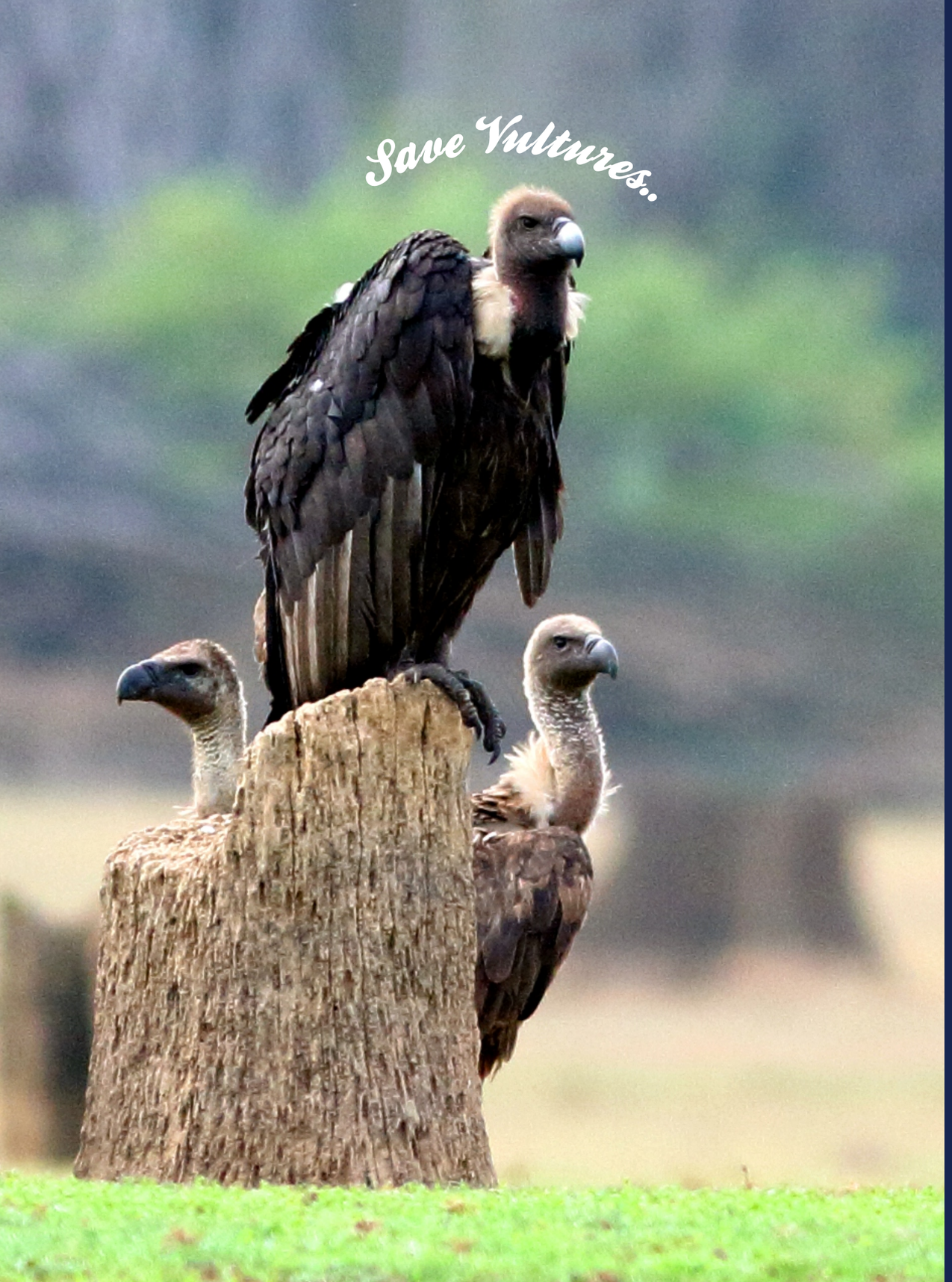

FINAL REPORT 2016

CONSERVATION STRATEGIES FOR SECURING CRITICALLY ENDANGERED

WHITE-RUMPED (*Gyps bengalensis*) AND LONG-BILLED (*Gyps indicus*) VULTURE SPECIES IN THE TAMIL NADU PART OF THE NILGIRI BIOSPHERE RESERVE

Submitted By

Government Art's College
Udhagamandalam

Submitted to

R·R·C·F
Raptor Research & Conservation Foundation

Principal Investigator
B. Ramakrishnan

Co-Principal Investigator
A. Veeramani

Project Fellow
A. Samson

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Conservation strategies for securing critically endangered White-rumped (*Gyps bengalensis)* and Long-billed (*Gyps indicus)* vulture species in the Tamil Nadu part of the Nilgiri Biosphere Reserve

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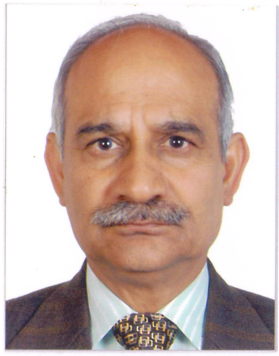
Final Report - December 2016



TAMIL NADU FOREST DEPARTMENT

Shri. P.C. Tyagi, I.F.S.
Principal Chief Conservator of Forests &
Chief Wildlife Warden
(Head of Forest Force)

Foreword

I am pleased to see the work done on **"Conservation strategies for securing critically endangered White-rumped (Gyps bengalensis) and Long billed (Gyps indicus) vulture species in the Tamil Nadu part of the Nilgiri Biosphere Reserve"** funded by the Raptor Research and Conservation Foundation, Mumbai.

Vultures play an important role in the ecosystem as a scavenger. Nowadays the vulture population is scantly distributed in India. Due to Diclofenac (Non Steroid Anti Inflammatory Drug) effect, the vulture population has been wiped out from most of its ranges across the country. In southern India there is a southern most wild viable vulture population successfully thriving in the Nilgiri Biosphere Reserve (NBR). The present study under the guidance of Dr. B. Ramakrishnan, Assistant professor in Wildlife Biology, Government Arts College, Udhagamandalam on documenting the population, breeding biology, threats and people's perception on White-rumped and Long billed vulture conservation in Tamil Nadu part of the NBR is very useful. This study will assist in long term conservation of endangered vulture species. I truly appreciate the fact that the team extended the scope of the work to include the perception of cattle owners toward conservation and use of diclofenac, the prime reason for mortality of vulture. The survey of drug stores stocking diclofenac and sensitizing them towards vulture conservation has been a major achievement of this project. I congratulate the entire Research team for collecting information in vulture and devising strategies for its conservation in the Nilgiris landscape.

I extend my sincere thanks to "Raptor Research and Conservation Foundation" for supporting this project on vulture conservation and I do hope that in coming future further support would be extended in this regard. My best wishes for the efforts taken for the vulture conservation in Tamil Nadu part of the NBR.

Pctyagi

P.C. TYAGI, I.F.S.
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GOVERNMENT OF TAMILNADU
FOREST DEPARTMENT

PREFACE

Vulture symbolizes service to the society and it is often seen by biologists as an epitome of humility. The role played by the vultures by cleaning up the environment is something we all have to learn in this era of "Swachh Bharat". Once found in large numbers across all the landscapes of India, Vultures are now confined to few pockets due to several anthropogenic reasons. One among them is the "Diclofenac", a non-steroid anti-inflammatory drug used as a pain killer for the cattle. For identifying this cause, it took nearly four years for the scientists to analyze the samples and confirm the cause of mass extinction. Therefore scientific pursuits are very much essential to understand the various factors determining the existence of the critically endangered species.

Tamilnadu has a healthy and stable population of four species viz., White rumped, Long billed, Nephron and King vultures in the vast open tracts of the Sigur plateau and Moyar valley. There is a mass nesting site of White backed vulture recorded by me and Dr. Ramakrishnanin the Jagalikadavu area of Nilgiris north division along a jungle stream. But the present situation is precarious as it is the last remaining wild population in the entire South India. Foresters and Scientists are working in tandem to guard this last remaining relict population by doing hard work on all fronts.

At this juncture, I would like to thank profusely "Raptor Research and Conservation Foundation" for lending a helping hand by sponsoring the project "Conservation Strategies for securing critically endangered White-rumped (*Gyps bengalensis*) and Long billed (*Gyps indicus*) Vultures species in the Tamilnadu part of the Nilgiris Biosphere Reserve". The outcome of this project will throw more light on the conservation requirements of this magnificent species in this landscape. I am sure the dedicated team headed by Dr.B.Ramakrishnan and young researchers will do justice for this timely intervention and come out with valuable insight which will go a long way in conserving this unique species.

S. RAMASUBRAMANIAN, IFS.,
CONSERVATOR OF FORESTS,
COIMBATORE CIRCLE.

Government Arts College
Udhagamandalam-643 002

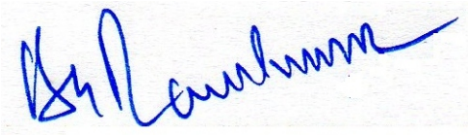
Dr. B. RAMAKRISHAN, M.Sc., Ph.D.,
Assitant Professor In Wildlife Biology

MESSAGE

The Nilgiri Biosphere Reserve (NBR) is a first and foremost biosphere reserves in India declared by UNESCO in which Tamil Nadu state comprising most of the area along with neighbouring states of Kerala and Karnataka in the Western Ghats with contiguous forest sharing with Eastern Ghats named as Nilgiris and Eastern Ghats Landscape in South India, harbouring an unique status of single largest Asian elephant population in the world, largest Tiger population for our country with other many endangered and critically endangered species such as Stripped Hyaena, Nilgiri Tahr, Nilgiri Morten, Nilgiri Laughing Thrush, etc. This landscape is also having significance in wildlife management because the occurrence of critically endangered vultures. Being a scavenger in habit vultures persistence is highly important in the ecosystem to complete. Although the vulture population had declined drastically in most of its ranges, it is good worthy to have a flourishing vulture population in the NBR and adjoining area of the Eastern Ghats in Southern India.

This project report is funded by the Raptor Research & Conservation Foundation intends to be a fore runner giving a glimpse into the realm of critically endangered two *Gyps* vultures in the Tamil Nadu part of the NBR first of its kind. The findings and recommended management solutions would help the managers to prepare a site and species specific management plan for the long run conservation of these species in this landscape.

As a Principal Investigator of this project, I did my best to bring out this final report with the support of Raptor Research & Conservation Foundation, Tamil Nadu Forest Department, Co-Investigator, dedicated field work done by my Project Fellow and tribal field assistants.



(Dr. B. RAMAKRISHNAN)

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First and foremost we thank Almighty God for this wonderful life and safeguarded our research team personnel life from elephants and tigers.

My sincere gratitude due to the Raptor Research & Conservation Foundation (RRCF), Mumbai for providing financial support of this project. We especially thank Mr. Kiran Srivastava of RRCF for releasing funds in right times which would help us enormously to carry out the field work without any hurdle as well as for his critical comments and suggestions given for interim and final reports.

My heartfelt thanks to the Principal Chief Conservator of Forests and Chief Wildlife Warden, Tamil Nadu Forest State Forest Department for providing necessary permission to enter into the forest areas. My sincere thanks are due to Mr. Srinivas R Reddy, IFS, Chief Conservator of Forests and Field Director, Mudumalai Tiger Reserve and Mukurthi National Park for his continuous support to all my endeavors.

I am thankful to Mr. S. Ramasubramanian, IFS, District Forest officer, Coimbatore Division for his inspiration and encouragement to ignite vulture studies in my career and still supporting all my endeavors.

I thank Mr.I.Anwardeen, IFS, Chief Conservator of Forests and Field Director Sathyamangalam Tiger Reserve for his constant encouragement and support for this study and all my endeavors. My gratitude are due to the District Forest Officers Mr. C. Badhrasamy, B.Sc., (Retd.,), Mr. S. Kalanithi, IFS, District Forest Officers, Nilgiri North Forest Division and Mr. K. Rajkumar, IFS., District Forest Officer, Nilgiri South Forest Division (Earlier Deputy Director, Sathyamangalam Tiger Reserve) and Mr. V.A. Saravanan, Deputy Director, Mudumalai Tiger Reserve for providing all logistic supports to carry out the field work.

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My sincere thanks to Dr. Narendran, for his valuable comments and inputs for the final report preparation.

Last but not least we are thankful to our Field Assistants Mr. R. Bomman, Mr. K. Manikandan, Mr. B. Vishnu and Mr. B. Prabhu (Tribal guys) without their commitment and dedication to taking care our lives in a high density of elephant and tiger landscape of the Nilgiris this wonderful work is not possible.

Dr. B. RAMAKRISHNAN, Ph.D.
Principal Investigator

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EXECUTIVE SUMMARY

An ecosystem is deemed to be stable if it has different levels of organisms in its ecological niches without which it is considered to be an unbalanced state. Trouble for any such organisms not only leads to collapse of the food chain but causes disorder in the existing food web. It is noteworthy to mention that the scavengers occupy an important niche and the last level in the food chain, without which the recycling or proper disposal of dead and decaying materials will be either stopped or delayed. Being prime scavengers vultures play an important role in the food chain by preventing spread of dangerous diseases, such as anthrax and rabies, which could cause havoc to wild animals, livestock and ultimately to humans. Therefore, it is believed that the absence of these scavengers can lead to a grave crisis in our ecosystem. About 95% of vultures have been lost from many parts of their former ranges across India. While captive breeding is a success in India, conservation of the country's southernmost wild viable vulture population in the Nilgiris Landscape is the need of the hour. With little or no studies sound management practices could not be implemented due lack of scientific data. Considering this lacunae the present study was conducted for a period of two years in the Tamil Nadu part of the Nilgiri Biosphere Reserve (NBR).

The Nilgiri Biosphere Reserve (NBR) is part of UNESCO’s world heritage sites and is the first and foremost biosphere reserve in India. The Tamil Nadu state harbors a sizeable number of vulture populations in Mudumalai Tiger Reserve (MTR), Nilgiri North Forest Division (NNFD) and Sathyamangalam Tiger Reserve (STR). Except for random short-term sweep surveys no long-term studies were attempted in this region. This study was focused on two vulture species namely, White-rumped Vulture and Long-billed Vulture for population estimation, breeding ecology, impact of Diclofenac and other threats, and to recommend feasible management steps with the Department of Zoology & Wildlife Biology, Government Arts College, Udhagamandalam in collaboration with Tamil Nadu State Forest Department.

Nest site count was made for population estimation; breeding ecology by direct field observation; Diclofenac and other threats were assessed by a survey with a questionnaire circulated to participants, after which management suggestions were recommended from findings of the project.

This study identified 7 nesting and 1 roosting location, used by the two vulture species mentioned above. 4 were nest sites of White-rumped Vulture and the other 3 of Long-billed Vulture. A total of 9 villages were recorded in and around the crucial nesting and roosting colonies of these two vulture species. Thorn forest was the preferred nesting and feeding habitat for vultures in this region.

Among 4 White-rumped vulture nesting colonies, the Jagalikadavu nesting colony has recorded a maximum number of individuals (68) whereas Long-billed Vulture population was high in Nilgiri Eastern Slopes nesting colony. A total of 52 White-rumped Vulture nests were recorded in 38 nesting trees. Jagalikadu nesting colony had recorded 28 nests in 21 trees. Two tree species namely *Terminalia arjuna* (37 trees with 51 nests) and *Spondias mangifera* (one tree with one nest) were used for nest construction. A total of 8 plant species materials were used by White-rumped Vultures for nest construction with maximum twigs of *Chloroxylon swietenia.* Most of the nests were located towards the north east direction, mainly for getting maximum sunlight in order to obtain thermal energy to fly.

An important outcome of this study revealed only 58% breeding success for White-rumped Vulture with 24 hatchlings from 40 incubations. Long-billed Vulture were more successful breeders.

A total of 391 livestock holders were interviewed in 26 hamlets, of which half were illiterate Irula tribals. A total of 8531 livestock numbers were recorded. The livestock holders were earning money mainly from selling dung (Rs.35,12,000/- per annum). Totally 8191 livestock were lost by 391 owners during the last five years. Out of which most of them were lost due to various diseases but many livestock were lost due to wild animal depredation. This was another important outcome of this project which recommended the urgent need for timely compensation/ex gratia payment to these livestock holders in order to curtail poisoning of carcasses as retaliatory killing. Most of the livestock holders threw the carcasses in the forest areas but close to their habitations. 174 respondents buried the carcasses. These two findings are a valuable outcome of this project to initiate a mechanism to ensure food security to nesting vultures.

The information on Diclofenac in relation to vulture conservation was based on interviews with livestock holders. The result revealed that a considerable number of people were not aware of Diclofenac being fatal to vultures. A sizable number of respondents knew that Diclofenac is a pain killer and some considered it as an ordinary drug. It was very important to note that many of the livestock holders thought that Diclofenac was harmful to vultures. Likewise, many livestock holders were of the opinion that Diclofenac was not a threat to vultures. Out of 391 respondents 339 knew vultures played the role of a scavenger in the forest ecosystem. The majority of respondents said the vulture population was declining as compared to earlier years. Another notable problem is the increase in stray dog population as compared to past decade. This was mainly due to livestock carcasses being thrown very near the forest boundary. Respondents complained that the compensation paid by the forest department for livestock killed by wild animals was fraught with lengthy time consuming procedures. Therefore, this study emphasizes the need for long-term monitoring mechanism to be initiated to win the confidence of livestock holders against retaliatory killings.

Totally 13 veterinary personnel were interviewed during this project period of which 4 were Veterinary Assistants (Quacks) and remaining Veterinary Assistant Surgeons (Doctors). All of them were very well aware on the ban on Diclofenac in veterinary practice and its fatal effects on vulture population as well. It was good to note that all of them used Melaxicum as a painkiller for veterinary practice. Another healthy trend was the Tamil Nadu Government provided Melaxicum to Government veterinary dispensaries. Our drug store survey result revealed that a total of 10 Diclofenac composition painkillers were being currently prescribed by the doctors for human use. It was alarming to note that 30 ml vials were still available in the drug stores.

During our study we recorded a total of 42 White-rumped Vulture deaths between 2013 and 2016. 34 individuals were adults and 8 were immature. A post-mortem was conducted only for 8 individuals. 32 individuals were seen with skeletal and feather remains rendered them unsuitable for post-mortem. The laboratory autopsy revealed that the tissues of the vultures were contaminated by ***Organo phosphorus and urea.*** This is a poisonous insecticide used in agricultural practice. This study has recorded none of the deaths were caused by Diclofenac instead, strongly suggests that retaliatory killing is the dominant factor effecting vulture populations. This year plenty of livestock carcasses were available to vultures due to failure of the monsoon. Even then the breeding success was only 58%. Therefore, this study concluded that long-term monitoring and breeding ecology should be initiated for long term conservation of country's southernmost vulture population.

INTRODUCTION

Scavengers play an important and critical role in the food chain without which the recycling or proper disposal, especially that of dead and decaying materials will be either stopped or delayed. The vultures are excellent scavengers on dead bodies and their status is critically tagged with the present situations (Mandel *et al.,* 2008). There are 22 species of vultures in the world which belong to two taxonomically distinct groups (Amadon, 1977; Sibely and Ahlquist, 1990). New World vultures are under the order Falconiformes of family Cathartidae and Old World vultures are Accipitridae family. Due to lot of variations in geographical and environmental gradient nine species are reported to be present in India namely White-rumped Vulture (*Gyps bengalensis*), Slender-billed Vulture (*Gyps tenuirostris*), Long-billed Vulture (*Gyps indicus*), Egyptian Vulture (*Neophron percnopterus*), Red-headed Vulture (*Sarcogyps calvus*), Indian Griffon (*Gyps fulvus*), Himalayan Griffon (*Gyps himalayensis*), Cinereous Vulture (*Aegypius monachus*) and Bearded Vulture or Lammergeier (*Gypaetus barbatus*) (Ali and Ripley, 1983). *Gyps* are a group of obligate scavengers that typically breed colonially or semi-colonially. *Gyps* vultures specialize in feeding the soft tissues that make up the bulk of animal carcasses and therefore comprise the majority of vultures numerically. Vultures are known to inhabit tall trees in forests, smaller trees in open areas, rocky cliffs, old monuments and countryside (Thompson *et al*., 1990; Liberatori & Penteriani, 2001; Donazar *et al*., 2002; Monadjem & Garcelon, 2005; Carrete *et al*., 2006; Thakur & Narang, 2012; Harris, 2013; Ramakrishnan *et al*., 2014).

Vulture population have declined in many parts of their former ranges owing to food shortages and loss of habitat (Pain *et al*., 2003). However, since the early 1990s there has been a catastrophic decline in three *Gyps* species in the Indian subcontinent namely, White-rumped (*G.bengalensis*), Long-billed (*G.indicus*) and Slender-billed Vultures (*G. tenuirostris*) (Prakash 1999, Virani *et al*., 2001, Prakash *et al*., 2003). In response to these population crashes, all of these three were reclassified as 'Critically Endangered', placing them among the species most threatened with global extinction (BirdLife International 2001). Oaks *et al.* (2004) found that the Diclofenac, a widely used painkiller and anti-inflammatory drug administered to livestock and humans caused mortality in vultures in Pakistan. A postmortem examination of dead or dying birds from India and Nepal also showed the high incidences of Diclofenac residues and visceral gout (Shultz *et al*., 2004). The results of these studies suggested that Diclofenac contamination was the major cause of vulture population crash across vulture range countries in Asia. However, other causes such as habitat destruction, food shortage, human persecution, poisoning and pesticide use have also caused a gradual decline in vulture population (BirdLife International 2001).

