Understanding the influence of tourism on behaviour and habitat use of Nilgiri tahr (*Nilgiritragus hylocrius* Ogilby, 1838) in Eravikulam National Park, Kerala

by

Aslam Mohammed
Enrolment no: 50BB22AF73006

Dissertation Thesis

Submitted to Academy of Scientific and Innovative Research

For the partial fulfilment for the degree

Master of Science
in
Wildlife Science

Under the supervision of

Dr. Ramesh Chinnasamy - Scientist E

Dr. K Ramesh – Scientist F

Dr Karunakaran P V -Senior Principal Scientist

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

AcSIR

June 2024

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

DECLARATION

I hereby declare that the work conducted under the thesis entitled **"Understanding the influence of tourism on behaviour and habitat use of Nilgiri tahr (*Nilgiritragus hylocrius* Ogilby, 1838) in Eravikulam National Park, Kerala"**, is a record of original and independent research work done by me and subsequently submitted for the award of the degree of **Master's in Wildlife Science** at the **Academy of Scientific and Innovative Research**. This research work has been carried out under the guidance and supervision of **Dr. Ramesh Chinnasamy - Scientist E of Wildlife Institute of India**, and co-supervision of **Dr. K Ramesh – Scientist F of Wildlife Institute of India**, Dehradun and **Dr Karunakaran P V -Senior Principal Scientist of SACON**. The work has not formed the basis for the award of any other degree, diploma, or any other qualification. I also declare that the thesis embodies my own work, analysis, observation, understanding and the particulars given in it are true to the best of my knowledge.

(Aslam Mohammed)
Enrolment No:50BB22A73006
Place: Dehradun
Date: 30/6/2024

(Dr. Ramesh Chinnasamy)
Supervisor

(Dr K Ramesh) **(Dr Karunakaran P V)**
Co-supervisor

पत्रपेटी सं. 18, चन्द्रबनी, देहरादून-248001, उत्तराखण्ड, भारत
Post Box No. 18, Chandrabani, Dehradun-248001, Uttarakhand, INDIA
ई.पी.ए.बी.एक्स. :+91-135-2640111 से 2640115, फैक्स :0135-2640117
EPABX : +91-135-2640111 to 2640115, Fax : 0135-2640117
ई–मेल/E-mail : wii@wii.gov.in, वेब/website : www.wii.gov.in

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

CERTIFICATE

This is to certify that the thesis by **Aslam Mohammed** entitled "**Understanding the influence of tourism on behaviour and habitat use of Nilgiri tahr (*Nilgiritragus hylocrius* Ogilby, 1838) in Eravikulam National Park, Kerala"** is an original and independent research work submitted to the **Academy of Scientific and Innovative Research**, for the award of the degree of **Master's in Wildlife Science**.

Aslam Mohammed has put one semester of research work embodied in this thesis under my guidance and supervision. The work presented in this thesis has not been submitted to any other University or Institute for the award of any degree, diploma or distinction.

(Dr. Ramesh Chinnasamy)
Supervisor

(Dr. Ruchi Badola)
Dean
Faculty of Wildlife Science

पत्रपेटी सं. 18, चन्द्रबनी, देहरादून-248001, उत्तराखण्ड, भारत
Post Box No. 18, Chandrabani, Dehradun-248001, Uttarakhand, INDIA
ई.पी.ए.बी.एक्स. :+91-135-2640111 से 2640115, फैक्स :0135-2640117
EPABX : +91-135-2640111 to 2640115, Fax : 0135-2640117
ई–मेल/E-mail : wii@wii.gov.in, वेब/website : www.wii.gov.in

CERTIFICATE OF PLAGIARISM CHECK

It is certified that the Master's dissertation thesis titled **"Understanding the influence of tourism on behaviour and habitat use of Nilgiri tahr (*Nilgiritragus hylocrius* Ogilby, 1838) in Eravikulam National Park, Kerala"** submitted by **Aslam Mohammed** has been examined by us for plagiarism check as per UGC (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulations. The following inferences are drawn from this check:

a) Thesis has significant new work/knowledge as compared to already published work or work under consideration for publication elsewhere.
b) No sentence, equation, diagram, table, paragraph or section is found to have been copied verbatim from previous work unless it was placed under quotation marks and the source was duly cited.
c) The work presented is original work of the author (i.e. there is no plagiarism) and there is no fabrication of data or result by manipulating research materials, equipment or processes, or by changing or by omitting data or results such that the research is not accurately represented.

