16 domestic and 12 wild animals (Table 4). Among the carcasses, most of them were found near human settlements (n=15) and considerable numbers were in forest areas (n=13). Out of 28 carcasses, 11 of them were Tiger kills, just one was Wild Dog kill and others (n=16) were natural deaths. Vultures were attended only 15 carcasses an average of 56.04±3.29 individuals of vultures were recorded viz White-rumped Vultures (51.62±3.1), Long-billed Vultures (2.2±0.2), and Red-headed Vultures (2.5±0.2). Interestingly, Elephant (61.8±5.1) and Indian Gaur (58.5±0.3) carcasses were attracted in greater numbers of vultures in subsequent days (3.5±0.2) than other carcasses. It is very important to note that out of 15 domestic animal carcasses, just 3 carcasses (2 cow and 1 buffalo) were attended by vultures and the rest of them (1 buffalo and 11 buffalo calves) were not attended by vultures. But these 12 carcasses were fed by wild boars (16.2±4.7) and stray dogs (5.4±2.1) as these carcasses were found very close to human habitations.

**People’s perceptions on vulture conservation**

A total of 109 local people were interviewed on vulture conservation which includes cattle owners and local veterinarian and drug store owners. Of which, 90.82% (n=99) of them were opined that the vulture conservation is good for ecosystem services. Interestingly most of them were opined that the vultures are nature scavengers (73.39%; n=80) and some of them were also presumed that the vulture is a bird (20.18%; n=22), and few of them were also opined that the vultures are hunter bird (6.42%; n=7). The

questionnaire survey revealed that most of the cattle holders were illiterate (93.10%; n=81) and unaware of the drug diclofenac and the threat it poses to vultures. The respondents opined that the tiger has killed their livestock more (n=252) followed by leopard and wild dogs each consumed 14 individuals during the last five years. The mode of livestock carcass disposal by the livestock holders revealed that most of them were (83.90%; n=73) just throw their carcasses into forests in the distance between 300-500m from the villages and rests (16.09%; n=14) were buried their cattle carcasses. All the veterinarians and quacks who were interviewed responded that they used meloxicam to treat livestock and none of them used diclofenac through 4 medical shops were selling diclofenac for the human purpose near vulture habitats in the study area.

## DISCUSSION

The population of vultures has declined dramatically across South Asia due to the drug diclofenac, a Non-Steroidal Anti-Inflammatory Drug (NSAID), and other veterinary drugs (Prakash et al. 2003; Oaks et al. 2004; Margalida et al. 2015). In Sigur Plateau, the vulture population is possibly protected from some of these drug effects, as they depend on 90% of their food from wild carcasses (Ramakrishnan et al. 2010), even though the remaining 10% could still pose risks. The present study recorded the minimum and the maximum number of White-rumped Vulture populations viz. 44-98 and 22-38 in Jagalika Davu and Siriyur colonies respectively from June 2011 to May 2012. It was quite interesting to note that the vulture population was very low in June, and gradually increased subsequent months and reached its maximum numbers at the end of May. A similar pattern was also noted by Baral et al. (2005) in the White-rumped Vulture population in Nepal. This could be mainly because, during non-breeding seasons, the adult's birds fly far away for food, and may not return to nesting colonies on the same day (Rabenold 1987). Therefore, the maximum number of vultures were seen in and around nesting colonies only during breeding months, unlike non-breeding seasons.

The nests were located on the fork of the trees which are well-foliaged along the watercourses. Similar observations were documented in India by (Das et al. 2011; Pande et al. 2013; Khan 2013; Ramakrishnan et al. 2014; Majgaonkar et al. 2018; Jha et al. 2020). The present study has recorded two tree species were preferred by White-rumped vultures for nest