In southern India there are seven species of vultures recorded namely, White-rumped (*G. bengalensis*), Long-billed (*G. indicus*), Red-headed (*Sarcogyps calvus*), Egyptian (*Neophron percnopterus*), Himalayan Griffon (*G.himalayensis*), Eurasian Griffon (*Gyps fulvus*) and Cinereous vultures (*Aegypius monachus*) (Sashikumar, 2001; Davidar & Davidar, 2002; Thejaswi, 2004; Subramanya & Naveen, 2006; Davidar, 2007; Umapathy *et al*., 2009; Ramakrishnan *et al*., 2010, 2012 & 2014 ; Praveen *et al*., 2014; Samson *et al*., 2014a,b ; Venkitachalam & Senthilnathan, 2015; Venkitachalam & Senthilnathan, 2016; Samson *et al*., 2015; Samson & Ramakrishnan, 2016a,b; Samson *et al*., 2016a,b,c) were recorded.

The Tamil Nadu part of the Nilgiri Biosphere Reserve (5540 sq. km) reported 6 species of vultures. Of which 4 of them holds sizeable numbers except for Eurasian Griffon. They are mainly dependent on wild carcasses (90%) as their diet (Ramakrishnan *et al*., 2010). This project's study area is part of the Nilgiris & Eastern Ghats Landscape which is considered to have the single largest Asian elephant population in the world. It also probably holds the largest tiger population in the country and their wild prey ensures continuous food availability to vultures. Among the lesser carnivores wild dog packs quickly consume their prey leaving behind skeleton remains. Leopards always prefer small or medium sized prey and usually hide the remains on the tree branches inaccessible to vultures. The tiger generally prefers large size prey and tend to consume their prey over a number of days which is accessible to vultures. The previous study by Davidar & Davidar (2002) reported that the given study area had a good number of vultures but had been lost mainly due to retaliatory killing of carnivores through poisoning of carcasses. This area is now harboring sizeable numbers of vulture populations and is considered to be the India's southernmost wild viable breeding population. Since captive breeding programmes have been undertaken in the northern Indian States, the conservation of this wild breeding vulture population is need of the hour. Due to lack of sustained studies there has been no science-based management in place to conserve this vulture population. Considering this lacunae this study was attempted in the Tamil Nadu part of the Nilgiri Biosphere Reserve to bring out feasible conservation perspectives of White-rumped and Long-billed Vultures between 2015 and 2016.

REVIEW OF LITERATURE

Davison (1883) had investigated in his notes on some of the birds collected on the Nilgiris and parts of Wynaad and southern Mysore. Primrose (1904) had studied birds observed in the Nilgiris and Wynaad. Thirumurthi & Balaji (1999) recorded raptors of Nilgiris - a preliminary survey. Sashikumar (2001) documented Vultures in Kerala. Davidar & Davidar (2002) recorded possible causes for the decline of Oriental White-rumped Vultures (*Gyps bengalensis*) in the Segur region (Nilgiris, Tamil Nadu), India. Davidar (2007) has observed Indian White-backed Vultures *Gyps bengalensis* in the Sigur region of Tamil Nadu. Ramakrishnan *et al* (2010) pointed out that the Diclofenac was not a culprit for declining *Gyps* vultures in the Moyar Valley. Kurupu (2011) has reported on the status and distribution of vultures in Wayanad district Kerala. Ramesh *et al.* (2011) recorded status of vultures in Mudumalai Tiger Reserve, Western Ghats, India. Ramakrishnan *et al.* (2012) noted the occurrence of Red-headed Vulture in Sigur plateau, Tamil Nadu. Ramakrishnan *et al*. (2014) has documented the nesting of White-rumped Vulture (*Gyps bengalensis*) in the Sigur Plateau. Samson *et al.* (2014b) recorded bathing behavior and importance of waterholes for White-rumped Vulture in the Sigur Plateau. Venkitachalam & Senthilnathan (2015) recorded the breeding behavior of Indian Vulture (*Gyps indicus*) in Moyar Valley, Tamil Nadu, India. Samson *et al.* (2015) have noted the occupation of Indian Giant Squirrel nests by White-rumped Vultures *Gyps bengalensis* in India. Venkitachalam & Senthilnathan (2016) has provided and an account of the status of the population of vultures in the Moyar valley, Southern India. Samson & Ramakrishnan (2016a) were celebrated at International Vulture Awareness Day at the Government Arts College, Udhagamandalam, Tamil Nadu. Samson *et al.* (2016a) observed wild boar predation of White-rumped Vulture fledgling in the Sigur Plateau. Samson *et al*. (2016b) reported that population status and habitat preference of vultures in Mudumalai Tiger Reserve, Tamil Nadu Southern India. Samson *et al.* (2016c) noted that taphonomy perspective on Tiger (*Panthera tigeris*) kills and natural deaths of domestic buffalo *Bubalus bubalis* (Linnaeus, 1786) with special reference to vultures and other scavengers.

AIM

- Securing the country's southernmost wild viable vulture population at regional and landscape level

OBJECTIVES

1. To estimate population status of two vulture species namely White-rumped and Long- billed vultures.
2. To assess breeding success of two vulture species.
3. To quantify Diclofenac sale and its usage in the fringe areas of the vulture habitat and
4. To suggest feasible scientific management recommendations for the long term conservation of these two vulture species in this region.

WHITE-RUMPED VULTURE

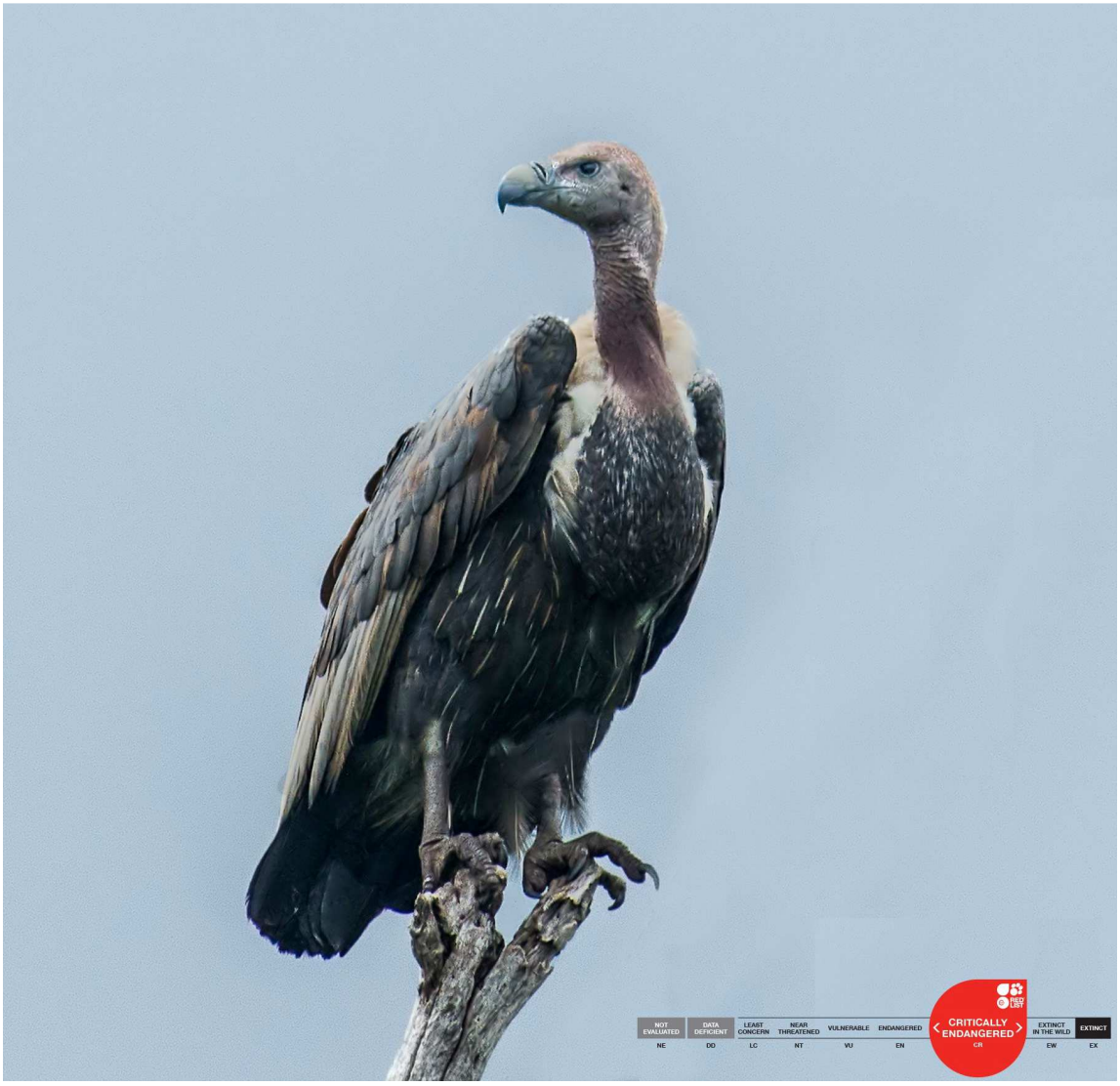


Photo Credit: Karthik Ramamurthy

Justification of Red List Category

The IUCN justified this species as Critically Endangered because it has suffered an extremely rapid population decline primarily as a result of feeding on livestock carcasses treated with the veterinary drug Diclofenac.

Population Justification

Formerly this species was the most abundant large bird of prey in the world and the global population almost certainly numbered several million individuals. However,

following dramatic decline through the 1990s across its range its global population is now estimated to fall within the band 2,500-9,999 mature individuals. This equates to 3,750-14,999 individuals, rounded here to 3,500-15,000 individuals (IUCN Red list Data, 2016)

Distribution and Population

G.bengalensis occurs in Pakistan, India, Bangladesh, Nepal, Bhutan, Myanmar, Thailand, Laos, Cambodia and southern Vietnam, and may be extinct in southern China and Malaysia (BirdLife International, 2001). It has been recorded from southeast Afghanistan and Iran where its status is currently unknown. However, it disappeared from most of South-East Asia in the early 20th century and the only viable population is found in Myanmar and Cambodia, mainly in the north (both probably less than hundreds of individuals) (Hla 2003, Anon 2003, 2008, Eames 2007a,b, Hance 2009). Since the mid-1990s, it has suffered a catastrophic decline (over 99%) across the Indian Subcontinent (the majority of its historic range), first noticed in Keoladeo National Park, India (Prakash *et al*. 2003), but mirrored in Pakistan (Gilbert *et al*. 2006) and Nepal (Baral *et al*. 2005, Chaudhary *et al*., 2012), to the point that the species is highly threatened with extinction.

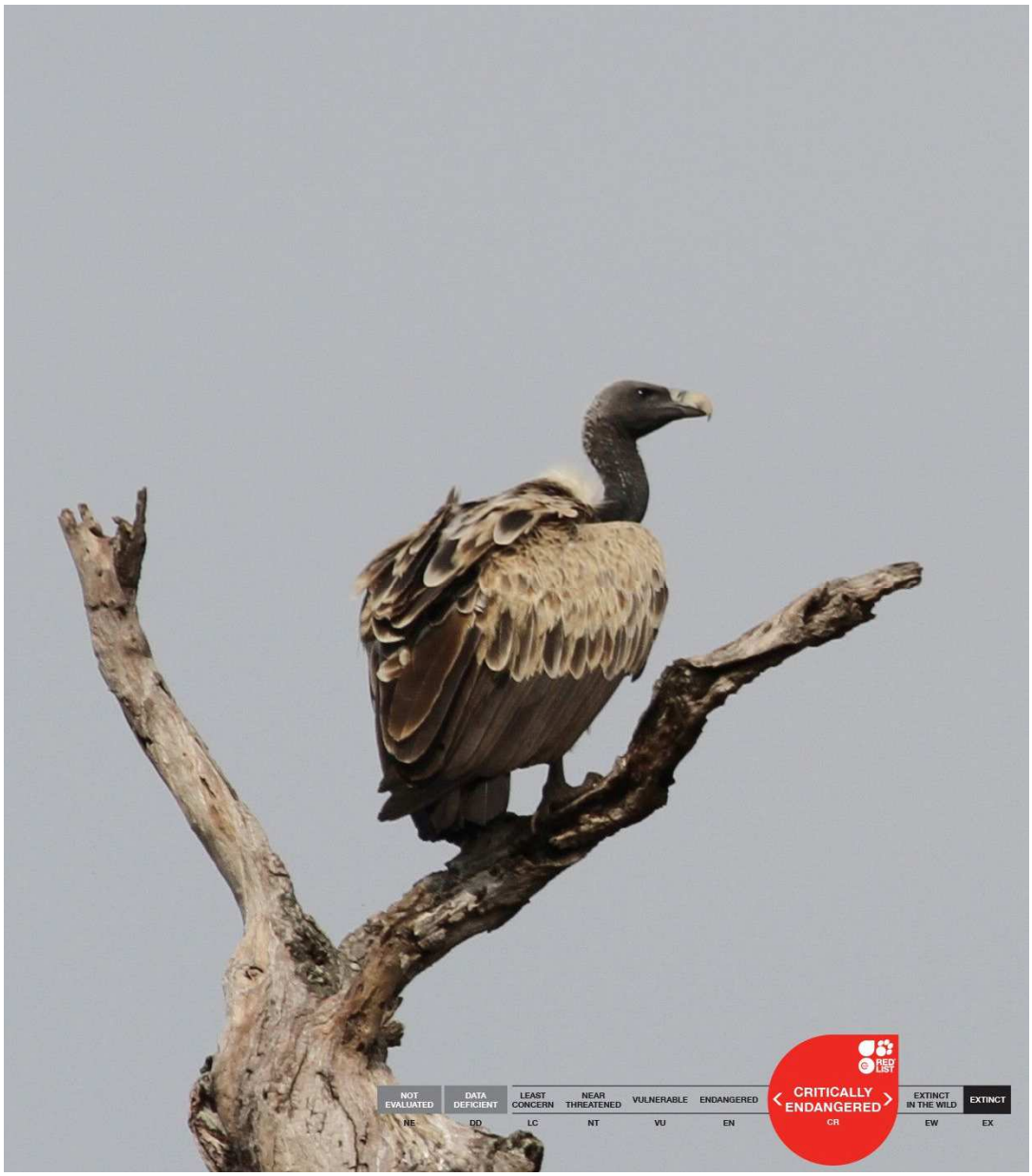
Declines in India between 2000 and 2007 averaged 43.9% per year (Prakash *et al*. 2007), and ranged between 11%-61% in Punjab province, Pakistan over the same period (Murn *et al*., 2008), while surveys of 23 known colonies in Punjab province in 2006 found a total of only 37 breeding pairs (Murn *et al*., 2008). In the lowland districts of Nepal, the species declined by 14% a year between 2002 and 2011 (Chaudhary *et al*., 2012). In Bangladesh, the species declined by 60% between 2008-2009 and 2011-2012 (Khan 2013). In India and Nepal, the rate of decline appears to have slowed, and may even have reversed (Prakash *et al*., 2012). Diclofenac is apparently entirely absent in Cambodia, adding greater importance to that remaining small population (171 counted at vulture restaurants in 2008) (H. Rainey in litt. 2008). Census results from Cambodia suggest the population there may have been increasing since 2004, or is at least stable (Eames 2007b, S. Mahood in litt. 2012). Surveys of vulture restaurants in Myanmar in 2006 and 2007 estimated a minimum of 62 White-rumped Vultures were present (Hla *et al*., 2011).

Physical Description

White-rumped Vultures are medium sized, dark vultures. Adults are 75 to 85 cm tall, their wingspan is 180 to 210 cm, and their weight ranges from 3.5 to 7.5 kg. The sexes are approximately equal in size. Adults are darker than juveniles, with blackish plumage, a white neck ruff, and a white patch of feathers on the lower back and upper

tail, from which their common name is derived. There is a pale gray patch on the upper surface of the wings, visible when the wings are folded. The undersides of the wings are a dark slate to brownish color. During the flight, the white under wing coverts are highly visible. Usually, the eyes are a yellowish brown color and the legs are blackish. The bill is short, deep, and stout. Immature *G. bengalensis* are dark brown and the lower back and rump area are browner rather than white. The under wing coverts are dark brown. Eyes are dark brown and the legs are blackish but lighter than the adult. Generally, adults are black in color, while younger individuals are browner. All *G. bengalensis* can be distinguished by the white bar located on the underside of the wing. (Grubh, 1974; Naoroji, 2006). The breeding season of *G.bengalensis* is from October to March. Mating is associated with loud calling. Mating is monogamous. Only one egg is laid in each clutch. The egg is white with very light markings of red, brown and overlying gray or lavender markings. Incubation usually lasts 45 to 52 days and both sexes participate in this process. The newly hatched chick is very small, about 15cm. Young remain in the nest for 2 to 3 months. The whole breeding cycle lasts six months (Naoroji, 2006).

LONG-BILLED VULTURE



(Photo courtesy: A. Samson, Project Fellow of this project)

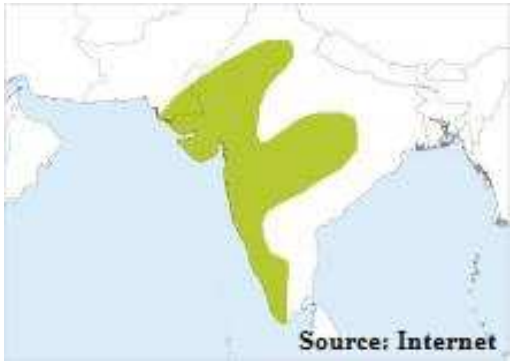
Justification of Red List Category

The IUCN categorized this species is as Critically Endangered because it has suffered from extreme rapid population crash due to feeding on livestock carcasses treated with the veterinary drug Diclofenac.

Population Justification

Prakash *et al*., (2007) estimated of c.45,000 individuals during 2007 survey and recorded 337 individuals along 18,000 km of road transects. This very roughly equates to 30,000 mature individuals.

Distribution and Population



Gyps indicus breeds in southeast Pakistan and peninsular India south of the Gangetic plain, north to Delhi, east through Madhya Pradesh, south to the Nilgiris, and occasionally further south (Collar *et al*., 2001). The species was first recorded in Nepal in 2011 (Subedi and DeCandido 2013). It was common until the mid-1990s. It suffered a catastrophic decline (over 97%) throughout its range. This was first noticed in Keoladeo National Park, India (Prakash *et al*., 2003), where counts of feeding birds fell from 816 birds in 1985-1986 to just 25 in 1998-1999. Just one tiny population in the Ramanagara Hills of Karnataka is known to remain in inland southern India, and it is rare elsewhere within its former range (Prakash *et al*., 2007). Data indicates that the rate of population decline of *G. tenuirostris* and *G. indicus* combined has now slowed in India (Prakash *et al*. 2012).

It is now rare in Pakistan, and although a colony of 200-250 pairs was discovered in 2003 in Sindh Province (A. A. Khan in litt. 2003). In 2007, the total Indian population, based on extrapolations from road transects, was estimated at 45,000 individuals, with a combined average annual decline for this species and *G. tenuirostris* of over 16% during 2000-2007 (Prakash *et al*., 2007). It is estimated that its relative abundance in Pakistan declined by 61% between 2003-2004 and 2006-2007; this was followed by a 55% increase by 2007-2008 (Chaudhry *et al*., 2012).

Physical Description

The Long-billed vulture is a typical vulture, with a bald head, very broad wings, and short tail feathers. It is smaller and less heavily built than the Eurasian Griffon, usually weighing between 5.5 and 6.3 kg (12–13.9 lbs) and measuring 80–103 cm (31–41 in) Long and 1.96 to 2.38 m (6.4 to 7.8 ft) across the wings. It is distinguished from that species by its less buff body and wing coverts. It also lacks the whitish median covert bar shown by Griffon. (Naoroji, 2006)

A robust and scruffy scavenger, the Indian vulture has a pale yellow bill, pale eye rings, and a sturdy, black neck and head, with pale down and a White neck ruff. The feathers on the back and upper wings are brown, fading to cream on the underside. The thighs are feathered, matching the underside in colour. Juveniles have a dark bill, pinkish head, and neck with pale down and brown and cream streaked undersides (Naoroji, 2006). Breeding season starts to form between mid-November and early March. The nests were placed mainly on cliffs and ruins but known to use trees to nest in Rajasthan, India. Nests are made of sticks and lined with green leaves and rubbish. Clutch size 1 the female vulture lays one oval, white egg which is incubated by both parents for 50 days. Both sexes contribute to the care of the chick, bringing food and defending it. It is found in cities, towns, and villages near cultivated areas, and in open and wooded areas (Naoroji, 2006). Vultures also play a key role in the wider landscape as providers of ecosystem services and were previously heavily relied upon to help dispose of animal and human remains in India.

NILGIRI BIOSPHERE RESERVE (NBR)

The Nilgiri Biosphere Reserve (NBR) is the first and foremost biosphere reserves established in the year 1986 in India. The reserve is situated in the Western Ghats, in the Nilgiri Hills range of South India and is considered as an International Biosphere Reserve. It was declared under the Man and Biosphere Programme (MAB) of UNESCO and is also under consideration by the UNESCO World Heritage Committee for selection as one of the World Heritage Sites.