The similarity indices for the individual chapters as reported by the software DRILLBIT are as follows:

S. No	Chapter	iThenticate® similarity index
1.	Introduction	10%
2.	Chapter 2	6%
3.	Chapter 3	1%
4.	Chapter 4	2%
Overall		**8%**

Dr. Manohar Pathak
Librarian

Dr. Ramesh Chinnasamy
Supervisor

ACKNOWLEDGEMENT

First and foremost, I want to convey my gratitude to my supervisors Dr. C Ramesh, Dr K Ramesh and Dr Karunakaran P V without whose support, guidance and encouragement this master's dissertation would not have been possible. Their feed backs, corrections and most importantly their trust and faith in me helped me immensely in building up the confidence to work efficiently on this project. I also want to thank Kerala Forest department, Wildlife Warden Vinod SV, Range Officer Nidhin Lal, Wildlife Assistant Ajeesh and all staffs of Eravikulam National Park, Kerala.

The life in wildlife institute became a joy because of my wonderful batch mates I want to thank all of you especially Abhi muth, Krisha, Charuthaa, Sanju, Nandi, Niyaz, Mukul, Davi, Adi bro, Arnab, Rakshith, Rishi and Shashank. Thank you to being in my life and giving me some amazing memories. I have enjoyed every moment with you guys and leaving all of you is the saddest part of finishing the MSc.

Any acknowledgement won't be complete without thanking our dear course director Dr Navendu. You are definition of joy and peace. I do miss you and thanks for everything you have done for us. I also want to thank Wildlife Institute of India (WII) for providing the opportunity to pursue this Master's degree and for showering the best experience any wildlife student could dream of.

Finally, I would like to thank Dr. Qamar Qureshi, Dr Parag Nigam, Dr S P Goyal, Dr Samrat Mondol and Dr Salvador for hearing my ideas, answering my queries and supporting me when I felt low. Thanks to all other faculties whom I have missed but you all will be there in my heart always.

CONTENTS

CERTIFACTE

ACKNOWLEDGEMENTS ……1

LIST OF TABLES…….…… 4

LIST OF FIGURES……..…….. 5

SUMMARY……...…..…… 7

INTRODUCTION.....9

1.1 Overview 9

1.2 Literature review.....10

1.2.1 The Nilgiri tahr (*Nilgiritragus hylocrius* Ogilby, 1838) 10

1.2.1.1 Taxonomy and Nomenclature 10

1.2.1.2 Physical appearance.....13

1.2.1.3 Population and Distribution.....16

1.2.1.4 Habitat 17

1.2.1.5 Diet 18

1.2.1.6 Social organisation 19

1.2.1.7 Behaviour and activity pattern 20

1.2.1.8 Threat.....20

1.2.2 Nilgiri tahr and tourism 22

1.2.2.1 tahr in captivity 22

1.2.2.2 Eravikulam National Park, Kerala 24

1.2.3 Influence of tourism on wildlife 25

1.2.4 Habituation.....26

1.2.5 Human Shield Hypothesis 27

1.2.6 Purpose of this study.....27

1.3 Aim 28

1.3.1 Objectives.....28

1.3.2 Research Question.....28

2. STUDY AREA 29

3. METHOD 35

3.1 Habitat use.....35

3.2 Behaviour pattern 36

3.3 Flight distance 37

3.4 Predator Presence 37
3.5 Analysis 38
4. RESULT **39**
4.1. Tourism area behaviour 39
4.1.1. Across tourism seasons 41
2. Behaviour in Core area 42
4.3. Activity pattern 43
4.4. Flight distance 46
4.5. Habitat use 47
4.5.1 Tourism area 47
4.5.2 Roadside behaviour 51
4.5.3 Habitat Use core area 53
4.4. Predator presence 56
5. DISCUSSION **60**
5.1. General behaviour observed in tourism zone 60
5.2. Group composition in tourism area 60
5.3. Group size and composition in core area 61
5.4. Human-tahr interaction in tourism zone 62
5.5. Food provisioning 63
5.6 Difference in behaviour within tourism area across tourism seasons 65
5.7. Difference in behaviour between tourism and core area 65
5.7.1. Flight distance 65
5.7.2. Activity pattern 66
5.8. Habitat use by tahr 67
5.9 Predator presence and Human shield hypothesis 68
6. CONCLUSION AND RECOMMENDATION **70**
APPENDIX I **72**
REFERENCE **73**