construction in the study area. Of which, more number (94.12%) of nests on *Terminalia arjuna* trees and just 4.88% of nests on *Spondias mangifera* trees in the riparian ecosystem. Because these two tree species were only seen as tallest trees in the study area. Similarly, many tree species were preferred by White-rumped vultures for nest construction across India and Bangladesh was documented by several authors. *Tectona grandis*, *Bombax ceiba*, *Terminalia tomentosa*, *Dalbergia sissoo* in Uttarakhand (Das et al. 2011); *Terminalia arjuna*, *Terminalia bellerica*, *Alstonia scholaris*, *Mangifera indica* in Maharashtra (Pande et al. 2013); *Ficus benghalensis*, *Ficus religiosa*, in erstwhile East Bengal now Bangladesh (Khan 2013) and *Terminalia arjuna* in Tamil Nadu (Ramakrishnan et al. 2014). Road (2010) reported that in Associated Private Nature Reserves located in the Limpopo Province, South Africa the African elephants (*Loxodonta africana*) interfere the nesting habitat and break the branches as well as debarking the nesting trees and destroyed the nesting trees of White-backed vultures (*Gyps africanus*). Similar kind of observation is observed in Sigur plateau Tusk punch mark on the nesting trees, debarking as well as feeding on bamboos under the nesting trees and interestingly note that 20 Honey Hives are recorded in the nesting trees in four nesting trees Sloth bear hunt the Honey hives we confirmed based on the nail marks on the bark on the nesting trees. Jha et al (2020) recorded that out of 44 tree species used by vultures for roosting, 14 (mostly shorter) trees were not used for nesting, indicating a preference for taller trees in Madhya Pradesh. Large trees (Chhangani 2007; Dhakal et al. 2014) provide predator avoidance, suitable microclimates (Campbell 2015), and increased mobility (Wright et al. 1986) for vultures. The present study has recorded 14-36m above the ground level of White-rumped vulture nests in the study area irrespective of the nesting tree species. 16.6m height was recorded by Chomba & M'Simuko (2013) in Lochinvar National Park on the Kafue flats, Zambia, 8-28m in central west Nepal (Subedi & DeCandido 2014), 14.8m in Himachal Pradesh, India (Thakur & Narang 2012), 18-36m (Naoroji 2006), above 21m in southern Pennsylvania, northern Maryland, and northeastern Virginia (Thompson et al. 1990) and 25-30m in Sigur Plateau of the Nilgiris (Ramkrishnan et al. 2014). Other species were recorded in smaller trees (*Mangifera indica*, *Acacia nilotica*, *Azadirachta indica*, *Prosopis cineraria*) in other regions such as arid Rajasthan and Maharashtra (Chhangani 2007; Kambale 2011; Khatri 2013). Among the 68 nests recorded by this study, 34% were facing towards north-east, 25% south-east, and 29% south-west directions.

This was mainly due to a possible influence of sunlight effect. The maximum nests' width and length were 1m and 40cm respectively. Canopy size plays a huge role for the selection of nesting trees by White-rumped vultures in the study area. The average length was  $16.82 \pm 0.68$ m and the width was  $28.63 \pm 0.75$ m recorded in the study area.

The present study found that out of 68 constructed nests, 34 were incubated and 30 chicks were successfully fledged out from the nests with 88% of breeding success during the year 2011–2012. Sashikumar & Vishnudas (2018) reported an overall 65% breeding success of White-rumped Vultures in Wayanad Wildlife Sanctuary, Kerala from 2003 to 2017. Majgaonkar et al. (2018) reported that overall 21.2% of occupied nests in a coconut plantation colony affected by storm damage, 52.9% was successful in a nearby forest colony in western Maharashtra, India. Thakur (2015) reported that 56.1% breeding success in 2009–2010, and slowly increased to 72.7% in 2010–2011 and finally 79.4% success in 2011–2012 from 24 breeding colonies of White-rumped Vultures in Shahpur, Nurpur, and Kangra regions in Kangra District of Himachal Pradesh. Baral et al. (2005) reported that 72–102 individuals of White-rumped Vultures in six colonies during their breeding season had 50% breeding success at 70 occupied nests in Rampur Valley, Nepal. In Pakistan, a total of 2,281 occupied nests of White-rumped vultures were recorded between 2000 and 2004 the nest success was observed in 1,231 nests taking the breeding success to 51% (Gilbert et al. 2006). The mean nesting success of African White-backed Vultures (*Gyps africanus*) in the Masai Mara over the five years was 59%, which compares favorably with previous studies conducted in southern Africa (Monadjem 2003; Herholdt & Anderson 2006). The nesting success rates after the year 2000 for White-rumped Vulture colonies in India, Nepal, and Pakistan ranged between 30% and 73% (Gilbert et al. 2006; Baral & Gautam 2007; Thakur & Narang 2012); however, the breeding success of White-rumped vultures in Bangladesh between 2009 and 2011 was only 15.6% and 25.8% due to the effect of multiple dosages of diclofenac (Khan 2013). The 88.23% breeding success of White-rumped vultures recorded by this study is a positive sign envisaged that this population is gradually growing when compared to other studies across the country and the world as a whole.