Location

The reserve encompasses 5,520 km² surrounded by Karnataka (1527.4 km²), Kerala (1455.4 km²), and Tamil Nadu (2537.6 km²) states. The Biosphere lies between 11o 36' to 12o 00' N Latitude and 76o 00' to 77o 15' E Longitude. Central location: 11°30'00 N, 76°37'30 E

Protected Areas in the NBR

The NBR has protected areas namely, Mudumalai Tiger Reserve (321.1 km²), Sathyamangalam Tiger Reserve (745.9km²) Wayanad Wildlife Sanctuary(344km²), Bandipur Tiger Reserve (874km²), Nagarhole Tiger Reserve (643 km²), Nugu Wildlife Sanctuary, Mukurthi National Park (78 km²) and Silent Valley National Park (89.52km²). This reserve also includes Nilgiris North Division (448.3 km²) and Nilgiris District, South Division (198.8 km²) and Coimbatore Division (696.2 km²) in Tamil Nadu (Map1). The reserve extends from the tropical moist forests of the windward western slopes of the Ghats to the tropical dry forests on the leeward east slopes. Rainfall ranges from 500 mm to 7000 mm per year. The reserve encompasses three eco-regions, the South Western Ghats moist deciduous forests, South Western Ghats montane rain forests, and South Deccan Plateau dry deciduous forests.

Flora and Fauna of NBR

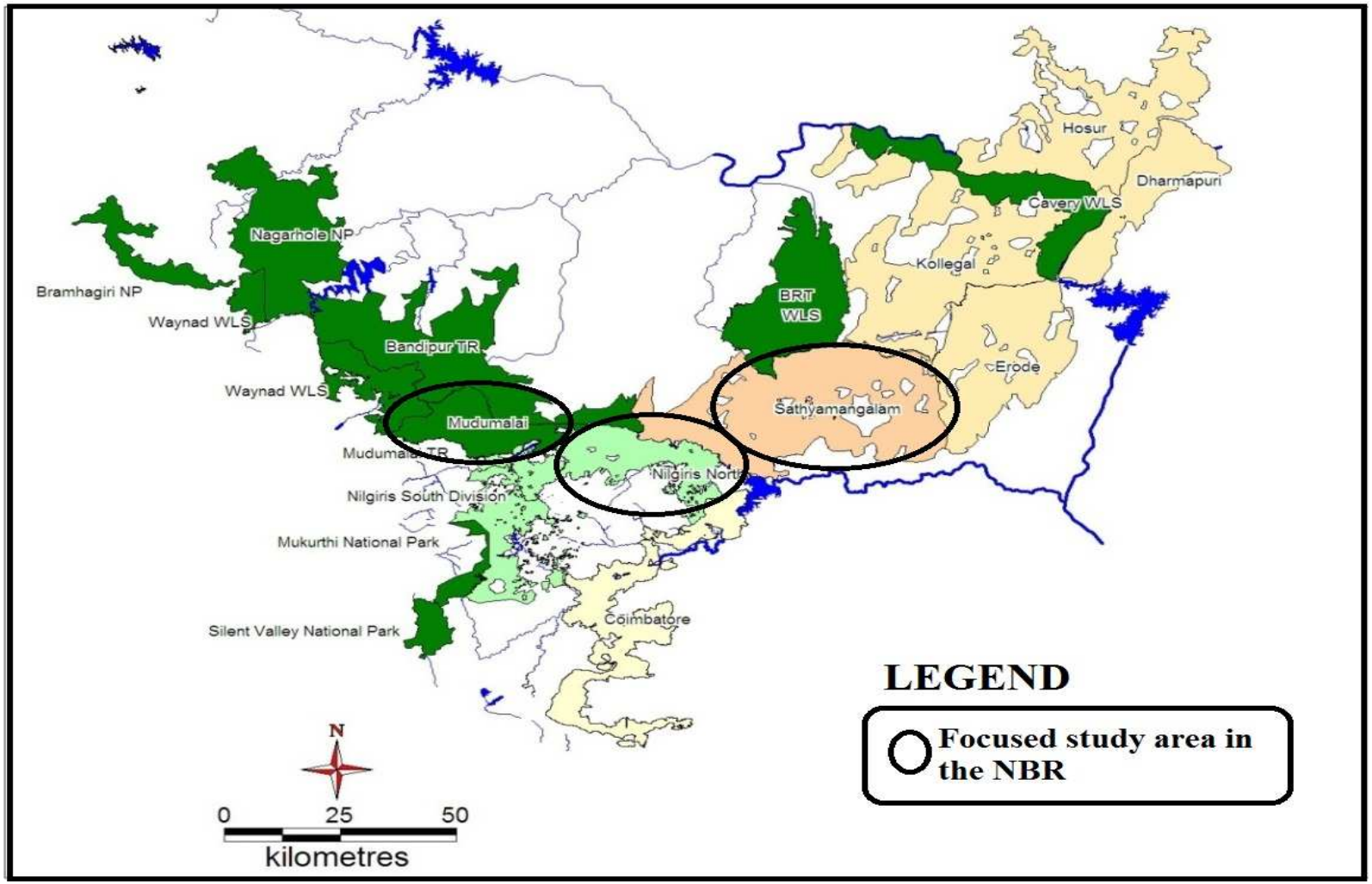
The Nilgiri Biosphere Reserve is very rich in plant diversity. About 3,300 species of flowering plants of which 1232 are endemic to the Nilgiri Biosphere Reserve. The fauna of the Nilgiri Biosphere Reserve includes over 100 species of mammals, 350 species of birds, 80 species of reptiles and amphibians, 300 species of butterflies and innumerable invertebrates. Of the vertebrate species recorded, 39 species of fish, 31 amphibians and 60 species of reptiles are endemic to the Western Ghats also occur in the Nilgiri Biosphere Reserve.

Water Resources

The NBR is one of the critical catchment areas of peninsular India. Many of the major tributaries of the river Cauvery like the Bhavani, Moyar, Kabini and Chaliyar, Punampuzha, etc., have their source and catchment areas within the reserve boundary.

Forests in NBR

The forests of NBR are spread over a vast area and cover various ecotypes. The overall classification of the different forest types are as follows: Evergreen, Semi-Evergreen, Moist Deciduous, Southern Montane Wet Temperate, Dry Deciduous, Dry Scrub Woodland, Grasslands and Evergreen Forest.

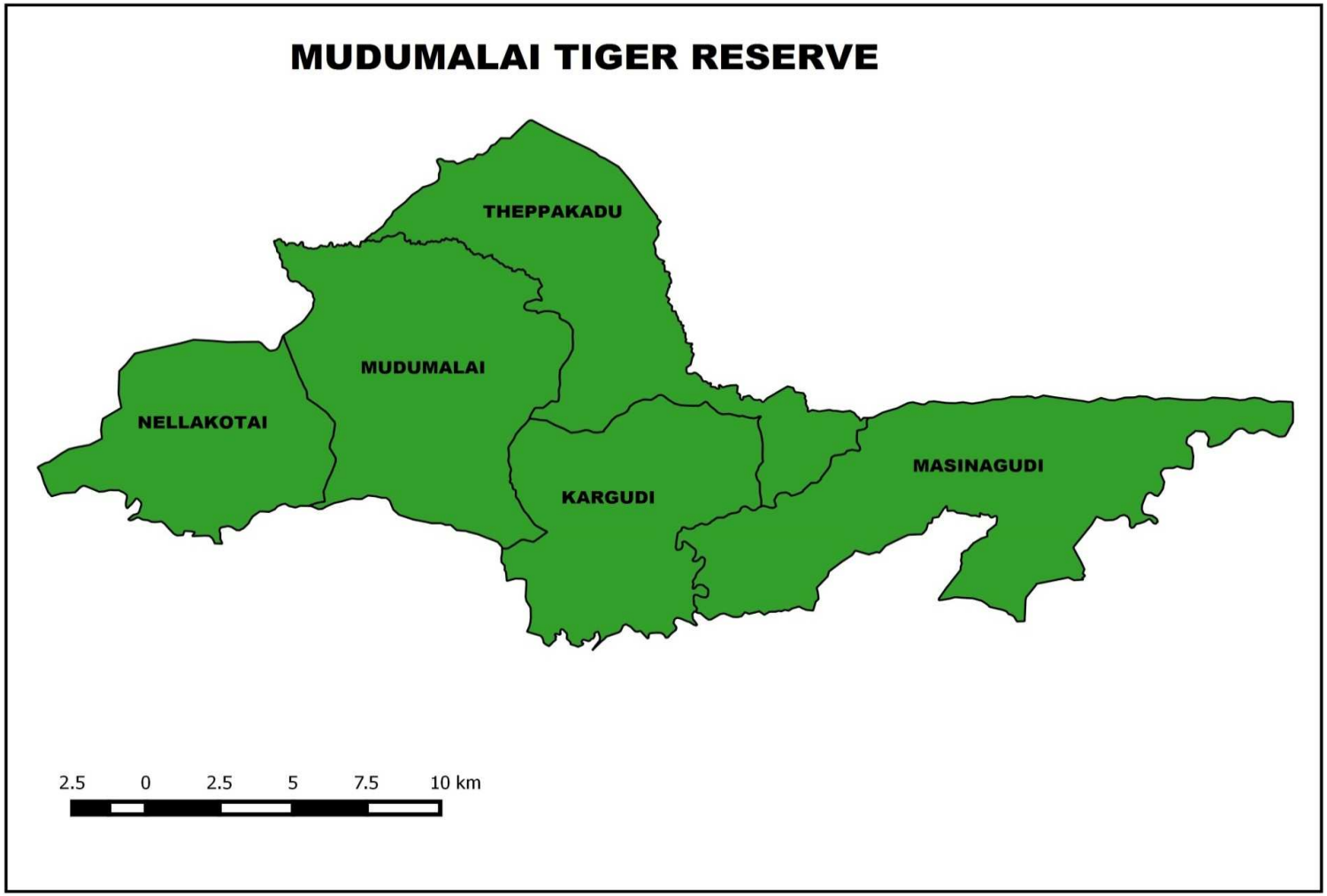


Map 1. Nilgiri Biosphere Reserve with focused study locations

Focused study sites in the Tamil Nadu part of the NBR

MUDUMALAI TIGER RESERVE (MTR)

The study area of the Mudumalai Tiger Reserve (MTR) (11^0 32' & 11^0 43' N and $76^0$22'& $76^0$45' E) is the newly created Tiger Reserve in the country since April 2007 and is situated at the tri-junction of Tamil Nadu, Karnataka and Kerala states. It is contiguous with Wayanad Wildlife Sanctuary to the northwest, Bandipur Tiger Reserve on the north, the south, and the east the Singara and Sigur Reserved Forests which forms the boundary of Nilgiri North Division. The MTR is located within the Nilgiri Biosphere Reserve (5,520 km2). The terrain is mostly gently undulating but flat towards the eastern portion with an average elevation ranging from 960 m to 1266 m. The park has a long wet season and a short dry season. It receives rainfall from the southwest and northeast monsoons. Two peaks of rainfall can be seen in the eastern part of the reserve, one during the month of June (100-150 mm) and the second peak during October (200 mm). Mudumalai is characterized by the presence of several swamps and bayous varying in size, which provides wallowing grounds for herbivores. The central part of the tiger reserve is slightly elevated with seasonal streams and three perennial streams. They are Moyar River; its tributaries drain the Tiger Reserve. Champion and Seth (1968) classified the vegetation type in Mudumalai as Southern Tropical dry thorn forest, Southern Tropical dry deciduous forest, Southern Tropical moist deciduous forest, Southern Tropical semi-evergreen, Moist bamboo brakes and Riparian forest. The MTR has got a high diversity of fauna with 55 species of mammals reported from the reserve (Dogera 2007). Domestic livestock (cattle, buffalo, and goat) occur in the village areas present inside the tiger reserve. Deciduous forest habitats support the highest small mammal abundance and biomass in the reserve (Venkataraman *et al*., 2005) (Map 2).

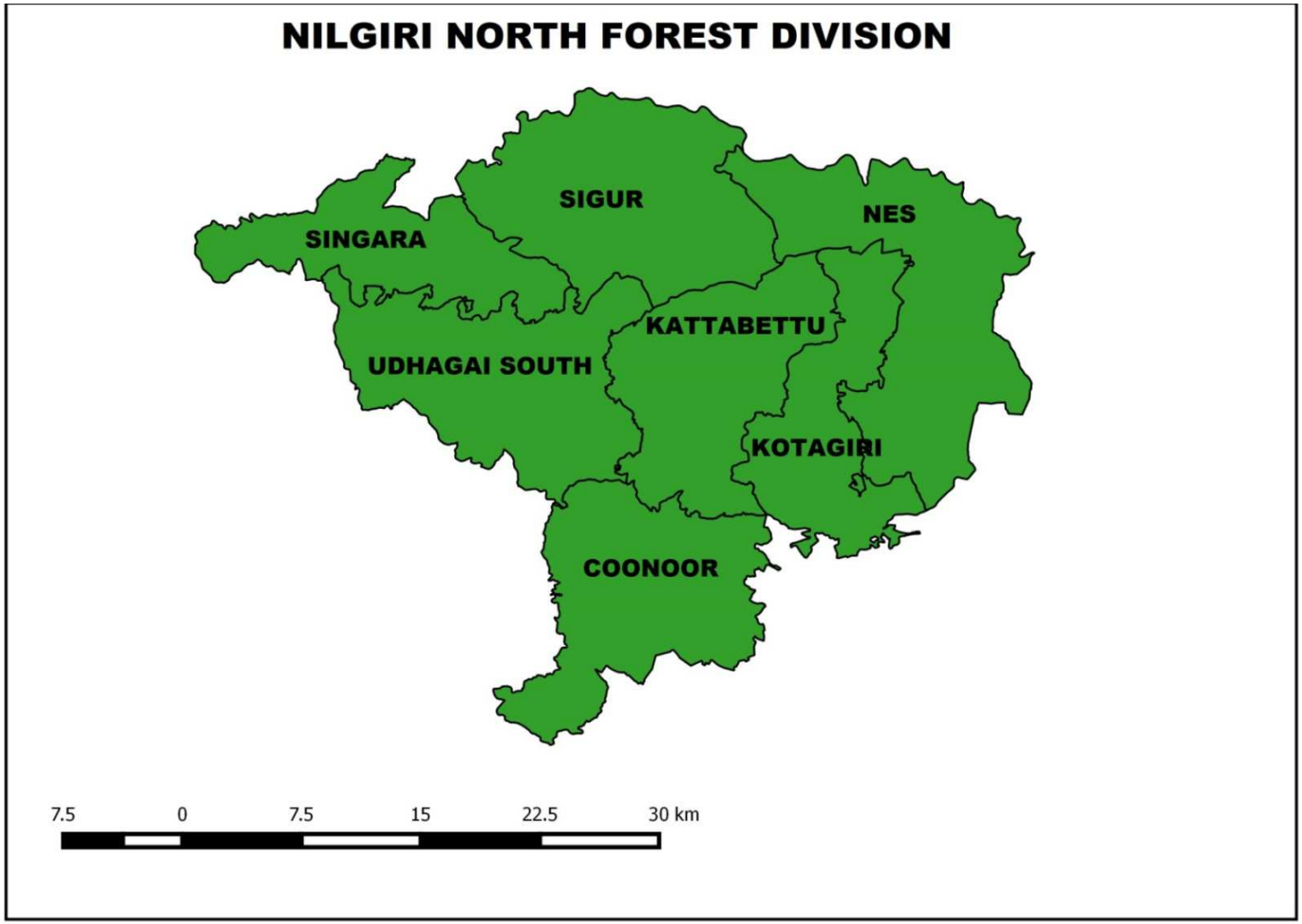


Map 2. Mudumalai Tiger Reserve with range boundary

Panoramic view of Mudumalai Tiger Reserve

NILGIRI NORTH FOREST DIVISION (NNFD)

Nilgiri North Forest Division lies between the North latitudes 11.14’35.26”, 11.36’60” and the East longitudes 76.31’52.86”, 77.00’56.35” (Map3). This division is bounded on the North by the state of Karnataka and Talamalai Range of Sathyamangalam Tiger Reserve, where Moyar river forms the common boundary, on the East by Bhavani Sagar Range of Sathyamangalam Tiger Reserve, Erode District, in the southeast by Sirumugai Range and South by Mettupalayam Range of Coimbatore Forest Division, Coimbatore District. On Southwest and West, it is bounded by The Nilgiris South and Gudalur Forest Divisions and on the northwest by Mudumalai Tiger Reserve within the Nilgiris District. It also forms part of the NBR. The terrain of this division exhibits a configuration with a significant range of variation in altitude and vegetation with a lot of valleys and plateaus. The terrain of the division may be divided into three naturally distinct regions which show variations in altitude and vegetation due to varying topographic, climatic and edaphic factors with forms the basis for rich biodiversity, wildlife richness and good weather. The regions are Nilgiris Plateau, Sigur Plateau, and Outer Slopes. The climate and temperate shows maximum 21 ºC to 25 ºC and the minimum 10 º to 12 ºC in summer. During winter the maximum is 16 ºc to 21 ºC and the minimum is being of 2 ºC. From November to March the sky is clear with ground frost in the night. Thunderstorms are frequent in April and May. Even though the Southwest monsoon is active from June to August followed by retreating (Northeast) monsoon till October it is mostly erratic and extends up to January, a shorter or longer breaks in rains having occurred in between. The annual rainfall varies from 700mm to around 2000m. Champion and Seth (1968) classified the vegetation type in NNFD as southern montane wet temperate forests, Southern subtropical hill forests and open deciduous scrub of Sigur plateau. In the forests with dense canopy holds Tiger, Elephant, Common Langur, Bonnet Macaque, Nilgiri Langur, Panther, India Jackal, Barking Deer, Wild Boar, Indian wild Dog, Sloth Bear, Gaur, Giant flying Squirrel, Mouse deer and variety of birds and snakes. In the open areas of Sigur and Nilgiris Eastern Slopes Ranges Sambar, Spotted Deer, Blackbuck, Flying fox, Giant Squirrel, Monitor lizard, Leopard, and Hyena are found. In Moyar river there is a good population of freshwater Crocodiles (Mugger) and numerous fish faunal community is present.

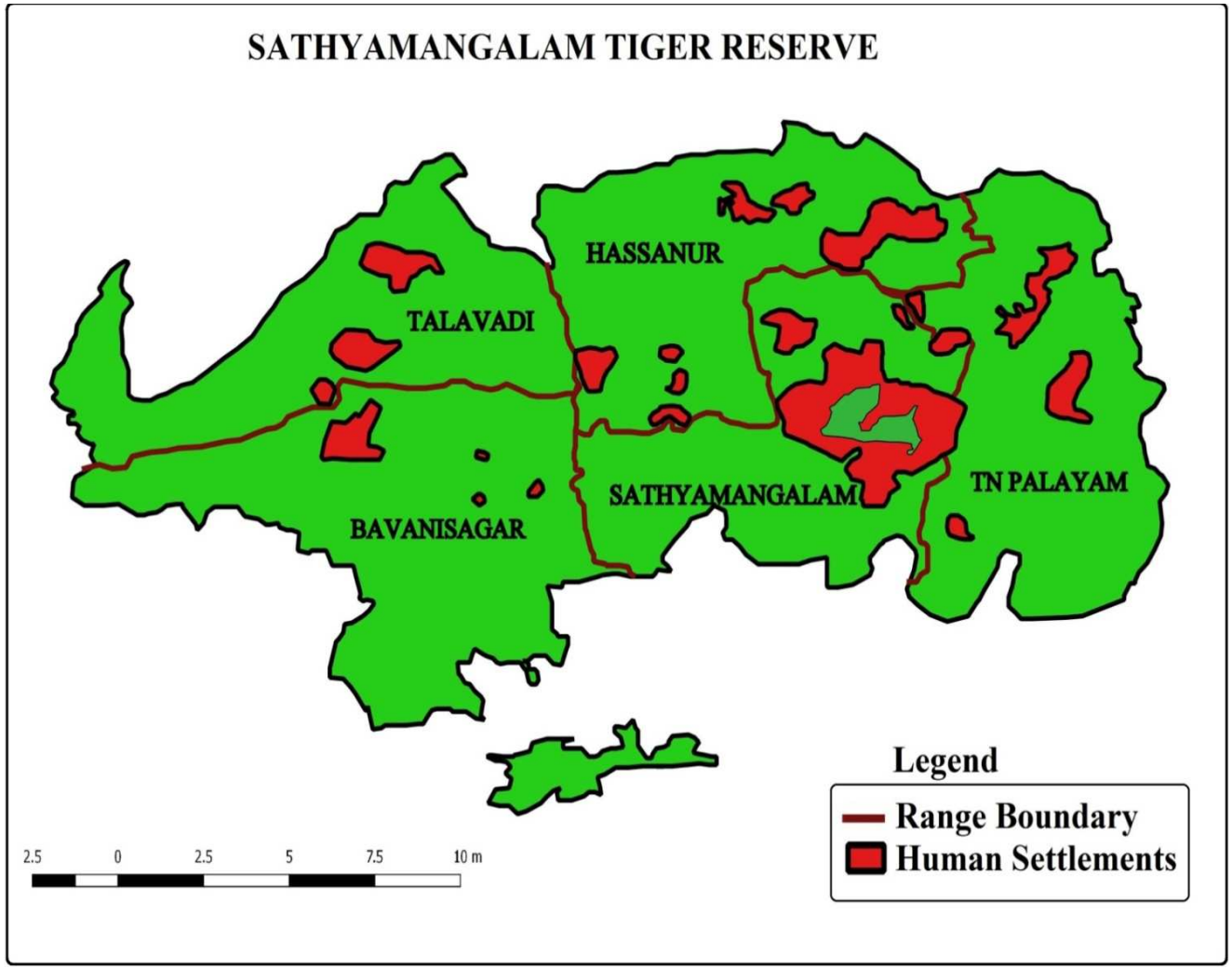


Map 3. Nilgiri North Forest Division with range boundary

Panoramic view of Nilgiri North Forest Division

SATHYAMANGALAM TIGER RESERVE (STR)

Sathyamangalam Tiger Reserve is located between the latitudes 11^{o} 29' 15" to 11^{o} 48" 41" and longitude 76 ^{0} 50' to 77 ^{0} 27' 22 (Map 4). It lies in the Northern Part of Erode District, and is bounded on the North by Karnataka State, on the East and South by Erode Forest Division and in the West by Nilgiris (North Forest Division). The terrain is gently undulated in the Moyar Valley with elevation ranges from 960m to 1266m in the Bhavanisagar, Sathyamangalam, Talavadi, Talamalai and Hasanur Ranges. The western part of the tiger reserve is almost flat. The average minimum and maximum temperatures are; 21.54o C and 27.02^{o} C on the plateau and the average minimum and maximum temperatures are 26.24^{o} C and 32. 84^{o} C in the plains. There are two perennial rivers in the tiger reserve, namely River Bhavani and River Moyar. A wide variety of habitats can be seen from eastern to western part of the sanctuary. There is a rainfall gradient from east to west and the change in vegetation is believed to be as a result of a spatial-temporal pattern. The Eastern part of this sanctuary falls in the rain shadow region of Western Ghats. This region has got dry thorn forest and the vegetation type gradually changes from dry thorn forest to mixed moist deciduous forests. The STR has been classified as an Eastern Ghats province as per the Bio-geographic classification, done by Wildlife Institute of India. The vegetation types found in STR are classified into the following types (Champion & Seth 1968). Southern tropical dry thorn forest, Southern tropical dry mixed deciduous forest, Southern subtropical hill forests, Southern tropical semi-evergreen forest and Riparian Forest. The STR has got a high diversity of fauna, notably White-backed Vulture and Brown Fish Owl amongst other bird species, similar to the adjoining Protected Areas (Mudumalai Tiger Reserve).