LIST OF TABLES

Table 1 Taxonomic classification of Nilgiri tahr 11

Table 2 Nilgiri tahr population count in ENP (source ENP Management Plan 2022-2032) 17

Table 3 Scan sampling observation across tourism core and tourism adjacent areas 39

Table 4 Behaviour frequency of different age sex class in tourism area 39

Table 5 Behavior occurrences in tourism area across tourism seasons 41

Table 6 Behavior percentage observed across tourism season 41

Table 7 G-Test result on comparing the behaviour across season 42

Table 8 Behaviour frequency of different age sex class observed in core zone 42

Table 9 Behaviour according to time of day observed in core area 44

Table 10 Behaviour according to time of day observed in tourism area **45**

Table 11 Result from TukeyHSD test showing significance in the flight distance **47**

Table 12 Behaviour across different habitat types in tourism area……..47

Table 13 Relationship between feeding and different habitat type in tourism area using……....49

Table 14 Activity in different habitats with respect to time of the day……...50

Table 15 Behaviour in different habitat types in core area…….52

Table 16 Relationship between feeding and habitat use in core area…….53

Table 17 Relationship between resting and habitat use in core area……..55

Table 18 Relationship between standing and observing and habitat use in core area…….55

Table 19 Relationship between Travelling and habitat use in core area……55

Table 20 Habitat use in core are with hour of the day…….56

Table 21 Behaviour and habitat use relation in core area **71**

Table 22 Table 13 Behaviour and habitat use relation in tourism area **71**

LIST OF FIGURES

Figure 1 Dendrogram of Nilgiri tahr Nilgiritragus hylocrius.....13

Figure 2 Age sex classes of Adult Nilgiri tahr…..……..…….……15

Figure 3 Horn and facial stripe in adult male……..……15

Figure 4 Bachelor Herd 19

Figure 5 Picture of Nilgiri tahr is San Diego Zoo Safari Park,USA.....24

Figure 6 Eravikulam National Park board 29

Figure 7 Study area map of Eravikulam National Park 30

Figure 8 Tourism road – 1km road from the Cafeteria till the end point.....32

Figure 9 Study area in Core zone near Varattukulam camp site 32

Figure 10 Some endemic birds seen in Eravikulam National Park.....33

Figure 11 Mammals of Eravikulam National Park 34

Figure 12 Percentage of age sex class observation in tourism area.....40

Figure 13 Percentage of behaviour observed in tourism area 40

Figure 14 Proportion of Behavior across tourism season.....41

Figure 15 Percentage of Behaviour observed in core area 42

Figure 16 Activity pattern of core area 44

Figure 17 Activity pattern of tourism area…….……..45

Figure 18 Flight distance of tahr group in different area……...46

Figure 19 Number of observations form each habitat type in tourism area…….……48

Figure 20 Percentage of behaviour in different habitat in tourism area…….……..48

Figure 21 Percentage of habitat used for each behaviour in tourism area…….……..49

Figure 22 Percentage of activity in habitat across time of the day in tourism area…..…50

Figure 23 Behaviour proportion in each habitat types in tourism area across tourism season…….…….51

Figure 24 Nilgiri tahr adult female and young one in tourism road……51

Figure 25 Behavior observed in roadside……...52

Figure 26 Proportion of behaviour in tourism road across tourism seasons……..52

Figure 27 Habitat use in core area……..53

Figure 28 Percentage of behaviour at each habitat type in core area……..…54

Figure 29 Percentage of habitat used for each behaviour in core area……...….56

Figure 30 T1 - Resident with most number of images ……..57

Figure 31 Predators present is tourism area…….....….58

Figure 32Predators present is core area……...…59

Figure 33 Tahr spending their initial hours of the day in rock after reaching tourism zone…….60