We observed a total of 38 (56%) nests were abandoned by the White-rumped vultures during the breeding season (October to December 2011) of the study period. Of which, 90% of the nests were abandoned before eggs were laid (October to November) and 10%

of the nests were abandoned after the eggs were laid (December). Similar observation was noticed in Nepal by Baral et al. (2005). Samson et al. (2018) reported that anthropogenic threats were resulted in nest site abandonment by White-rumped Vultures in Sigur Plateau. Newton (2002) stated that certain pairs may occupy a territory for only a few days or a few weeks, or may even build a nest, but the process stops there. He added the major factor influencing on the egg-laying process in vultures was the food supply, and in poor food years, territorial pairs in some populations fail to lay eggs. Baral et al. (2005) seen that the nest abundance by vultures due to mortality of chicks in the previous year and Moran-lopez et al. (2006) explained that anthropological threats in the nesting areas would also cause the nest abandoned behaviour in vultures. This study recorded the Gray langur and Bonnet macaques were caused severe threats to the breeding population of White-rumped Vultures (n=8 nests) by jumping or shaking the branches, destroying the nests and depredation of eggs especially by the Bonnet macaques. A similar observation was observed in Himachal Pradesh where monkeys were recorded continuously in nesting site (Pehad nesting site) although, no direct evidence of interference of the monkey troops with vultures were observed, the number of vulture nests at Pehad nesting site decreased from six occupied (breeding season 2009–2010) to one occupied nest (breeding season 2010–2011), he stated that it may be due to interference by monkeys. Finally, the vultures at Pehad shifted to a new nesting site at Chattri (around 1km away) with three occupied nests (breeding season 2010 to 2011) (Thakur and Narang 2012). The present study observed the direct impact of Grey langurs and Bonnet macaques play behavior in both the White-rumped vulture nesting sites in Sigur plateau. Many studies in Africa confirmed that the monkeys and baboons interfered in the normal breeding of African vultures (Mundy et al. 1992; Emmett 2003; Roche 2000 & 2006).

In Sigur Plateau, both the nesting colonies were located near to human settlements (average of 1.92km). Green et al. (2004) stated that based on demographic modeling, less than 0.8% of ungulate carcasses available to foraging vultures would need to contain a lethal dose of diclofenac for this to have caused the observed population declines. Therefore, educating livestock holders, farmers, and veterinary personnel on the usage of diclofenac awareness may help to secure the vulture population although 93.10% of livestock holders did not aware of diclofenac and its effects as per this study.

## Management Recommendations

- The present study suggests that the creation of awareness is important among the school children for the schools that are surrounded by the vulture habitat to bring out future conservationists.

- Declaration of “Vulture Sanctuary” would support legally for the population. The Karnataka Government has declared a “Vulture Sanctuary” to conserve another Critically Endangered Long-billed Vulture species in Ramnagaram Hills, Karnataka as a first of its kind. The sanctuary was declared for a total of 346.14ha area was to secure 15–18 individuals and their nesting sites in the hill.

- Sigur Plateau is strategically located at the tri-junction of three Tiger Reserves namely Mudumalai Tiger Reserve, Biligiri Rangaswamy Tiger Reserve, and Sathyamangalam Tiger Reserve. This would ensure long-term food supply to vultures as they are dependent to tiger kills majoritively than other co-predators

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