Map 4. Sathyamangalam Tiger Reserve with range boundary

Panoramic view of Sathyamangalam Tiger Reserve

METHODOLOGY

Population Estimation

Nest and Roost Site Count

At the initial stage of the project a questionnaire was circulated among the local people and various forest field staff in order to locate roosting and nesting colonies of White-rumped and Long-billed Vultures. Once roosting and nesting locations were confirmed we monitored the colonies with vulture counts twice in a month. The rivers and nullahs (streams) were also surveyed since White-rumped Vultures preferred to roost and nest in tall trees nearby. The population size of vulture species was estimated in the roosting sites and nesting colonies in the morning (0630 to 0930 hrs.) and late evening (1730 to 1930 hrs.) by foot surveys as described by Baral (2005). We assumed fidelity of nesting colonies, fixed time of roosting and geographic closure, no movement into (immigration) or out of (emigration) colonies to estimate population size and the vulture mortality rate. The nesting and roosting colonies were thoroughly searched for dead vultures to estimate mortality rate.

Breeding Ecology of Two Vulture Species

To study the nesting and breeding ecology of two vulture species namely, White-rumped Vulture and Long-billed Vulture, on average each nesting colony was visited 4 times in a month during breeding season (September to May) to check the status and number of vultures present in each colony. All observations were with binoculars (Nikon 52×10) from an appropriate distance (100-300m) in nesting colonies. Focal animal sampling method was used to monitor the status and behavior of breeding population of the two vulture species in nesting colonies (Postupalsky, 1974; Acharya et al., 2009; Awan et al., 2017). During the visits, five to ten minutes were spent to observe the breeding status of each nest in the colonies. All observations were made from 0700 hrs to 1200 hrs. Nests were identified by the presence of the fresh nesting material and whitewash (excreta) below the nest or by the presence of the incubating vulture in the nest. All the nests were identified and nesting trees were tagged and monitoring for future work (Postupalsky, 1974). Nest exposure on the nesting trees as well as rocks was determined by compass. Nest location 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 based on the criteria laid down by Postupalsky (1974). An active breeding pair was defined as one that laid an egg, and non-breeding pair was one 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. On each visit a nest was considered occupied by a pair when two adult vultures were observed at the nest, one standing and one incubating or one incubating adult was present or one adult with chick or a young chick alone was

present in the nest. Information on mortality, especially of adult mortality was recorded at nesting colonies (Baral *et al.*, 2005; Steenhof & Newton, 2007). A colony was considered as active, if it was occupied by at least one active egg (Xirouchakis and Mylonas, 2005).

People's perception on vulture conservation and assessment of diclofenac usages and others threats

People's attitude towards the vulture conservation was assessed through a questionnaire survey. The questionnaire detailed (i) general background of the respondents (ii) livestock holding pattern and, (iii) local knowledge and perception of vulture conservation. Most questions were close-ended, although some open-ended contingency questions were included. The variables such as livestock population, medication of livestock, the extent of use of Diclofenac, methods of carcasses disposal, compensation/ ex gratia details and wild animals' depredation on livestock, etc (Subadi, 2005; Baral & Gautam, 2007) were collected in the villages that were located in the vicinity of vulture habitats. Diclofenac prevalence survey and its usages were determined again by questionnaire surveys with veterinary doctors and quacks including drugs stores adjoining vulture habitats to document various veterinary practices for treating livestock in villages fringing vulture habitats. Other threats were quantified by direct field observation during the field trips.

Photo Plate 1. Monitoring vultures movement and Collecting nest data

Principal Investigator, Project Fellow and Field Assistant looking vultures movement in and around the nests

Vultures' white wash droppings observed under the nesting trees

Tagging the nesting trees for future monitoring

Principal Investigator, Project Fellow and Field Assistant recording nesting activities of vultures

CHAPTER I: POPULATION ESTIMATION

Confirmation of Nesting, Roosting and Foraging Colonies of Vultures

Based on the questionnaire and foot surveys, White-rumped and Long-billed Vultures nesting and roosting locations were identified, confirmed and depicted in MTR, NNFD, and STR on the survey of India map.

Nilgiri North Forest Division (NNFD)

Table 1. Nesting and roosting habitats of White-rumped and Long-billed vultures in the NNFD

S. No	Name of the Locations	Name of the vulture Species	Nesting and Roosting Colonies	Micro Habitat	Name of the Nearest villages	Distance to the Human Habitation Km	Over all km M±SE
1	Jagalikadavu	WRV	Nesting Habitat	Riparian area	Semmanatham	2.70	2±0.44
					Moyar	2.64	
					Bothanatham	2.17	
2	Anaikatty	WRV	Nesting Habitat	Riparian area	Anaikatty	2.24	
3	Siriyur	WRV	Nesting Habitat	Riparian area	Siriyur	0.29	
4	Ebbanad	WRV	Nesting Habitat	Riparian area	Ebbanad	2.24	
5	Nilgiris Eastern slopes	LBV	Nesting Habitat	Slopes	Koddanadu	2.01	2.41±0.17
					Puthukadu	2.99	
6	Ebbanad	LBV	Nesting Habitat	Slopes	Ebbanad	2.24	
7	Moyar falls	LBV	Roosting Habitat	Moyar gorge	Moyar	2.64	
					Bothanatham	2.17	

A total of 7 nesting and 1 roosting location were recorded in the NNFD of which 4 of them belonged to the White-rumped Vulture and 3 of them to Long-billed Vulture. White-rumped Vultures preferred to construct their nests on trees along the riparian forest whereas the Long-billed Vultures construct their nests on cliffs of the slopes and gorges. A total of 8 villages were recorded in and around the nesting and roosting colonies of two vulture species altogether. Of which Siriyur tribal settlement is located nearest to White-rumped Vulture nesting colony (0.29km). On the other hand, the Ebbanad revenue village is located nearest to Long-billed Vulture nesting colony (2.24km). The mean distances of villages located from White-rumped Vulture nesting habitat was 2±0.44 and the Long-billed Vulture nesting habitat was 2.41±0.17. (Table 1 & Map 5).

Map 5. Nesting and roosting colonies of White-rumped and Long-billed Vultures in the NNFD

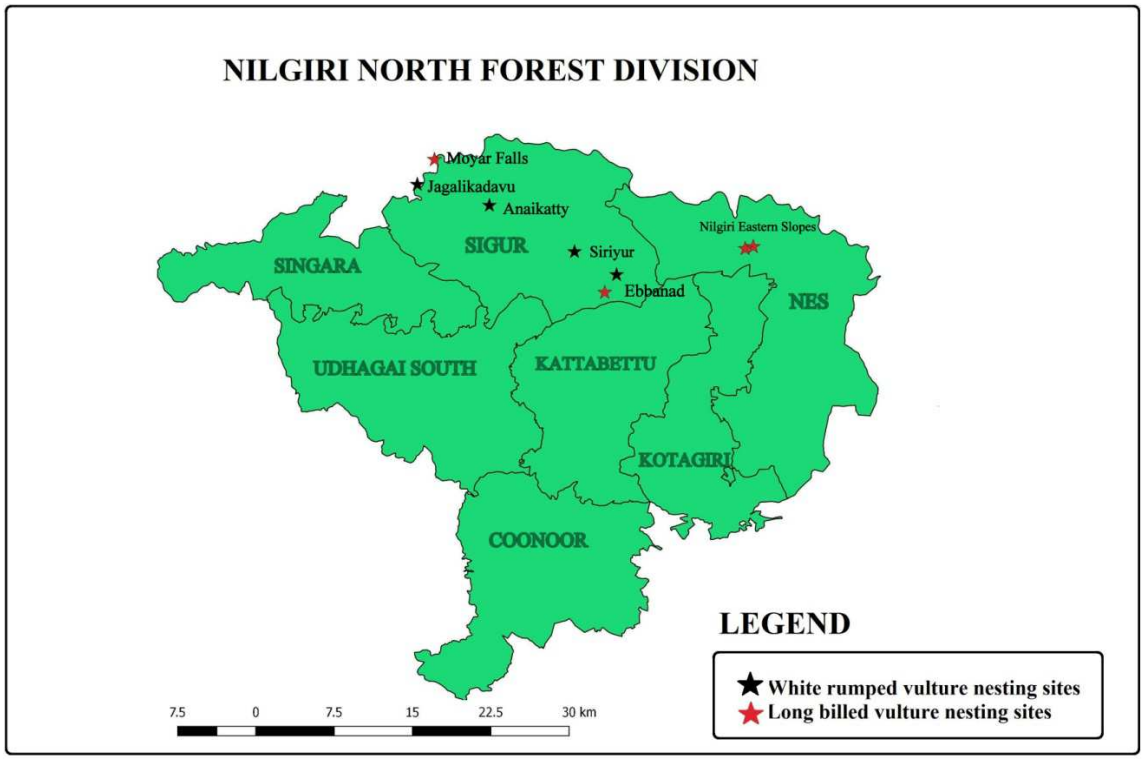


Table 2. Population status of all vulture species recorded in the NNFD

S.No	Vulture Species	Total number of sightings	Total number of individuals sighted	Overall Sightings Mean ± SE
1	White-rumped vulture	76	1814	23.87 ± 3.23
2	Long-billed vulture	29	83	2.86±0.33
3	Red headed vulture	18	60	3.35±0.38
4	Egyptian vulture	3	6	2.00±0.58
	Total	**126**	**1963**	**15.58± 2.15**

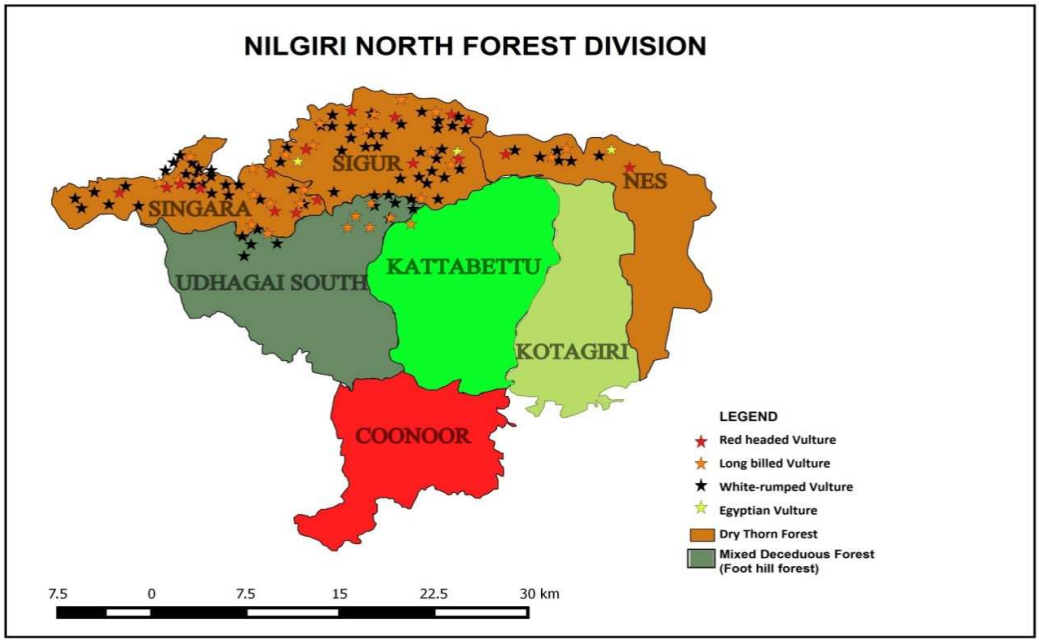
A total of 1963 individuals were recorded in 126 sightings comprising of 4 vulture species. White-rumped Vultures was recorded in higher numbers (n=1814 (23.87 ± 3.23)) followed by a Long-billed Vulture (n=83 (2.86±0.33)), Red-headed Vulture (n=60 (3.35±0.38)) and Egyptian Vulture. (n=6 (2.00±0.58)) (Table 2 & Map 2) in repeated sightings during the study period between July and December 2015. 139 was the maximum and 7 was the minimum number of White-rumped Vultures sighted during the study period. Similarly, 8 was the maximum and 1 was the minimum number of Long-billed vulture sighted; 6 was the maximum and 1 number was minimum for Red-headed Vulture and 2 was the maximum number and 1 was minimum number of Egyptian Vulture recorded during the study period (Table 2)

Table 3. Distribution pattern of various vulture species with reference to vegetation types in the NNFD

S.No	Vegetation types	Total number of sightings	Total number of individuals sighted	Overall Sightings Mean ± SE
1	Thorn Forest	98	1586	16.18±2.53
2	Mixed Deciduous Forest (Foot hill forest)	28	377	13.46±3.97
	Total	**126**	**1963**	**15.58± 2.15**

The occurrence of vultures with respect to different vegetation types in NNFD shows that more sightings were recorded in Thorn Forest (n=1586; 16.18±2.53) and sizable numbers were also sighted in Mixed Deciduous forest (Foothill forest) (n=377 13.46±3.97) (Table 3 & Map 6).

Map 6. Distribution pattern of various vulture species with respect to ranges and different vegetation structure in the NNFD.



Mudumalai Tiger Reserve (MTR)

Table 4. Population status of all vulture species recorded in the MTR

S.No	Vulture Species	Total number of sightings	Total number of individuals sighted	Overall Sightings Mean ± SE
1	White-rumped vulture	28	98	3.5±1.39
2	Long-billed vulture	2	2	1±0
3	Red headed vulture	6	14	2.33±0.80
4	Egyptian vulture	5	6	1.2±0.2
	Total	**41**	**120**	**2.92±0.96**

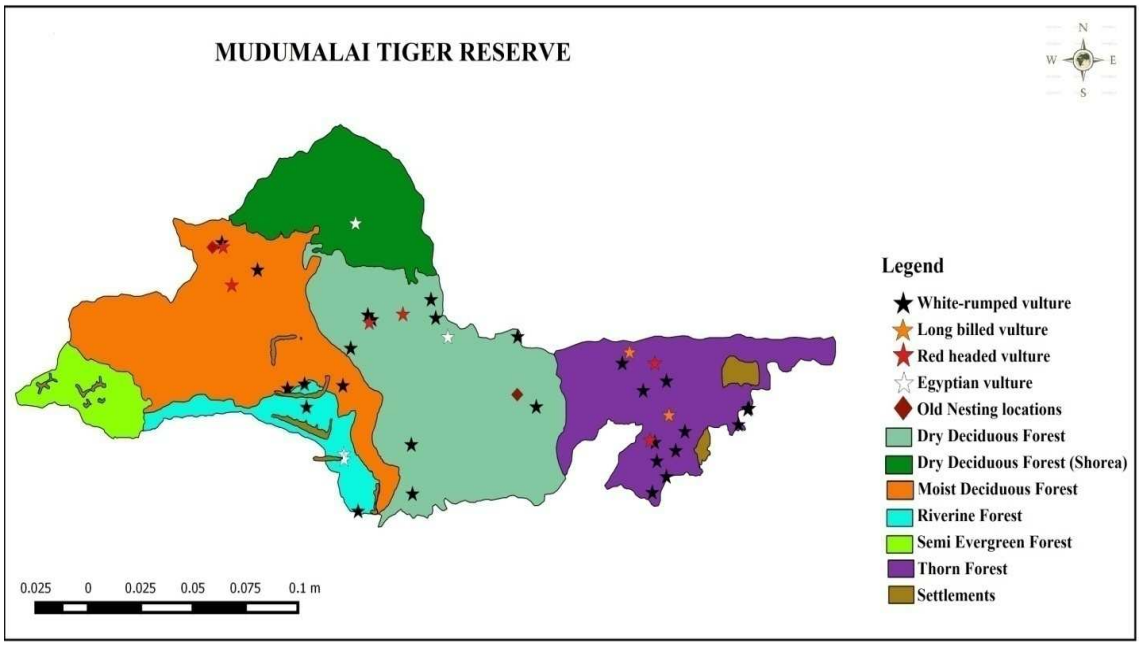
A total of 120 individuals of vultures were recorded in MTR with 41 sightings comprising 4 vulture species. Of which, White-rumped Vulture was recorded in highest numbers (n=98) followed by a Red-headed Vulture (n=14), Egyptian Vulture (n=6) and Long-billed Vulture (n=2) in repeated sightings during the study period between January and June 2015 (Table 4).

Table 5. Occurrence of various vulture species with respect to different vegetation types in MTR

S.No	Vegetation types	Total number of sightings	Total number of individuals sighted	Overall Sightings Mean ± SE
1	Thorn Forest	17	75	4.41±2.27
2	Dry Deciduous Forest	14	21	1.5±0.20
3	Moist Deciduous Forest	4	12	3±1.08
4	Riverine Forest	6	12	2±0.82
5	Semi Evergreen Forest	0	0	0
	Total	**41**	**120**	**2.92±0.96**

The occurrence of vultures with different vegetation types in MTR showed that more sightings were recorded in Thorn Forest (n=75 4.41±2.27) followed by Dry Deciduous Forest (n=21 1.5±0.20), Moist Deciduous Forest (n=12 3±1.08) and Riparian Forest (n=12 2±0.82) (Table 5). 40 was the maximum and 1 was the minimum number sighted in Thorn Forest. Similarly, 6 was the maximum and 1 was the minimum in Moist Deciduous Forest as well as in Riverine Forest. 3 was the maximum and 1 was the minimum in Dry Deciduous Forest (Table 5 & Map 7).

Map 7. Distribution pattern of various vulture species with reference to vegetation structure in the MTR.



Sathyamangalam Tiger Reserve (STR)

Table 6. Population status of all vulture species recorded in the STR

Sino	Vulture Species	Total number of sightings	Total number of individuals sighted	Overall Sightings Mean ± SE
1	White-rumped vulture	38	379	9.97±1.29
2	Long-billed vulture	15	28	1.86±0.13
3	Red headed vulture	14	26	1.85±0.23
4	Egyptian vulture	2	3	1.5±0.5
	Total	**69**	**436**	**6.31±0.86**

In STR, a total of 436 individuals were recorded in 69 repeated sightings. White-rumped Vulture was recorded in highest numbers (n=728; 9.97±1.29) followed by a Long-billed Vulture (n=68; 1.86±0.13) Red-headed Vulture (n=40; 1.85±0.23) and Egyptian Vulture (n=4; 1.5±0.5) in during the study period between May and October 2016 (Table 6).

Table 7. Occurrence of various vulture species with respect to different vegetation types in STR

S.no	Vegetation types	Total number of sightings	Total number of individuals sighted	Overall Sightings Mean ± SE
1	Scrub and Thorn Forest	39	327	8.38±1.26
2	Scrub and Mixed Deciduous Forest	15	75	5±1.79
3	Dry Mixed Deciduous Forest	6	16	2.66±0.33
4	Deciduous Forest	7	11	1.57±0.20
5	Moist Deciduous Forest	2	7	3.5±0.5
	Total	**69**	**436**	**6.31±0.86**

The occurrence of vultures with different vegetation types in STR showed that more sightings were recorded in Scrub and Thorn Forest (n=327; 8.38±1.26) followed by Scrub and Mixed Deciduous Forest (n=75; 5±1.79), Dry Mixed Deciduous Forest (n=16; 2.66±0.33), Deciduous Forest (n=11; 1.57±0.20) and Moist Deciduous Forest (n=7; 3.5±0.5). 68 was the maximum and 1 was the minimum number sighted in Scrub and Thorn Forest. Similarly, 27 was the maximum and 1 was the minimum in Scrub and Mixed Deciduous Forest; 4 was maximum and 3 was minimum in Dry Mixed Deciduous Forest as well as in Moist Deciduous Forest. 2 was the maximum and 1 was the minimum in Deciduous Forest (Table 7 & Map 8).