Figure 34 Young ones observing tourists from above……....61

Figure 35 Tourists interaction with the tahr……...62

Figure 36- Food provisioning in cafeteria where tahr feeds on paper, food waste and at times plastic…….…63

Figure 37- Tahr licking the walls of washroom……..64

Figure 38- Bachelor herd feeding in Range office……...……...64

Figure 39 Tahr behaviour in burnt habitat in tourism area……...65

SUMMARY

Eravikulam National Park is the home for the largest number of Endangered Nilgiri tahr in the world (Predit et al, 2015; Saju,2012) and the park is also having an ecotourism programme dedicated for observing tahr at closer distance (Saju,2012). This population in the tourism area have high human interaction and have become habituated to the presence of humans. Habituation is known to influence the wild behaviour and instincts of animals (Shackley,1996; Knight,2009; Mazur, 2006; Marler & Hamilton,1966; Hingham & Shelton,2011) and this study was intended to understand the influence of tourism on the behaviour and habitat use of Nilgiri tahr in the Eravikulam National Park.

The field work was carried out for four months from January 2024 to April 2024, of which tourism was closed during the months of February and March, creating three sampling seasons: preclosing, closing and reopening season with varying human presence. Scan sampling and focal sampling (Altman, 1974) were carried out and observations of the population in tourism area were compared to the populations in Varattukulam region of core area which have minimum human interaction.

The result showed a significant difference in the behaviour and habitat use between tourism and core area and also across tourism season. The activity pattern in the tourism zone is different from that of the core. Habitat use was also different as most of the behaviour in tourism area were not showing any significant relationship with a particular habitat unlike the population in core area. The flight distance in tourism area was also found to be very much shorter (1.8m) in compared to core area(118m) which is evidence for the extend of habituation tahr has gone through. Interestingly, the tourism adjacent hills which belonged to the same landscape as that of the tourism zone showed higher flight distance.

The tourism zone also had high density of predators (Tiger and leopard) and there was spatial overlap between tahr and predators. Study was not able to prove the existence of human shield hypothesis (HSH) (Berger, 2007) as large carnivores were still present in the tourism area and even when tourism was closed, which reduced the number of people on the road, tahr were still coming to tourism area. However, tahrs were observed to be avoiding the carnivore by temporal separation as all camera trapping of predators happened during night time but no tahr was active at that time in tourism road.

INTRODUCTION

1.1 Overview

Nilgiri tahr (*Nilgiritragus hylocrius)* is the only wild mountain ungulate in Peninsular India and is endemic to the high elevation shola grassland habitat in the Western Ghats (Davidar,1963; Schaller, 1977; Lydekker,1898; Rice,1984). They are highly adapted to live in rugged terrain and steep cliff and they are considered a key stone species of the shola habitat (Lydekker,1898; Rice,1984). They were previously recorded throughout Western Ghats but habitat loss and hunting reduced its population (Davidar,1963; Schaller, 1977; Davidar, 1978). Currently Nilgiri tahr is listed as Endangered in the IUCN Red List of Threatened Species due to its restricted geographical distribution and declining population (Alempath & Rice, 2008) and is protected under Schedule I of the Wildlife (Protection) Act of India, 1972. Over the past few years, conservations initiatives have helped in increasing their numbers at least in the protected areas. However, the increase in urbanisation, habitat alteration, climate change and higher human wildlife interaction could affect their population, survival and behaviour (Predit et al, 2015; Sony et al, 2018;).

Another factor, often an ignored one, which could influence the behaviour and survival of tahr is the tourism which increases the Human-tahr interactions. Eravikulam National Park in Kerala, which is also having the largest population of Nilgiri tahr, is the only protected area having a tourism program dedicated for Nilgiri tahr which provides an opportunity to see them at a very close distance to the visitors (Saju, 2012). The tourism helps in generating revenue for conservation of species and habitat as well as provide employment for the tribal community in the national park (Saju, 2012). However, the influence of tourism on the behaviour and habitat use of Nilgiri tahr has not been studied or documented.