Map 8. Distribution pattern of various vulture species with reference to vegetation structure in the STR.

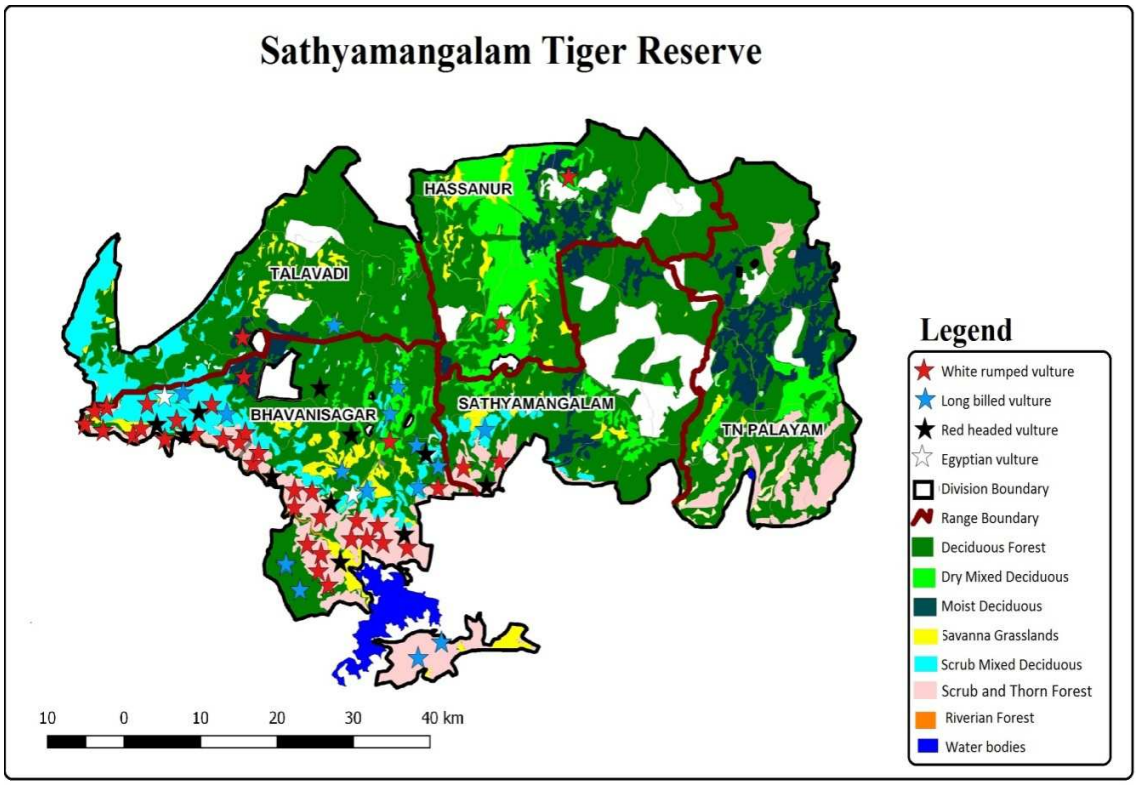


Table 8. Population Estimation of White-rumped and Long-billed vultures at nesting Colonies

S.No	Locations	Habitat Type	Vulture Species	Months	Total number of visits	Overall visits Mean ±SE		
						Total	Adult	Immature
1	Jagalikadavu	Nesting Habitat	WRV	June 2015 to May 2016	24	N=1651 (68.79±3.19)	N=1151 (47.95±2.71)	N=499 (20.79±0.74)
2	Siriyur	Nesting Habitat	WRV	June 2015 to May2016	24	N=75 (3.12±0.58)	N=55 (2.39±0.35)	N=20 (1.53±0.38)
3	Anaikatty	Nesting Habitat	WRV	September 2015 to May2016	18	N=862 (47.88±1.64)	N=494 (27.44±1.29)	N=368 (20.44±0.65)
4	Ebbanad Valley	Nesting Habitat	WRV	January 2016 to May 2016	10	N=307 (30.7±0.63)	N=197 (19.7±0.42)	N=110 (11±0.49)
5	Ebbanad Valley	Nesting Habitat	LBV	September 2015 to May 2016	18	N=34 (1.88±0.11)	N=33 (1.83±0.09)	N=1 (1±0)
6	Nilgiri Eastern Slopes	Nesting Habitat	LBV	October 2015 to May 2016	14	N=65 (4.06±0.30)	N=50 (3.12±0.20)	N=15 (1.15±0.10)
7	Moyar Falls	Roosting Habitat	LBV	October 2015 to May 2016	14	N=31 (1.93±0.19)	N=25 (1.56±0.12)	N=6 (1±0)

Food Note: LBV - Long-billed Vulture, WRV – White-Rumped Vulture.

Photo Plate 2. Population estimation of White-rumped and Long billed vultures at nesting and roosting areas

A venue of White-rumped vultures roosting on a Tree

Long billed vulture and White-rumped vultures at a carcass site

White-rumped vultures spread their wigs on a tree top before flight

Egyptian Vultures roosting on fencing poles around the agriculture farm

Tiger killed domestic buffalo

Regular field work activity by the team

The population status of White-rumped Vultures at 4 nesting colonies the Jagalikadavu nesting colony recorded a maximum number of individuals (68.79±3.19) as well as adults (47.95±2.71) and immatures (20.79±0.74) followed by Anaikatty Nesting Colony (47.88±1.64), Ebbanad (30.7±0.63) and Siriyur nesting colonies (3.12±0.58) (Table 8). Long-billed Vulture population was high in Nilgiri Eastern Slopes nesting colony with the maximum number of population (4.06±0.30) as well as adults (3.12±0.20) and immature (1.15±0.10) followed by Moyar valley roosting colony (1.93±0.19) and Ebbanad nesting colony (1.88±0.11) (Table 8).

CHAPTER II: BREEDING ECOLOGY

WHITE-RUMPED VULTURE

Table 9. Nesting trees preference by White-rumped vulture in nesting colonies

Name of the nesting colonies	Total number of trees with nests	Name of the tree species	Total number of nests
Jagalikadavu	21	*Terminalia arjuna*	28
Siriyur	2	*Terminalia arjuna*	3
Ebbanad	6	*Terminalia arjuna*	8
Annakatti	8	*Terminalia arjuna*	12
	1	*Spondias mangifera*	1
Total	38		**52**

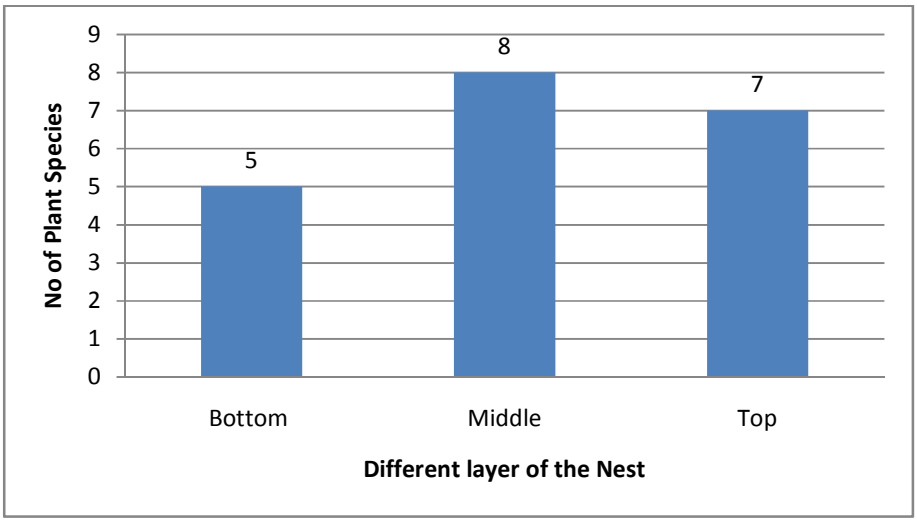
A total of 38 nesting trees comprising 52 nests of White-rumped vulture was recorded in 4 nesting colonies in the study area. A number of nests (n=28), as well as nesting trees (n=21), were recorded in the Jagalikadavu nesting colony followed by Anaikatty nesting Colony (13 nests in 9 nesting trees), Ebbanad nesting colony (8 nests in 6 nesting trees) and Siriyur nesting Colony (3 nests in 2 nesting trees). There were only 2 tree species preferred by the White-rumped Vultures to construct their nests in all four nesting colonies altogether. Of which *Terminalia arjuna* (37 trees with 51 nests) was highly preferred tree species. One nest in one tree *Spondias mangifera* which recorded (Table 9).

Table 10. Nesting materials used by White-rumped vulture for nest (n=52) construction

S.No	Tree species	Bottom	Middle	Top	M±SE
1	*Cassine glauca*	29	3	1	11.00±9.02
2	*Chloroxylon swietenia*	28	36	26	30±3.06
3	*Ficus mollis*	5	2	0	2.33±1.45
4	*Givotia rottleriformis*	7	2	5	4.67±1.45
5	*Pongamia pinnata*	18	20	11	16.33±2.73
6	*Terminalia arjuna*	0	4	31	11.00±10.11
7	*Spondias mangifera*	0	1	1	0.67±0.33
8	*Grass*	0	2	2	1.33±0.67
	Total	**5**	**8**	**8**	

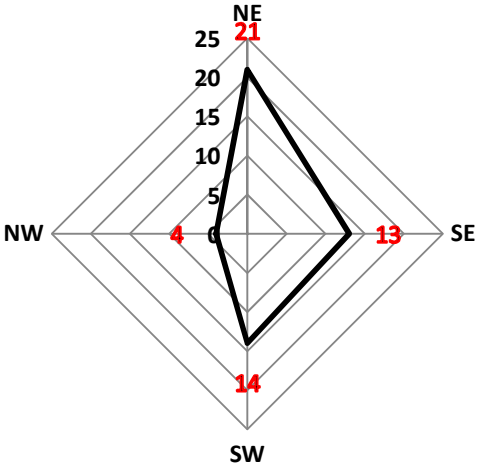
A total of 8 plant species materials were used by White-rumped Vultures for nest construction. Twigs of *Chloroxylon swietenia* were used maximum with the Mean±SE (30±3.06) followed by *Pongamia pinnata* (16.33±2.73), *Cassine glauca* (11.00±9.02), Grasses (1.33±0.67) and *Spondias mangifera* (0.67±0.33). Nests were divided into 3 segments according to the construction pattern i.e., bottom section, middle section, and top section. *Cassine glauca* (n=29), *Chloroxylon swietenia* (n=28) and *Pongamia pinnata* (n=18) were used more in the bottom section. *Chloroxylon swietenia* (n=36) and *Pongamia pinnata* (n=20) were used for middle sections and *Terminalia arjuna* (n=26) and *Chloroxylon swietenia* (n=26) were used for the top section (Table 10). Among the 8 plant species, 5 of them were used for bottom section and 8 species were used for middle and 7 species of plants were used for top section in nest construction (Fig.1)

Figure 1. Number of plant species used in nest construction in top, middle and bottom sections:



The results of the nest position revealed that about 60% of the nests (n=31) were placed on the top (crown) of the nesting trees. On the other hand, 40% of the (n=21) nests were located at the limb of the nesting trees. Most of the nests were located towards the North East direction (n=21) followed by South West (n=14), South East (n=13) and North West (n=4) (Fig.2)

Figure 2. Nest direction in nesting in trees



NE: North East **SE:** South East **SW:** South West **NW:** North West

Table 11. Nesting successes of White-rumped vultures in four nesting colonies

Name of the Nesting Colonies	Total Number of Nests	Status of the Nests	
		Number of Active Nests	Number of Abandoned Nests
Jagalikadavu	28	23	5
Siriyur	3	2	1
Ebbanad	8	6	2
Anaikatti	13	9	4
Total	**52**	**40**	**12**

Among the 52 nests, 40 nests were observed as active nests evidenced by frequent activities of a nesting pair. The Jagalikadavu nesting colony had recorded the maximum number of active nests (n=23) as well as abandoned nests (n=5) followed by Anaikatty nesting colony (9 active nests and 4 abandoned nests), Ebbanad nesting colony (6 active nests and 2 abandoned nests) and Siriyur nesting colony (2 active nests and 1 abandoned nest) (Table 11)

Table 12. Breeding successes of White-rumped vultures in four nesting colonies

Nesting Colonies	Total number of nests in incubation	Total number of nests with hatchlings	Total number of nests with fledglings	Percent of breeding Successes (%)
Jagalikadavu	23	15	14	**61**
Siriyur	2	2	2	**100**
Ebbanad	6	4	4	**67**
Anaikatty	9	3	3	**33**
Total Number of Nests	40	24	23	**58**

The breeding success was calculated from a total number of fledglings divided by a total number of nests seen in incubation for each nesting colony. Overall 58% of breeding success was recorded in all four White-rumped Vulture nesting colonies altogether. Among the 4 nesting colonies, Siriyur nesting colony found 100% of breeding success, followed by Ebbanad nesting Colony (67%) and Jagalikadavu nesting Colony (61%). Least breeding success was observed in Anaikatty nesting colony (33%) (Table 12).

LONG-BILLED VULTURE

Table 13. Nesting success of Long-billed Vulture in two nesting colonies

Nesting Colonies	Number of Nests	Status of the Nests	
		Number of Active Nests	Number of Abandoned Nests
Ebbanad Valley	1	1	**0**
Nilgiri Eastern Slopes	3	2	**1**

2 nesting colonies of Long-billed Vultures were recorded on rocky slopes in the study area. Totally 4 nests were recorded. 3 were active nests concluded by frequent activities of the nesting pairs. Nilgiri Eastern Slopes nesting colony recorded the maximum number of active nests (n=2) as well as an abandoned nest (n=1). The Ebbanad Valley has recorded just 1 active nest (Table 13).

Table 14. Breeding successes of Long-billed vultures in two nesting colonies

Nesting colonies	Total number of nests in incubation	Total number of nests with hatchlings	Total number of nests with fledglings	Breeding Successes %
Ebbanad Valley	1	-	-	**0%**
Nilgiri Eastern Slopes	2	2	2	**100%**
Total	3	2	2	**67%**

67% breeding success was recorded in two Long-billed Vulture nesting colonies altogether. Among the two nesting colonies, Nilgiri Eastern Slopes nesting colony observed 100% of breeding success (Table 14).

CHAPTER III: ASSESSMENT OF DICLOFENAC USAGES

Table 15. Livestock population in and around vulture nesting colonies

S.No	Name of the hamlets	Total number of livestock holders	Livestock population				Total
			Buffalo	Cow	Goat	Sheep	
1	Achakarai	12	135	254	39	121	549
2	Anaikatty	11	212	226	-	-	438
3	Bothanathham	2	-	182	-	-	182
4	Chokkanalli	3	-	52	-	-	52
5	Kovil Patti	7	-	100	34	79	213
6	Kurumbar Padi	26	-	179	62	19	260
7	Kurumbar Pallam	16	-	61	99	22	182
8	Masinagudi	17	61	317	32	-	410
9	Mavanalla	25	-	199	185	36	420
10	Moyar	29	-	361	61	-	422
11	Semmanatham	13	90	152	148	70	460
12	Singara	5	-	68	18	-	86

Photo plate 3. Breeding ecology of vulture species

An adult White rumped vulture seen on its nest on *T. arjuna* tree

White rumped vulture nest on *T. arjuna* tree

White rumped vulture nest on *T. arjuna* tree

White rumped vulture nest on *T. arjuna* tree

Long billed Vulture roosting on a tree

Long billed vulture nesting on Cliff

S.No	Name of the hamlets	Total number of livestock holders	Livestock population				Total
			Buffalo	Cow	Goat	Sheep	
13	Siriyur	9	72	231	10	50	363
14	Takkal	10	3	140	101	13	257
15	Thodulangi	23	-	17	237	101	355
16	Vazhaithottam	10	-	234	-	55	289
17	Yanna Padi	3	-	5	-	-	5
18	Hallli Moyar	21	-	131	239	82	452
19	Keezh.kalampalayam	12	-	120	175	58	353
20	Mel.kalampalayam	17	-	90	128	6	224
21	Gulithoraipatti	12	3	75	175	13	266
22	Puthukadu	22	-	25	273	11	309
23	Boothikuppai	12	-	46	123	27	196
24	Sithirampatti	18	27	17	153	66	263
25	Sugilkuttai	19	43	207	340	246	836
26	Thengumarahada	37	93	132	327	137	689
	Total	**391**	**739**	**3621**	**2959**	**1212**	**8531**

Totally 391 livestock holders were surveyed in 26 hamlets and result recorded a total of 8531 livestock. The cow was dominant (n=3621) followed by goat (n=2959), sheep (n=1212) and buffalo (n=739). The Sugilkuttai village attributed the maximum number of livestock (n=836) followed by Thengumarahada (n=689) and Achakarai (n=549) hamlets. Anaikatti, Masinagudi, Mavanalla, Moyar, Halli Moyar and Semmanatham villages held 400+ livestock. The least number of livestock population was observed in Yanna padi (n=5) which is located in the core area of Mudumalai Tiger Reserve (Table 15).

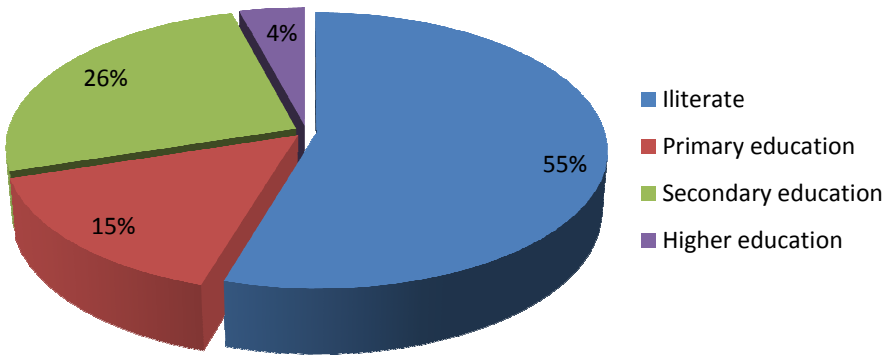
Table 16. Demography and age group of livestock owners/manages interviewed

Total respondent	Mean age of male respondent (N=233)	Mean age of female respondent (N=158)
	Mean ±SE	Mean ±SE
391	48.27±(1.12)	47.91±(1.28)

Out of 391 respondents most of them were belonged to the tribal community (n=281) while a large number (n=110) were non-tribal. Male category was more (n=233) than the female (n= 158). The average age of the male respondents were 48.27±(1.12) and the female respondents were 47.91±(1.28) (Table 16).

The literacy profile of the respondents revealed that more than half were illiterate (53%; n=213). A sizeable number of people were holding Secondary education (5th STD to 10th STD) (26%; n=101) and Primary education (1st STD to 5th STD) (15%; n=61). Very few of them (4% (n=16) completed their Higher education (12th STD to Degree) (Fig. 3).

Figure 3. Education profile of the livestock's holders



Livelihood status of the livestock holders was determined. Results showed that for most of them (n=241) were depending livestock was their only source of livelihood. On the contrary, considerable number (n=150) of them said they earned from other sources i.e., agriculture labour. The livestock holders made money mainly from sale of dung (Rs.35,12,000/-) followed by meat (Rs. 19,44,000/-) and milk (Rs.7,52,000/-). 391 persons earned about Rs. 62,08,000/- in 1 year through sale of dung, meat and milk (Fig.4).

Figure 4: Income status of the livestock holders from livestock:

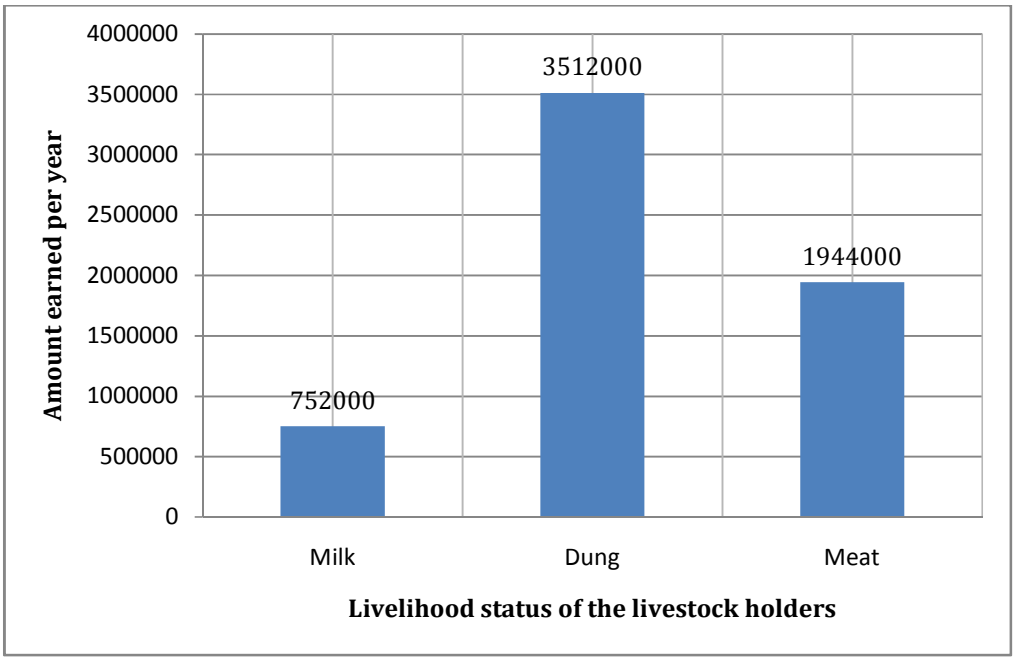


Table 17. Details of livestock depredation by wild animals

Total number of people interviewed	Total number of livestock lost for the past five years	Reason for the death of livestock	
		Number of livestock lost due to diseases	Number of livestock lost due to wild animals depredation
391	8191	5631	2548
Average per year	1638.2	1126.2	509.6

Totally 8191 livestock were lost by 391 people during the past 5 years. Most of the livestock (n=5631) were lost due to various diseases and considerable amount (n=2548) of livestock were lost due to wild animal predation. On average about 1638.2 livestock had been lost every year. Approximately, 1126.2 deaths were due to diseases and 509.6 individuals by wild animal predation in a year (Table 17).

Livestock carcasses disposal

Methods of livestock carcasses disposal were obtained from 391 livestock holders. Most of them (n=217) responded that they just threw away the livestock carcasses into the forest areas. On the other hand, 174 respondents said they buried their dead livestock carcasses (Fig 5).

Figure 5: Mode of livestock carcasses disposal

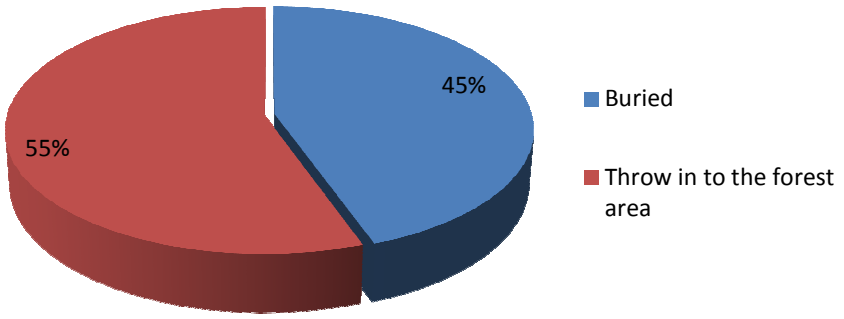


Table 18. Livestock holder's knowledge on Diclofenac

Total number of respondents	Diclofenac knowledge among respondent		What is Diclofenac		Diclofenac is harmful to vultures	
	Yes	No	Painkiller	Drug	Yes	No
391	137	254	46	91	84	53

The information on Diclofenac in relation to vulture conservation was obtained in interviews with livestock holders. The result revealed that a considerable number (n=137) of respondents knew about Diclofenac but at the same time most of them (n=254) were not aware of Diclofenac-related issues. A sizable number of respondents (n=91) and (n=46) knew that the Diclofenac was a pain killer and drug respectively. It was very important to note that most of the livestock holders (n=84) thought that the Diclofenac was harmful to vultures while a sizeable number (n=53) said that the Diclofenac was not threat to vulture population (Table 18).

Table 19. Livestock holders knowledge on vulture conservation

S.No	Questions asked to the livestock owners/managers	Respondents (n=391)	
		Yes	No
1	Do you Know vultures?	387	4
2	Vultures are doing scavenger roll in the environment?	339	52
3	Is vulture declining in your area?	313	78
4	Vultures are beneficial to humans?	370	21
5	It is important to educate vulture conservation to the people?	386	5
6	There are more stray dogs than before?	347	46

Totally 391 livestock holders were interviewed during the study period. It was a positive sign that most of the respondents had some knowledge about vultures (n=387). Out of 391 persons, 339 of them opined that vultures played the role of scavengers in the forest ecosystem. The majority of the people (n=313) responded that the vulture population was declining as compared to past few years. Respondents had accepted that vultures were beneficial to humans (n=370). An important issue to note was that the stray dog population had increased as compared to the past 10 years as per information gleaned from 347 respondents. Almost all of them (n=386) agreed that education on vulture conservation is warranted (Table 19).

The status of compensation/ex gratia received by the livestock holders from the forest department was obtained. Although the compensation was recently increased by Tamil Nadu Forest Department the payment was still a lengthy process that resulted in delays as told by livestock holders (n=388).

A total of 13 veterinary personnel were interviewed of which 9 Veterinary Assistants Surgeons (doctors) and 4 were Veterinary Assistants (quacks). All were aware of the ban on the use of Diclofenac in veterinary practice and its effects on vulture population as well. They were using Melaxicam as a painkiller for veterinary practice. It is interesting to note the Tamil Nadu Government provided meloxicam to Government Veterinary hospitals for livestock practices. The veterinary persons also opined that an average of 31 cases was attended by them per month of which most of the cases were attributed to sickness (n=20) and carnivore attacks (n=11).

Table 20. Diclofenac combination drugs available in the drug stores in and around the study area

S.No	Name of the Drug	Type of the Vials	Price Rs
1	Dolokind*	3ml	21.50
2	Voveran*	3ml	12.00
		1ml	3.50
3	Definac*	30ml	49.50
		3ml	4.00
4	Clofenac*	3ml	16.50
		1ml	5.75
5	Lofnac*	30ml	47.00
		3ml	15.20
		1ml	4.45
6	Diazox	3ml	20
7	Nac	1ml	3.60
8	ARK	30ml	87.00
9	Hifenac	30ml	39.72
		1ml	4.75
10	Reactin	30ml	51.70
		3ml	11.79
		1ml	3.70

***Fast selling medicines**

The drug store survey results revealed that a total of 10 Diclofenac composition painkillers were currently prescribed by the doctors. As per Government's Gazette Notification dated 17th July 2015 (attached) doctors can prescribe only 3 ml and 1 ml vials for human uses. It's interesting to note that 30 ml vials are still available in the drug stores. (Table 20)

Photo Plate 4. Assessment of Diclofenac and other NSAIDs usages

Tiger killed domestic buffalo

Tiger killed domestic buffalo

Questioner to livestock holders

Questioner to local people

Observing medication practices to livestock treatment

Conducting questionnaire to veterinary person

Table 21: Mortality details of White-rumped Vulture during 2013 – 2016

S.No	Demography of death White-rumped vultures	Numbers	Poisoning	Remarks
1	Adult	34	7	**Poisoning** (Post-mortem carried out by the FAVS of MTR)
2	Immature	8	1	**Poisoning** (Post-mortem carried out by the FAVS of MTR)
	Total	42	8	

A total of 42 White-rumped Vultures died between 2013 and 2016. 34 individuals were adults and 8 were juveniles. Post-mortem could only be conducted on 8 individuals and the results revealed that their tissues were contaminated by ***Organophosphorus and urea.*** The former is a poison used as an insecticide in agriculture practice. 1 vulture died while feeding when its neck got stuck between the vertebral bones of a domestic buffalo carcass. Skeletal and feather remains from 32 individuals was insufficient for mortem analysis (Table 21). 1 immature fell from its nest and was eaten by wild boars.

CHAPTER IV: OTHER THREATS

Bathing, cooking and washing under nesting trees

White-rumped Vulture nesting colonies were located very close to the human habitation at Siriyur village. The local people used the Siriyur vulture nesting area for many purposes such as bathing, cooking, washing, and as a place for festivities. These activities impacted on vultures especially, during breeding season, incubation, with frequent interruptions during feeding of hatchlings by the parents. Thus, these activities resulted in breeding failure. As per literature a vulture lays only 1 egg in one breeding season. With above-mentioned human disturbance any nesting failure would seriously affect the population in future.

Livestock grazing

The noise from grazing of livestock under the nesting trees, especially during the incubation period, disturbed the breeding pairs. Cattle from Moyar, Semmanatham, Vazhaithottam and Masinagudi villages were coming into the Jagulikadavu vulture nesting colony for grazing and drinking water along the Jagulikadavu river. The people involved in livestock grazing generally make sounds at 10-minute intervals to avoid encounters with elephants, tigers and other carnivores, and to keep them away from their livestock.

Non-Timber Forest Produce (NTFP) Collection

Although NTFP collection is not permitted in the Protected Areas such as Sanctuaries and National Parks, it is permitted in Reserve Forest areas. The NTFP

Photo Plate 5. Conducting post mortem to White-rumped Vulture deaths

Vulture postmortem carried out by FVAS in MTR

Full of food content seen in the stomach

Dead immature white rumped vulture

Project Fellow investigating the dead white rumped vulture

Dead immature white rumped vulture

Dead Adult white rumped vulture

collection generally takes place between January and May and peaks in February for the collection of *Phoenix* leaves for broomstick manufacturing. Other than *Phoenix, Sapindus emarginatus, Phillanthus emblica, Bombax ceiba, Treminalia chebula, Tamarindus indica and Marapaasam* (Tree algae) was also collected during this period. Although the NTFP collection does not affect the nesting trees either physically or directly the presence of collectors will have effect on the White-rumped Vulture population as this activity happened during the breeding season. Due to the reduced feeding intensity by parent birds starvation and consequently, mortality was a serious factor for nestlings.

Bamboo Collection

Bamboo is vital to tribals in the Sigur plateau. The bamboo is mostly used for construction of their houses, boundary wall, livestock pens and temporary construction during religious festivals. The tribals cut bamboo under nesting trees. Generally, White-rumped Vultures select the nesting trees that are densely covered by bamboo clumps at the base in order to avoid wild carnivores (Tiger, Leopard, Sloth Bear) and herbivores (Elephant and Gaur) approaching the nesting trees. Therefore, such activity under the nesting trees might cause disturbance to the breeding pair and they may not select the same tree next year for nesting.

Threat from presence of pilgrims

Series of temple festivals occur during summer (January-May) in the Sigur Plateau coinciding with the breeding season of vultures. The most important and relevant festival is Siriyur Maariamman Temple festival. This temple festival is celebrated in the month of February or March every year for three to five days. About 10,000 to 20,000 people from various tribal settlements and villages visit the temple. The White-rumped Vulture nesting colony is located at Siriyur river near Siriyur tribal village. The pilgrims offer free food (Anna Dhaana) for the devotees by cooking along the Siriyur river bed. This activity brings large gatherings along the Siriyur river bed under the White-rumped Vulture nesting trees which caused serious disturbance by interrupting their breeding activities. We recorded one nesting tree burnt by the pilgrims while cooking food. This resulted in the loss of 2 nests out of 5 nests on the burnt tree.

Honey collection

Honey collection is also one of the major threats for vulture conservation in the Sigur Plateau. Generally, honey collection takes place twice in a year: May-June and August to October months. The nest construction of White-rumped Vulture starts between September and October and so is directly affected by the fire and smoke used by tribals to collect honey. Our observation revealed that there is a direct impact on nest construction with this activity. This resulted in a change of nesting trees by vultures for nest construction during the next year. If there are no suitable trees around it may to lead to breeding failure for that particular breeding pair.

Photo Plate 6. Various anthropogenic threats seen in and around the nesting sites

Bathing, Cooking and Washing under nesting trees

A herd of cattle grazing under nesting trees in Jagalikadavu nesting Site

Non Timber Forest Produce (NTFP) Collection

Non Timber Forest Produce (NTFP) Collection

Anna Dhaana food preparation under vulture nesting trees at Siriyur nesting colony

Bamboo Cutting under nesting trees

Honey collection on nesting trees

Honey collection on nesting trees

Honey collection on nesting trees

Delibrate Poisioning

DISCUSSION

Among the vulture species, the decline of *Gyps* vulture population was alarming in the Indian subcontinent with high mortality rate and breeding failure (Prakash, 2001). It is likely to lead to their extinction if the problems are not urgently addressed (Birdlife international, 2001). Hence, this population study was taken up in the Tamil Nadu part of the Nilgiri Biosphere Reserve (NBR) in order to protect the country's southernmost viable wild population. This project focused on two critically threatened vulture species namely, White-rumped (*G. benghalensis*) and Long-billed Vulture (*G. indicus*) to determine population status, nesting ecology, threats from Diclofenac and other NSAIDs, etc. This study recorded totally 7 nesting colonies: 4 colonies of White-rumped Vultures and the remaining 3 of Long-billed Vultures. We found the White-rumped Vulture nesting colonies located at an average distance of 2 kms from human habitation while it was 2.28 kms in the case of Long-billed Vulture. Previous literature were also supported that the location of breeding Colonies near to human habitation in Nepal and Gujarat (Baral *et al*., 2005; Baral and Gautam, 2007; Dave, 2011; Harris, 2013).

The distribution of vultures in the study area showed remarkable variation according to vegetation and habitat types with most sightings and nesting colonies in Thorn Forest areas mainly because of its open vegetation structure. Thus vegetation structure played a vital role on the vulture's ability to find out animal carcasses with their acute eyesight. Brown (1985) established two hypotheses concerning vegetation structure and carcass finding by vulture species in South-West Africa, Namibia. In his first hypothesis, he had quoted that the increased vegetation density caused by bush encroachment decreases the likelihood of vultures locating a carcass, as they rely almost entirely on eyesight when foraging. In the second hypothesis, vultures, which are heavy birds adapted for soaring and unsuited for flapping flight in confined spaces, will not land at carcasses they have located if they do not have sufficient space in which to take off again. This hypothesis was supported by Schultz (2007), who showed that Cape Vultures (*Gyps coprotheres*) in the Waterberg region of Namibia were unable to locate carcasses when the vegetation density was greater than 2,600 trees per ha. Land-use patterns influence raptor diversity and density (Herremans & Herremans-Tonnoeyr 2000).

Although this project focused on White-rumped Vulture and Long-billed Vulture, information on Red-headed vultures (*Sarcogyps calvus)* was also collected. We recorded a total of 60, 40 and 14 individuals of Red-headed Vultures in NNFD, STR, and MTR respectively. Earlier literature revealed that Red-headed vultures are fresh carcass feeders in nature and will track the predator's presence for their food (Naoroji, 2006; Chhangani, 2007). This is substantiated by the evidence of 6 Red-headed Vultures recorded in 8 incidences where the movement of tigers was high in our study areas (Ramakrishanan *et al*., 2012; Samson *et al.*, 2016b).

This study observed a fluctuation in White-rumped Vulture numbers ranging between 33 and 82 in Jagalikadavu, 1 and 16 in Siriyur and 29 and 54 in Anaikatty and 29 and 34 at Ebbanad nesting colonies. A similar trend was also noticed for Long-billed Vulture population 1 and 3 in Ebbanad, 1 and 3 in Moyar Falls, and 2 and 6 in NES range during our field work from June 2015 to May 2016. In the month of June, the vulture populations were less in the nesting colonies and gradually increased and reached its maximum numbers at the end of the breeding season in May. A similar pattern was also noted by Baral *et al*. (2005) for White-rumped Vulture population in Nepal and in Rajasthan by Chhangani and Mohnot (2004). During non-breeding seasons the adults flew far away from the nesting colonies in search of food, and sometimes away for as much as 2 days to acquire food. With food availability close to their nests it enabled them to spend longer time in parental care and feeding their young in the breeding season. Therefore, maximum number of vultures was seen in and around nesting colonies mainly during breeding months. This study observed breeding season was from September to May and non-breeding season from June to August in NBR.

In all 4 nesting colonies, the White-rumped Vulture preferred to construct their nests on *Terminalia arjuna* trees. This could be due to tree height and basal girth, which kept away people and other wild animals, especially elephants (Road, 2010). The *Terminalia arjuna* is the only tallest tree species seen abundantly along the riparian forests of Southern India. We observed that the White-rumped Vultures usually preferred the same tree for nesting and roosting in the study area. Our observation is also in accordance with Baral *et al*., (2005), as single tree preference (Kapok tree) by White-rumped Vultures in Nepal.

The total white-rumped vulture population at four nesting colonies altogether ranging between 92-186 individuals in 52 constructed nests and 23 occupied nests with 58% breeding success. The previous studies in Rampur Valley showed that there were 72–102 individuals of White-rumped Vultures in six nesting colonies during their breeding season, with 50% breeding success at 70 occupied nests (Baral *et al*., 2005). In Pakistan, a total of 2281 occupied nests were recorded between 2000 and 2004 and the nest success was observed in 1231 nests with the breeding success of 51% (Gilbert *et al*. 2006). In Africa, it was estimated that 48% of breeding success in White-backed vultures (*Gyps africanus*) (Martinez *et al*., 1997). Among earlier studies in Asia as well as Africa this study has recorded highest percentage of breeding success despite the various disturbances cited in the preceding section makes for a strong argument of the viability of this wild population.

In this study we also observed a total of 56% (n=29) of nest abandoned White-rumped Vulture species during the breeding season from October to December 2015. Newton (1979 & 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 here. Not all raptor

pairs occupying nesting territories lay eggs every year. A major factor influencing egg laying is food supply and in poor food years, territorial pairs in some populations fail to lay eggs. On the other hand, nest abundance was seen due to mortality of chicks and nesting pair (Baral *et al*. 2005) and anthropological threats in the nesting areas would also cause the nest abundance criteria (Moran Lopez *et al*. 2006).

We observed troops of Hanuman langur (*Presbytis johinii*) and Bonnet macaque (*Macaca radiate*) near nesting trees and this may cause disturbance to a breeding population of white-rumped vulture in nesting colonies. Their play antics of jumping and shaking the branches of nesting trees could make the nesting adults to abandon their nest (n=14). The literature review supported that the langurs were causing a disturbance in the nesting of vultures in Nepal (Subadi 2007), and also in Africa monkeys and baboons have been reported to interfere in the normal breeding of African vultures (Mundy *et al*. 1992; Emmett 2003; Roche 2000 & 2006).

It was recorded that the cattle population was higher in our study area in twenty-six surrounding villages. The villagers keep livestock mainly for dung followed by meat and milk. There is a high demand of dung from upper Nilgiris inhabitants for mushroom culture, tea and coffee plantations. Silori and Mishra (1995) called this cattle as "Dung producing machine" in and around Masinagudi Village of the Sigur plateau. The statement of Silori and Mishra, (1995) was now evidenced by dung sale cost of Rs. 35,12,000/- per annum by 391 livestock holders in the study villages. It was quite interesting to note that Rs. 19,44,000/- was earned by selling their livestock to the butchers for slaughter houses. This is mainly because of the adjoining state of Kerala where the people consume both cattle and buffalo meat. Hence the selling cattle for meat was in second position followed by sale of milk. The milk production was the very low (Rs. 7,52,000/-) because of the scrub cattle are a country breed which produces lower quantity of milk, unlike cross breed varieties. The reserve forests are considered to be common pool resources which cattle owners enjoy at low-cost investment.

This study has confirmed that most of the livestock carcasses (55%) were thrown out and made available for natural disposal and remaining (45%) of them were buried. Unfortunately, these carcasses were not thrown far away from the villages. They were thrown between 300 to 500 meters around the villages. Due to disturbances, these carcasses were not accessed by vultures. On the other hand, these carcasses were heavily utilized by wild boars and stray dogs. It was evidenced by the increase of stray dogs population in the villages thus resulted in behavioral change and health risks of human beings when they closely associated with them (Cunningham *et al*., 2003; Pain *et al*., 2003).

The carnivores' depredation on livestock was recorded through a questionnaire survey. Although tiger, leopard, and wild dogs are reasons for loss of cattle attacks by the former were high on cows, bulls and buffalos. Ullas Karanth (2003) stated that livestock is the easiest prey for tigers when the cattle graze inside the forest areas. Leopards and

wild dogs fed on goat, sheep and calves of cows and buffalos. Carcasses of wild dogs were quickly consumed by wild dog packs so were not available to vultures. Similarly, leopards hid their prey remain in branches of trees which were nor accessible to vultures. So most of the food for vultures were obtained from tiger kills including lifestock that died natural deaths and from diseased animals. It is quite interesting to note that this landscape arguably holds the highest tiger population in the country. Therefore, the vultures in this landscape is heavily dependent on tiger kills and that are not poisoned by livestock owners in retaliation.

This study found that most of the livestock holders were illiterate and depended on livestock as their major livelihood. Awareness about the Diclofenac and its effects on vulture populations was very poor. On the other hand knowledge on vulture's importance and their role in the ecosystem was well known by the livestock holders. The livestock holders opined that the vulture population is declining in their area. Generally, the livestock holders treat their injured livestock by traditional methods and sometimes they bring veterinary doctors or quacks only for extreme cases.

The questionnaire survey from the veterinary doctors revealed that they use Melaxicum as a painkiller (a safe drug for vultures). It was gleaned from the vulture mortality records also. So far none of the vulture deaths were scientifically or clinically proved to be caused by Diclofenac, and instead attributed to poisoning of the carcass (Laboratory Report is enclosed as Annexure-I). Hence this study strongly suggests that education is needed for the livestock holders to change their attitude towards retaliatory killing.

A similar effort has to be made to the forest department also in order to ensure adequate and quick payment of compensation/exgratia to the livestock holders to stop the further poisoning of the carcass, which is considered as a severe threat to this vulture population rather than Diclofenac. Davidar (2002) reported that the retaliatory killing activity of livestock holders was the reason for declining of Tiger and vultures in the Sigur Plateau followed by Ramakrishnan *et al* (2010) stated that the Diclofenac is not a culprit for declining vulture population in this region as the vultures feeding on wild carcasses (including tiger killed livestock) as their major diet. Arumugam & Arivazhagan has recorded dead Hyena (1) and White-rumped vultures (1) and Jungle Crow (1) in Mudumalai Wildlife Sanctuary (MTR interpretation center). Three Wild dogs deaths due to ***Organophosphorus and Urea*** also had been recorded in Mudumalai Tiger Reserve (Vijayaragavan Pers. Comm.). The reason for this issue is mainly because of increasing tiger population in a contiguous stretch of Tiger Reserves on both ends of the Sigur Plateau. As of now even though negative effects of Diclofenac was not recorded scientifically in this vulture population, multiple awareness programmes are needed for the proper disposal of contaminated carcasses and Diclofenac use in veterinary practice. Green *et al* (2004) stated that based on demographic modeling, it has been found that less

than 1% of lethal level of Diclofenac can cause a rapid population decline to vulture. Therefore, educating livestock holders, farmers and veterinary personnel may help to secure healthy food for vultures.

This presence of Organo-Phosphorus and Urea of White-rumped vultures envisages that long-term monitoring is needed by establishing a laboratory for the analysis of various poisonous chemicals as well as NSAIDSs (Diclofenac) from the tissues of dead vultures. The toxicology analysis by Oaks *et al*., (2004) on many dead vulture tissues in Pakistan found the presence of Organochlorides, Organophosphate, Carbamates and heavy metals.

MANAGEMENT RECOMMENDATIONS

- From 19 White-rumped Vulture nests at Siriyur nesting colony in 2011 not a single nest was left at the end of 2016. In order to prevent other colonies from disappearing we need to continue investigating reasons for vultures abandoning the nesting site at Siriyur. We also need to involve tribal councils and local communities in vulture conservation.
- This study has concluded that the thorn forest was extensively used by both vulture species, followed by deciduous forests and riverine forests and were monitored for population estimation and feeding ecology. This was mainly because of open vegetation structure in thorn forests. Removal of invasive alien species, such as *Lantana camara* and *Eupotorium* spp. in dry deciduous forests is urgently warranted to ensure carcass detection by vultures.
- Among the three focused study sites, Mudumalai Tiger reserve, Nilgiris North Forest Division and Sathyamangalam Tiger Reserve, it is recommended that more attention should be given to the Nilgiris North Forest Division as this is the only area having all the nesting colonies of both the vulture species. Unlike Mudumalai and Sathyamangalam Tiger reserves (Protected Areas), the Nilgiris North Forest Division is categorized as Reserved Forests and therefore, is not accorded sufficient protection. Declaring it as a "Vulture Sanctuary" will be vital in protecting all the nesting colonies.
- This study recorded 52 nests of White-rumped vulture in six locations. The outcome of this study is a milestone for vulture conservation as this population seems to be the southernmost viable population in our country. Therefore, this research project strongly recommends that long-term monitoring of this population is highly warranted for securing and ensuring the future of this vital population.
- Among the four nesting colonies of White-rumped vulture, more attention should be given to Jagalikadavu nesting colony (28 nests in 21 nesting trees) followed by Anaikatty nesting Colony (13 nests in 9 nesting trees) and Ebbanad nesting colony (8 nests in 6 nesting trees).
- This study strongly recommends protection of tree species, such as *Terminalia arjuna* and *Spondias mangifera* and from human activities like honey and bamboo collection to ensure successful nesting of White-rumped vultures in this region. It was observed higher number of nests was recorded on the trees that had protection from thick Bamboo clumps around their bases. Bamboo clumps may also prevent elephants and large predators from approaching these nest trees.
- This study documented that out of 52 nests 12 nests were abandoned. Out of the 40 White-rumped Vulture nests in incubation only 24 nests were found with

hatchlings (58%) of which 23 fledglings (95%) survived. This study recommends that more long term research is needed to determine the reasons for only 58% survival rate of hatchlings.

- 100% success was recorded for Long-billed vulture breeding in the Nilgiri Eastern Slope nesting colony, because of less human disturbance compared to Ebbanad Valley nesting colony.
- This study has recorded 26 villages having a population of 8531 livestock managed or owned by 391 persons near the vulture habitat. Although none of the vulture deaths were scientifically confirmed with Diclofenac contamination so far, awareness against usage of Diclofenac (and other NSAID's) must be continued for the long-run survival of our country's southernmost viable vulture population.
- Out of 391 livestock holders the majority belonged to the illiterate tribal community. For them livestock is their only means of livelihood. Therefore, this community will go any level to protect their livestock so education and awareness programmes for vulture conservation is also a necessary aspect.
- An important outcome of this study revealed that majority of the livestock carcasses although thrown in the forest areas they were very close to village boundaries. As a result these carcasses were not accessible to vultures due to high human disturbance. Livestock holders also buried their livestock carcasses depriving vultures of food. This study recommends initiating a long-term mechanism for people's participatory approach in collaboration with the Tamil Nadu state forest department, animal husbandry department and village panchayats to ensure availability of livestock carcasses to vultures, provided that they are completely free from any contagious pathogens and NSAID's.
- Although Diclofenac and Ketoprofen drugs are banned as a veterinary drug and for vet use but not banned for human use by both Central and State Governments, Diclofenac-combination drugs are still being sold in the drug stores. This study identified 10 fast-selling Diclofenac-combination drugs freely available in the drug stores for human medication [this is still legal] in and around the vulture habitat. Toxicity analysis is urgently needed for Diclofenac and other unknown NSAID's necessary for the vulture conservation so that harmful drugs can be suggested for a complete ban]. This study also found the availability of 30 ml vials, which are totally illegal since June 2015, and the need to alert the drug authorities. All this requires a thorough monitoring on a continuous basis.
- Out of 42 White-rumped vulture deaths post-mortem could only be conducted on only 8 individuals. These were collected from different locations around Chemmanatham Tribal Settlement on 28.12.2014. No carcass was found near these vulture deaths. Out of 8 individuals, 7 them were adults and 1 was an

immature (see table 21). No injuries nor evidence of gout was noticed. Although prima facie Diclofenac was not a threat to this vulture population there is still a need for a systematic analysis of cattle and vulture tissues to determine exact causes of these vulture deaths. The results revealed that the tissues of the vultures were contaminated by organo phosphorus compounds and urea. The former is a poison and is used as an insecticide in agriculture practice.

- The study area is popularly known Nilgiris and Eastern Landscape, approximately 12,000 sq. km, shared by 3 States, and holding perhaps, the largest tiger population in India. Livestock seemed to be the preferred prey for tigers over wild herbivores. Livestock holders show strong intolerance to tiger kills and readily poison their carcasses targeting the tiger as retaliatory killing. As a result, vultures consuming these carcasses also die of poisoning. Now the Tamil Nadu Forest Department is providing compensation/ex-gratia to the livestock holders. However, a faster process of giving compensation must be initiated with assistance from researchers who can co-ordinate with livestock holders to prevent further poisoning of livestock carcasses. Awareness campaigns with livestock holders and requesting the forest authorities to simplify claim procedures through workshops is very vital for long term conservation of vultures in this region.
- This study recommends awareness campaigns to be conducted to limit, if not eliminate honey and bamboo collection, control and educate large number of pilgrims during religious festivals, Non-Timber Forest Produce collection, and sundry activities, such as bathing, cooking, washing and livestock grazing near nesting trees. Such continuous disturbance is likely to result in a high failure rate nestlings. With the increase in stray dogs it is imperative to also highlight spread of rabies from dog bites and consuming cattle carcasses which is food not only for vultures but other wild predators as well.
- This study proposes continuation of research and conservation activities till all its proposed recommendations are implemented and monitored vital for vulture conservation. I strongly believe that the research is not completed unless its recommendations are fulfilled and mechanisms for successful implementation on the ground level are firmly established, with multi-agency involvement for achieving sustainable results on the conservation of the target species.

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PROFILE OF RESEARCH TEAM

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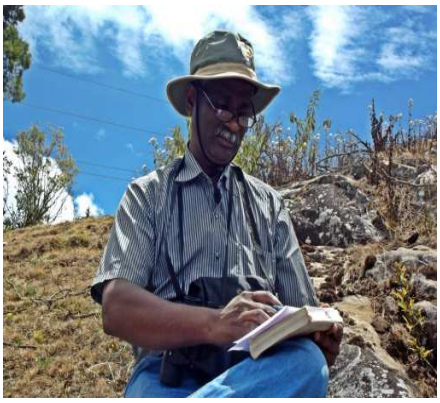
I completed my post-graduation and Ph.D., in Wildlife Biology. I worked as a Junior Research Fellow and Senior Research Fellow in Salim Ali Centre for Ornithology and Natural History (SACON), Coimbatore and WWF-India from 1995 to 2005. Thereafter, worked as a Field Officer in Wildlife Trust of India from 2007 to 2010. Since 2011, I am employed as Assistant Professor in Wildlife Biology in Government Arts College, Udhagamandalam, Tamil Nadu. Presently, 8 Ph.D. students pursuing under my supervision. So far 4 M. Phil. students completed their research and presently 3 students are doing their M.Phil. under my supervision on vultures, elephants and tiger conservation. I am a member of various national and international bodies namely IUCN - Asian Elephant Specialist Group, National Biodiversity Authority - Invasive Alien Species, State Board for Wildlife - Tamil Nadu State, State Level Steering Committee - Nilgiri Biosphere Reserve, NTCA - Mudumalai and Sathyamangalam Tiger Reserves - Governing Body. I have published 50 papers in national and international peer reviewed journals. I delivered 21 oral presentations national and international workshops, seminars, conferences and symposia so far. I am one of the editors in An Anthology of Nilgiri Biosphere Reserve Proceedings. I have published two books on Asian elephants. As a PI and Co-PI I have completed 19 research projects so far.



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Occupation of Indian Giant Squirrel nests by White-rumped Vultures *Gyps bengalensis* in India

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Short Communication

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Abstract
This note reports a case of nest occupation of the Indian Giant Squirrel *Ratufa indica* by the White-rumped Vulture *Gyps bengalensis* in India.

For species nesting on cliffs, the availability of suitable nesting platforms is a severe limitation and hence there is considerable competition for these, both at inter- and intra-specific levels (Collias & Collias 1984). Here we describe the first cases of the nests of Indian Giant Squirrels *Ratufa indica* being taken over by pairs of White-rumped Vultures *Gyps bengalensis* in southern India.

Riparian areas constitute the most important habitat of the White-rumped Vulture, currently listed as critically endangered (BirdLife International 2001). Tall trees with large crowns and within continuous canopy are ideal for providing nesting and roosting sites (Ali & Ripley 1979; Ramakrishnan *et al*. 2014).

The Indian Giant Squirrel is a solitary species occurring in riparian areas as its most important habitat (Ramachandran 1988). Giant Squirrels are predominantly arboreal, thriving in high canopies, and also need tall trees for making their nests (or drays). Twigs and dry leaves are used in the construction of the shallow nests. The breeding season of the Giant Squirrel starts in October and ends in January. To reduce the risks of predation and infection of the nests by parasites or disease, the Giant Squirrels build several nests within their territories (Ramachandran 1988: Borges 1989). The breeding season of the White-rumped Vulture starts in September and ends in May. Nest construction peaks in September and October and the chicks fledge in April and May (Baral *et al*. 2007; Grubh 1984; Ramakrishnan *et al*. 2014).

During the period 2012 to 2015, we observed a total of four Indian Giant Squirrel nests that were occupied by pairs of White-rumped Vultures in the Jagulikadau area of the Sigur Range in Nilgiri North Forest Division, Nilgiri District, Tamil Nadu, Southern India. Two of the nests were in *Terminalia arjuna* trees (Fig. 1) and two were in *Ficus bengalensis* trees (Fig. 2). *Terminalia arjuna* and *Ficus bengalensis* are dominant tree species in riparian ecosystems in southern India. Among these four occupied nests, two nests contained chicks which fledged successfully; one in a *Terminalia arjuna* tree in 2012 and 2013, and one in a *Ficus bengalensis* tree in 2014 and 2015. Incubation was observed in the other two nests in the 2013 and 2014 breeding seasons but no chicks were reared.

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Fig. 1. Indian Giant Squirrel nest occupied by the White-rumped Vulture in a *Terminalia arjuna* tree; newly hatched nestling at nest.

Fig. 2. Indian Giant Squirrel nest occupied by the White-rumped Vulture in a *Ficus* tree; new born nestling at nest.

Cases of nest competition and occupation of the nests of other species have previously been reported in several cliff-nesting raptor species (Collias & Collias 1984; Newton 1979; Newton 1998). Especially in vultures nest occupation was observed in cliff nesting species to occupy other cliff nesting raptors nest (Fernandez & Donazar 1991; Margalida & Garcia 1999; Crowson & Kruger 2014). We have not come across such cases in the published literature. Therefore, the present observations suggest that this is most likely the first known case of this behaviour for the White-rumped Vulture.

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Population Status and Habitat Preference of Vultures in Mudumalai Tiger Reserve, Tamil Nadu, Southern India

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Abstract
Vultures are nature's most successful scavengers, and they provide an array of ecological, economic and cultural services. There are nine species of vulture found in the Indian sub-continent, four of which are found in the Mudumalai Tiger Reserve viz. Egyptian Vulture *Neophron percnopterus*, Red-headed Vulture *Sarcogyps calvus*, White-rumped Vulture *Gyps bengalensis* and Long-billed Vulture *Gyps indicus*. During this study, a total of 120 (Mean SE 2.92± 0.96) individuals of four vulture species and two old nests were recorded, with the White-rumped Vulture *G. bengalensis* (n=98, 3.5±1.39) being the dominant species. Among the vegetation, Thorn Forest (n=75, 4.41±2.27) attracted the greatest number of vultures. Apparently, Mudumalai Tiger Reserve still provides a sufficient number of wild ungulates as food for vultures.

1. Introduction

Vultures are nature's most successful scavengers and provide an array of ecological, economic and cultural services (Moleon *et al*. 2014). Nine species of vulture are found in the Indian sub-continent (Ali & Ripley 1987), five of which are found in southern India *viz.* Egyptian Vulture *Neophron percnopterus*, Red-headed Vulture *Sarcogyps calvus*, White-rumped Vulture *Gyps bengalensis*, Long-billed Vulture *Gyps indicus* and Cinereous Vulture *Aegypius monachus* (Davidar 2007; Davidar & Davidar 2002; Ramakrishnan *et al*. 2010, 2012 & 2014; Samson *et al*. 2014, 2015; Sashikumar 2001; Shivanan
d 2004; Subramanya & Naveen 2006).

The sudden decline of vultures in the Indian subcontinent in the last decade was attributed to disease, poisoning and reduction in food availability, although Diclofenac is now widely regarded as the principal cause in India (Green *et al*. 2004 & 2007; Prakash *et al*. 2003; Shultz *et al.* 2004; Ramakrishnan *et al*. 2010; Swan *et al*. 2006). In view of the sharp decline, three species of *Gyps* vulture, namely Long-billed Vulture, White-rumped Vulture and Slender-billed Vulture *G. tenuirostris*, are now considered to be Critically Endangered (BirdLife International 2000). The Indian Government has also listed these three species in 'Schedule-I', and they are protected by the Indian Wildlife (Protection) Act, 1972. The populations of Egyptian Vulture and Red-headed Vulture have also declined rapidly (Cuthbert *et al*. 2006). The status of the Red-headed Vulture has deteriorated from Near Threatened (Birdlife International 2004) to Critically Endangered (BirdLife International 2007a), and that of the Egyptian Vulture has changed from Least Concern to Endangered (BirdLife International 2007b). Apart from their own threatened status, vultures are ecologically

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important in human-dominated areas as scavengers at primitive slaughterhouses and carcass dumps (Satheesan 1989; Mundy *et al.* 1992), and in natural areas as scavengers on animal carcasses of large mammals killed by carnivores (Houston 1974; Hunter *et al.* 2007; Majumder *et al*. 2009).

The present study aimed to assess the population status and habitat preference of vulture species in the Mudumalai Tiger Reserve, Southern India.

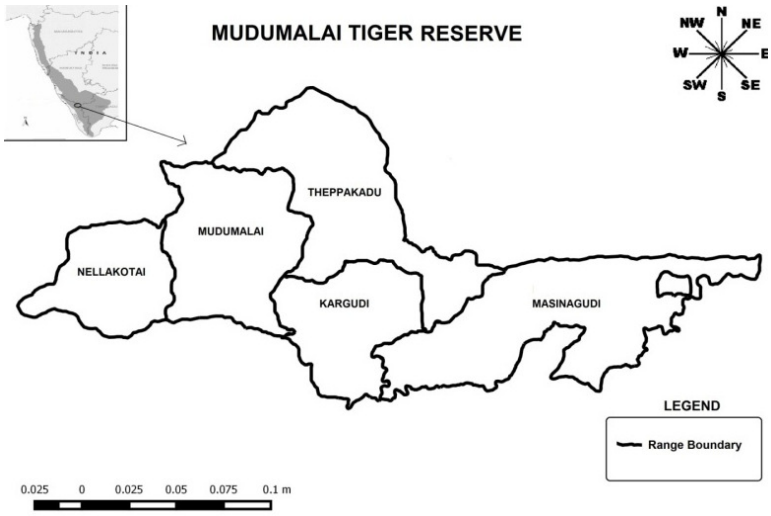

Fig. 1. Mudumalai Tiger Reserve with the range boundaries.

2. Materials and Methods

2.1. Study Area

Mudumalai Tiger Reserve (MTR) (11º32'–11º43'N, 76º22'–76º45'E) lies on the northern flank of the Nilgiri Mountain Range in the Western Ghats and is contiguous with Wayanad Wildlife Sanctuary (WWS) in the west, Bandipur Tiger Reserve (BTR) in the north and Nilgiri North Forest Division (NNFD) in the south. The MTR also forms part of the Nilgiri Biosphere Reserve (NBR). The area is renowned for its rich ecological diversity of flora and fauna. The total area of the MTR is 588.59 km^2 (core area 321 km^2). According to Champion & Seth (1968), the vegetation types in Mudumalai are classified into Southern Tropical Dry Thorn Forest, Southern Tropical Dry Deciduous Forest, Southern Tropical Moist Deciduous Forest, Southern Tropical Semi Evergreen forest, Moist Bamboo Brakes and Riparian Forest.

2.2. Methodology

In Mudumalai Tiger Reserve, vultures were counted on road transects; tarred roads and metal roads are maintained by the Tamil Nadu Forest Department to provide easy access to the villages in the protected areas of MTR. Five major types of habitat were chosen, namely Thorn Forest (TF), Dry Deciduous Forest (DDF), Moist Deciduous Forest (MDF), Riverine Forest (RF), and Semi-evergreen Forest (SF). Road transects were selected according to these habitat types. A total of 27 km of road transect were sampled on 10 occasions (n=270 km). The transects were driven between 08:00 and 17:00 local time at 20–30 km/h on 10 occasions from January to June in 2015. We also walked on elephant footpaths and alongside streams and rivers to search for vulture nests. When spotting vultures, the number of individuals, the activity of the birds and the major vegetation type in the surrounding area were noted. The geo-coordinates were recorded using a GPS handset for all vulture sightings during the survey period. These geo-coordinates were subsequently used for the preparation of maps using Quantum GIS Wien 2.8.2.

3. Results

A total of 120 individual vultures were recorded in Mudumalai Tiger Reserve in 41 sightings (Mean SE 2.92± 0.96), comprising four species *viz.* White-rumped (n=98, 3.5±1.39), Red-headed (n=14, 2.33±0.80), Egyptian (n=6, 1.25±0.25) and Long billed (n=2, 1±0) (Table 1). The maximum and minimum group size of each vulture species were as follows: White-rumped Vulture (max. 40, min. 1), Red-headed Vulture (max. 6, min. 1), Egyptian Vulture and Long-billed Vulture (max. 1, min.1). Two old and abandoned nesting areas were also identified.

Table 1. Counts of the four vulture species in MTR.

Vulture species	Total number of sightings	Total number of individuals sighted	Mean /SE
White-rumped Vulture *Gyps bengalensis*	28	98	3.5±1.39
Long-billed Vulture *Gyps indicus*	2	2	1±0
Red-headed Vulture *Sarcogyps calvus*	6	14	2.33±0.80
Egyptian Vulture *Neophron percnopterus*	5	6	1.25±0.25
Total	**41**	**120**	**2.92±0.96**

Table 2. Occurrence of the four vulture species in different vegetation types in MTR

Vegetation type	Total number of sightings	Total number of individuals sighted	Mean / SE
Thorn Forest	17	75	4.41±2.27
Dry Deciduous Forest	14	21	1.5±0.20
Moist Deciduous Forest	4	12	3±1.08
Riverine Forest	6	12	2±0.82
Semi-evergreen Forest	0	0	0
Total	**41**	**120**	

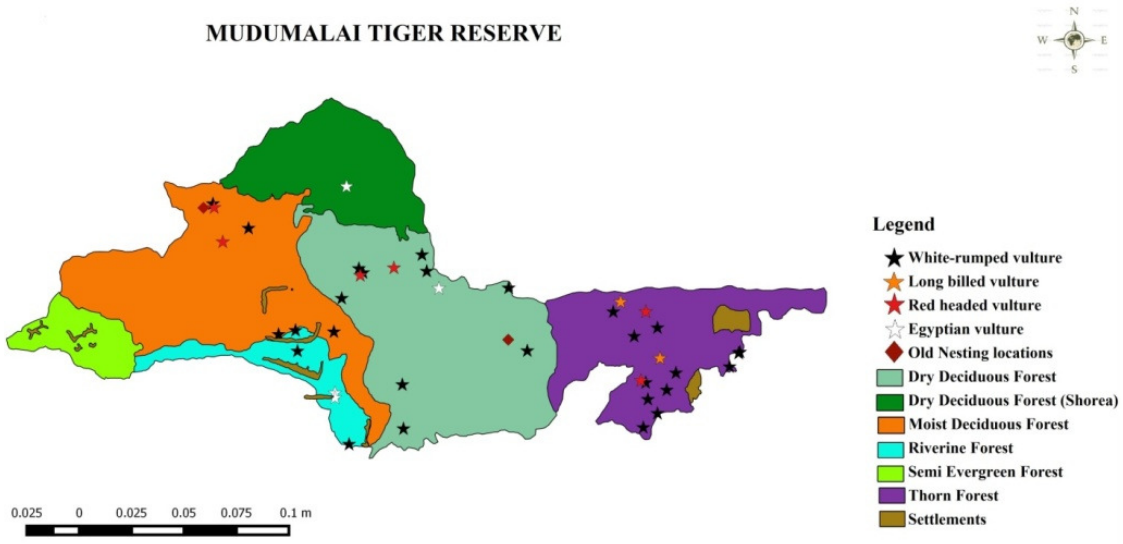

Fig. 2. Vulture sightings within different vegetation structures in Mudumalai Tiger Reserve.

As regards the occurrence of vultures within different vegetation structures in MTR, most vulture sightings were recorded in Thorn Forest (n=75 4.41±2.27), followed by Dry Deciduous Forest (n=21 1.5±0.20), Moist Deciduous Forest (n=12 3±1.08) and Riverine Forest (n=12 2±0.82) (Table 2). The maximum and minimum group sizes of vultures recorded in the different vegetation types were as follows: Thorn Forest (max. 40, min. 1), Moist Deciduous Forest and Riverine Forest (max. 6, min. 1), and Dry Deciduous Forest (max. 3, min. 1).

Fig. 3. White-rumped Vultures roosting on a dead tree in MTR.

4. Discussion

The distribution of vultures in MTR was scattered and it seems that the reserve was mostly used as a foraging site. Two old nesting areas were identified, but neither of these was currently being used by vultures. However, a few fresh nesting areas of vultures have been identified in areas adjoining MTR (Ramakrishnan *et al*. 2014; Samson *et al*. 2014). Earlier studies found only three species of vulture in MTR (Ramesh *et al*. 2011), but the Egyptian Vulture was also recorded in the present study. A similar study in Panna Tiger Reserve, Central India (Gurjar & Gawande 2011), found four species of vulture. These included the Himalayan Vulture *Gyps himalayensis*, but not the White-rumped Vulture.

A total of 14 individuals of the Red-headed Vulture were recorded during the present study. Six individuals were recorded in a single sighting, two individuals in three sightings and a single individual in two sightings. A similar finding was observed in the Sigur Plateau, an area adjoining MTR. Six Red headed Vultures were recorded at the carcass of a Spotted Deer killed by a tiger (Ramakrishnan *et al*. 2012). These observations suggest relationship between this predator and its prey in MTR. Red-headed Vultures are fresh carcass feeders in nature and the predator's presence indicates existence of their prey (Naoroji 2006; Chhangani 2007; Ramakrishnan *et al*. 2012).

Vultures were observed in all type of vegetation, but particularly Thorny Forest which attracted more vultures than other vegetation types (MDF, DDF, SF and RF). Vultures are aerial scavengers and will spot carcasses with their acute eyesight. Thus vegetation structure has an important influence on the vultures' ability to find carcasses. Brown (1985) established two hypotheses concerning vegetation structure and carcass finding by vulture species. In the first hypothesis, the increased vegetation density caused by bush encroachment decreases the likelihood of vultures locating a carcass, as they rely almost entirely on eyesight when foraging. In the second hypothesis, vultures, which are heavy birds adapted for soaring and unsuited for flapping flight in confined spaces, will not land at carcasses they have located if they do not have sufficient space in which to take off again. This hypothesis was supported by Schultz (2007), who showed that Cape Vultures *Gyps coprotheres* in the Waterberg region of Namibia were unable to locate carcasses when the vegetation density was greater than 2,600 trees per ha. Land-use patterns influence raptor diversity and density (Herremans & Herremans-Tonnoeyr 2000). However, vultures have the highest density at the interface between protected and non-protected areas (Herremans & Herremans-Tonnoeyr 2000). In the present study also, vultures were seen most frequently on the periphery of the sanctuary near human settlements (Fig. 2). According to Prakash *et al*. (2007), although thousands of vultures may remain in India, they are now spread very thinly across a huge area. This is a dangerous situation for such social birds, which build nests and roost communally and rely on information gained from one another when searching for widely dispersed food sources.

Conclusion

The present study shows that the vegetation types in Mudumalai Tiger Reserve provide a good foraging area for vultures. Removal of invasive alien species such as *Lantana camara* and *Eupotorium spp*. is urgently warranted to ensure that carcass finding is facilitated in forested areas, especially dry deciduous forest. It is recommended that regular monitoring of vultures in the study area to assess habitat utilization is crucial for the preparation of a management plan to conserve the vultures in the reserve. The largest numbers of vultures were observed near the human settlements in the reserve where there is a serious threat from the use of Diclofenac. The use of Diclofenac in the villages around the reserve should be monitored as it has caused large-scale mortality in vultures in other regions of the country. The use of Diclofenac has already caused a 97% decline in *Gyps* vulture populations in India, and now, when the vultures are so few in number, even if only 10–15 vultures are killed by deliberate poisoning of carcasses or transmission lines, this could have a great impact on the population. Therefore, there is an urgent need to raise awareness among the local people living in areas surrounding vulture habitat.

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Wild boar predation on White-rumped vulture fledgling

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Predation on fledgling of Old World vultures is scantily reported (Brown and Amadon 1968; Mundy 1982). Only few studies have been reported predation on fledglings by mammalian species (Rodriguez and Balcells 1968; Donazar and Ceballos 1988). In this note we report wild boar predation on the fledgling of White-rumped vulture. This observation was done at Sigur Plateau, Nilgiri hills of Tamil Nadu.

On 25 March 2016, while monitoring the White-rumped vulture fledglings on the nests, a fledgling's call was frequently observed, initially we associated the call with mother feeding the young one, after a few minutes the sound stopped abruptly. Soon after we went to the nesting tree to observe the fledglings on the nest. Suddenly we noticed four wild boars running away from the site. On further observation in the area we found that some feathers were spread around, and on intensive search we found remains the legs of White-rumped vulture fledgling (Fig 1).

Literature search showed four instances of mammals predating on vulture fledgling on the species of Egyptian vulture and African White-backed vulture (Stoyanova and Stefano 1933; Marlow 1983; Donazar and Ceballos 1988). The previous records shows only carnivores (Jackal, Red Fox, Wolves and Honey Badger) predating vultures but in this observation an omnivore is reported even though it is an opportunistic behaviour.

Fig 1. Uneaten leg remains of White-rumped vulture fledgling

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Letters to the Editor

Accidental death of a feeding vulture

On 09 November 2016, at 1030 hrs we observed a flock of 145 White-rumped Vultures *Gyps bengalensis,* eight Indian Vultures *G. indicus,* four Red-headed Vultures *Sarcogyps calvus,* and two Egyptian Vultures *Neophron percnopterus* feeding on a domestic buffalo carcass (a tiger's kill) on Sigur Plateau, Tamil Nadu. We noted the exact location of the carcass for future visits. When we re-visited the carcass at 1530 hrs, an adult White-rumped Vulture was found dead next to the carcass. Its head and upper neck seemed stuck inside the carcass. The vulture probably intended to feed on the visceral organs by inserting its head through the gaps in the vertebral column of the carcass, but its neck got inextricably stuck between two vertebrae, resulting in its death. Such unusual vulture deaths have been recorded in the past too (Allen 1920; Greenwood 1938).

This observation was carried out under a project supported by the Raptor Research and Conservation Foundation for which Tamil Nadu state forest department granted the necessary permissions, and we acknowledge with gratitude their respective roles. We extend our thanks to our field assistants. R. Bomman, K. Manigandan, and B. Vishnu.

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Editors' note: The picture that accompanied this note has not been printed, as it requires a strong stomach. Those interested in viewing it may contact the corresponding author directly.

House Sparrows *Passer domesticus* feeding on dressed meat

On 17 February 2017, at 1015 hrs, in the course of fieldwork we observed an unusual feeding behavior of the House Sparrow *Passer domesticus* in the meat market at Udhagamandalam, The Nilgiris. Both the parents of a family of sparrows were seen collecting **[70, 71]**, and subsequently feeding pieces of dressed mutton to their nestlings. The nest was built in the deploying nest box of the butcher's shop, and we observed three nestlings in it. The adult pair picked up at least 18 pieces of meat in the shop, and visited their nest 16 times to feed their young during the one hour (1015–1115 hrs) we could observe them. Though the species is primarily granivorous, it is known to be an opportunistic feeder and consumes whatever food is available (Gavett & Wakely 1986; Anderson 2006). Protein-rich food, like insects, is essential for the growth of their nestlings. Anderson (2006) mentions that House Sparrows take advantage of whatever foods are abundant when they are nesting, to feed their young. Red meat contains high levels of biological value protein, important micronutrients, and a range of fats (Williams *et al.* 2006), and hence might be an ideal replacement for the regular insect diet of sparrow chicks. Despite their well-known catholic taste, we thought this observation worthy of a formal record.

70. House sparrow male feeding on mutton pieces.

71. House sparrow female feeding on mutton pieces.

Pics: Karthick S.

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Scavenging Mode of Vertebrate Scavengers on Domestic Buffalos *Bubalus bubalis* (Linnaeus, 1785) Killed by Tiger *Panthera tigris* and Natural Deaths in Southern India

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Abstract
Scavengers such as vultures, eagles and wild boars play important ecological functions within their ecosystems. A total of 60 domestic buffalo carcasses (40 killed by tigers and 20 natural deaths) of the size of about 364 kg were recorded in forest areas in 2011 and 2015. We recorded 25 species of vertebrate fauna (19 bird and six mammal species) eating the carcasses. The presence of vertebrate scavengers was associated with five decomposition stages: initial, bloated, decay, post decay and dry. Our study provides evidence that domestic buffalo remains are routinely scavenged or visited by a broad range of avian and mammalian scavengers and decomposed by microbes. Vultures, one of the most versatile scavenging birds, were the only group of vertebrates observed during almost the entire process. Mammalian scavengers also play a significant role in carcass decomposition.

1. Introduction

Scavengers are defined by Campbell & Reece (2005) as animal species such as birds or insects which feed on dead or decaying matter. Active competition occurs between animal scavengers and carcass decomposers (Janzen 1977, Burkepile *et al.* 2006), scavengers may be the primary carcasses consumers (Putman 1983). Scavengers such as vultures, eagles and wild boars are playing important ecological functions within the ecosystem. Scavengers prevent the accumulation of dead biomass in the ecosystem, thereby contributing to the removal of waste, regulation of diseases and nutrient cycling (Margalida & Colomer 2012). Many studies have been conducted using bird and rodent carrion to monitor scavenger activities (De Vault *et al.* 2003) while only a few studies have utilized large vertebrate animals or gut piles (Wilmers *et al.* 2003; Roen & Yahner 2005; Selva *et al.* 2005). Therefore the present study aimed to document scavenging mode of vertebrate scavengers on domestic buffalos *Bubalus bubalis* (Linnaeus, 1785) killed by tiger *Panthera tigris* and natural deaths in southern India.

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2. Methodology

During 2011 and 2015, a total of 60 domestic buffalo carcasses in the weight size of approximately 364 kg were recorded in the Sigur Plateau of the Nilgiri Biosphere Reserve, Tamil Nadu, India. Forty of these 60 domestic buffalo carcasses were hunted by tigers and 20 were observed as naturally dead. With the aim of recording vertebrates feeding on these carcasses, we did regular monitoring survey for 24 hours/day, from the death moment until the skeletonization. We placed one camera at each of two sides of carcasses and one camera trap for the nocturnal animals. The carcasses monitoring was divided into five decomposition stages as described by the literature, viz. initial, bloated, decay, post decay and dry. The presence of scavengers was recorded based on these five stages (Caroline Demo *et al*. 2013).

3. Results and Discussion

A total of 25 species of vertebrates (19 bird and six mammal species) were recorded (Tables 1–2). The presence of vertebrate scavengers was associated with the five stages of decomposition: initial, bloated, decay, post

decay and dry (Table 1). Vultures, one of the most versatile scavenging birds, were the only vertebrates observed during the whole study. They are known to have a diet composed almost entirely of carcasses (Ruxton & Houston 2004). Nine species of vultures live in the wild in India (Ali & Reply 1987), six of which namely, White-rumped Vulture *Gyps bengalensis*, Long-billed Vulture *Gyps indicus*, Red-headed Vulture *Sarcogyps calvus*, Egyptian Vulture *Neophron percnopterus*, Himalayan Vulture *G. himalayensis* and Cinereous Vulture *Aegypius monachus* are found in Tamil Nadu of the Nilgiri Biosphere Reserve (NBR) (Ramakrishnan *et al.* 2010, 2012, 2014; Praveen *et al.* 2014; Samson *et al*. 2014a,b, 2015, 2016a,b, 2017). These birds are usually the first vertebrate scavenger to access carcasses (Ramakrishnan *et al*. 2012; Samson *et al.* 2014b) and can eat the meat in advanced stage of putrefaction. Among these vulture species, the White-rumpled Vulture visited the caracasses with higher number of individuals than other species. Buffelo has a bulk amount of flesh contents and vultures spent more than 4 to 5 days feeding each carass completely. Therefore, repeted counts per vist of caracss gave a total of 15,600 individuals recored during sightings of buffelo caracsses (average 78.5 per vist to each carcass) (Table 2).

The tiger is the top carnivore present in the forest ecosystem, because of its ability to hunt larger prey (Prater 2005). Karanth (2003) stated that tigers are very active to hunt in nocturnal sessions and buffalos are semi-nocturnal species. Therefore, it is easily accessible prey of tigers (*N*=24) in certain circumstances when some of the cattle holders allow their buffalos for browsing at night. Vultures are the largest scavenging birds in the world (Huston 1985). The tiger feeding mechanism was starting from the anus to the head while vultures prefer feeding on open carcasses (Karanth 2003). Therefore, vultures in this juncture wait for assessing those carcasses sufficiently open for feeding. Anatomically, tigers are very strong animal to rotate the carcass and facilitate consumption of the carcass by other scavenger vertebrates. Karanth (2003) stated that tigers initially consume 20–35 kg of the flesh from its previous meal and it will stay at rest for 1–7 days according to the prey size. Wild boars are opportunistic scavengers and compete with vultures on carcasses. In the present study, the entire buffalo carcass was fully fed by the wild boars in 20 cases. In four cases of fresh buffalo killed by tigers, wild dogs were recorded from the initial stages to consume the fresh flesh. Hyenas were recorded in six buffalo carcasses in the post decay periods. Basically, hyenas are the scavengers which eat up to the bone level of the carcasses (Prater 2005).

White-rumped and Long-billed Vultures were seen in four initial stages of carcass decay. The Red-headed Vulture was seen only at the initial and bloated stages of carcass decomposition, as it feeds on fresh carcass and plays an important role in opening fresh carcass because it has a strong bill used for tearing thick skin (Ramakrishnan *et al*. 2012; Samson *et al.* 2016). The Egyptian Vulture was also seen in the first two or three stages of the carcass decomposition. It consumes flesh to the bone (Boyan *et al*. 2012). The presence of the Tawny Eagle on the carcasses was recorded in the fresh stage of the carcass only at one case. Crows are common scavengers in the environment and their occurrence was recorded from the advance stage of decaying until the dry. Jones (2011) recorded that ravens are feeding on the carrion flesh, eggs and larva present on or inside the carrion. We also found that quite a few species of birds, neither predator not scavenger, were around putrefying carcasses to feed on maggots. Free-roaming stray dogs were also seen on carcasses at every stage until only dry bones were left. Dogs also take away the bones, particularly smaller ones, to eat during their leasure time. Some bones were recorded 1–2 km away from the carcass.

Table 1. Frequency of vertebrate species recorded in various decomposition stages of buffalo carcasses in Sigur Plateau. X= Efficient visiting, Y= Inefficient visiting.

Orders	Common Name	Species	Decomposition Stages				
			Initial	Bloated	Decay	Post decay	Dry
Accipitriformes	White-rumped Vulture	*Gyps bengalensis*	X	X	X	Y	
	Long-billed Vulture	*Gyps indicus*	X	X	X	Y	
	Red-headed Vulture	*Sarcogyps calvus*	X	Y			
	Egyptian Vulture	*Neophron percnopterus*			X	Y	
	Tawny Eagle	*Aquila rapax*	X				
Bucerotiformes	Common Hoopoe	*Upupa epops*		X	Y		
Passeriformes	Magpie Robin	*Copsychus saularis*		X	Y		
	Pied Bush Chat	*Saxicola caprata*		X	Y		
	Indian Robin	*Copsychus fulicatus*		X	Y		
	Red Vented Bulbul	*Pycnonotus cafer*		X	Y		
	House Sparrow	*Passer domesticus*		X	Y		
	Jungle Myna	*Acridotheres fuscus*		X	Y		
	Common Myna	*Acridotheres tristis*		X	Y		
	Brahminy Starling	*Sturnia pagodarum*		X	Y		
	Jungle Crow	*Corvus macorhynchos*		X	X	X	Y
	House crow	*Corvus splendens*		X	X	X	Y
Columbiformes	Eurasian Collard Dove	*Streptopelia decaocto*		X	Y		
	Laughing Dove	*Spilopelia senegalensis*		X	Y		
Galliformes	Grey Jungle Fowl	*Gallus gallus*		X	Y		
Artiodactyla	Wild Boar	*Sus scrofa*	X	X	X	X	X
Carnivora	Stray Dogs	*Canis lupus familiaris*			X	X	X
	Tiger	*Panthera tigris*	X				
	Wild Dog	*Cuon alpines*	X				
	Stripped Hyena	*Hyaena hyaena*			X	X	Y
Rodentia	Indian Porcupine	*Hystrix indica*				Y	X

Table 2. Density of vertebrate species recorded in the buffalo carcasses in Sigur Plateau.

Common name	Species	Mode of feeding behaviour	Feeding				
			N	Max.	Min.	Mean	Feeding parts
White-rumped Vulture	*Gyps bengalensis*	Scavenger	15,600	147	41	78.5	Flesh
Long-billed Vulture	*Gyps indicus*	Scavenger	726	13	2	6	Flesh
Red-headed Vulture	*Sarcogyps calvus*	Scavenger	386	7	1	4	Flesh
Egyptian Vulture	*Neophron percnopterus*	Scavenger	26	2	1	1.3	Flesh
Tawny Eagle	*Aquila rapax*	Scavenger	1	1	1	1	Flesh
Common Hoopoe	*Upupa epops*	Non Scavenger	59	2	1	0.98	Maggots
Magpie Robin	*Copsychus saularis*	Non Scavenger	83	4	1	1.38	Maggots
Pied Bush Chat	*Saxicola caprata*	Non Scavenger	38	4	2	0.63	Maggots
Indian Robin	*Copsychus fulicatus*	Non Scavenger	43	2	1	0.71	Maggots
Red-vented Bulbul	*Pycnonotus cafer*	Non Scavenger	1,236	25	6	20.6	Maggots
House Sparrow	*Passer domesticus*	Non Scavenger	189	8	2	3.15	Maggots
Jungle Myna	*Acridotheres fuscus*	Non Scavenger	28	3	1	0.46	Maggots
Common Myna	*Acridotheres tristis*	Non Scavenger	989	23	5	16.38	Maggots
Brahminy Starling	*Sturnia pagodarum*	Scavenger	127	4	1	2.11	Maggots
Jungle Crow	*Corvus macorhynchos*	Scavenger	586	18	2	9.76	Flesh
House crow	*Corvus splendens*	Non Scavenger	210	4	2	3.5	Flesh
Eurasian Collard Dove	*Streptopelia decaocto*	Non Scavenger	84	3	1	1.4	Maggots
Laughing Dove	*Spilopelia senegalensis*	Non Scavenger	69	2	1	1.15	Maggots
Grey Jungle Fowl	*Gallus gallus*	Non Scavenger	39	2	1	0.65	Maggots
Wild Boar	*Sus scrofa*	Scavenger	5,860	18	5	16.2	Flesh/ Bone
Stray Dogs	*Canis lupus familiaris*	Scavenger	617	8	2	2.57	Flesh/Bone
Tiger	*Panthera tigris*	Predator	68	2	1	1.7	Flesh
Wild Dog	*Cuon alpines*	Predator	16	16	16	16	Flesh
Stripped Hyena	*Hyaena hyaena*	Scavenger	6	2	1	0.01	Bone
Indian Porcupine	*Hystrix indica*	Scavenger	28	2	1	0.46	Bone

Our study provides evidence that domestic buffalo remains are routinely scavenged or visited by a broad range of avian and mammalian scavengers and decomposed by microbes. Vultures consume carcasses quickly, and their absence was related to notably slower decomposition period. The total number of facultative mammalian scavengers and the time they spent at carcasses were increased in the absence of vultures. Although changes in the composition and abundance of scavengers have been anticipated as an effect of the decline of top-level scavengers (Pain *et al.* 2003; Sekercioglu *et al.* 2004; Jones *et al.* 2007), changes in species composition may be determined by a number of factors, including competition between top-level scavengers, temporal availability of carcasses and the carcass origin (e.g. natural death, predator kill, or catch by hunter) (Wilmers *et al.* 2003; Selva & Fortuna 2007). It was found that mammalian scavengers also play a significant role in carcass decomposition. Butler & du Toit (2002) stated that mammalian scavengers may serve as functionally equivalent roles to vultures in terms of their ability to rapidly locate and consume carcasses at night.

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