The aim of this study is to understand the influence of tourism on the behaviour and habitat use of Nilgiri tahr across tourism and non-tourism seasons in Eravikulam National Park, Kerala.

1.2 Literature review

1.2.1 The Nilgiri tahr (*Nilgiritragus hylocrius* Ogilby, 1838)

1.2.1.1 Taxonomy and Nomenclature

Nilgiri tahr is an even toed ungulate belonging to the family Bovidae and Subfamily Caprinae. The name "tahr" is an anglicized form of the Nepal term for Serow, *Capricornis sumatraensis thar* which was at times confused with Himalayan tahr when seen from a distance (Green, 1978). Nilgiri hills are part of the southern western ghats spread across the states of Kerala, Tamil Nadu and Karnataka and the mountain ungulate in this habitat was named Nilgiri tahr. "Nilgiri wild goat" and "Nilgiri ibex" were also names previously used by English sportsmen, local people and few authors (Blandford, 1888; Lydekker, 1898; Thyagarajan, 1958; Jerdon 1984).

Nilgiri tahr was first described by Ogilby from a skin he exhibited at Zoological Society of London on August 8th 1837 and he included it in newly formed genus Kemas as *Kemas hylocrius* where Greek word "*hyla"* means jungle and "*krios*" means ram, as the animal was known to Madras and Bombay sportsmen by the name "Jungle Sheep" (Ogilby, 1838). In 1842 they were included in genus Capra by Gray as *Capra warrayato* but in 1852 he reassigned it to genus *Kemas* as *Kemas warrayato* (Lydekker, 1913). The name *warrayato* was from their local Tamil name "*Varai Aadu*" meaning "cliff goat". Other common names include *Mala Aadu* in Malayalam and *Kaad Aadu* in Kannada/Canarese.

In 1841, Hodgson created the genus *Hemitragus* for the Himalayan tahr and in 1859 Blyth included Nilgiri tahr in this genus along with Himalayan tahr (*Hemitragus jemlahicus*)

and Arabian tahr (*Hemitragus jayakari)* and named it *Hemitragus hylocrius* (Lydekker, 1913). Heinemann and later Haltenorth had listed all the three tahrs as subspecies of *H.jemlahicus* (Haltenorth, 1963; Heinemann, 1968). Study by Benirschke and Kumamoto found that Nilgiri tahrs have 58 chromosomes with only one pair of metacentric chromosome and sub acrocentric Y chromosome whereas Himalayan tahr have 48 chromosomes with six pairs of submetacentric autosomes and a minute metacentric Y chromosome and hence disregards the idea of all three tahrs being subspecies (Benirschke & Kumamoto, 1980). The karyotype display of Nilgiri tahr was also found to be very similar to that of Urial *Ovis orientalis* and of Barbary sheep *Ammotragus lervia* (Benirschke & Kumamoto, 1980). Additionally, the horns in males of *H. hylocrius* and *Ovis* does not have a prominent keel in front, and are marked by deep transverse wrinkles, unlike the horns of the two other species of tahr (Ropiquet & Hassanin, 2005). After the molecular study by Ropiquet and Hassanin found that Nilgiri tahr is a sister group of *Ovis* (sheep) whereas Himalayan tahr is assigned with *Capra* (goat) and Arabian tahr allied with *Ammotragus* (aoudad), Nilgiri tahr is currently included in a monospecific genus *Nilgiritragu*s (from "Nilgiri hills" in southern western ghats and Greek word for he-goat "*tragos"*) as *Nilgiritragus hylocrius* (Ropiquet & Hassanin, 2005) and this name continues till date.

Table 1 Taxonomic classification of Nilgiri tahr

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Artiodactyla
Suborder	Ruminantia
Family	Bovidae
Subfamily	Caprinae
Tribe	Caprini
Genus	*Nilgiritragus*
Species	*Hylocrius*

Schaller suggests that the ancestors of cliff dwelling Nilgiri tahr must have lived in relatively flat terrain during part of their history for they could not have reached southern India without crossing at least 300 km of Indus or Gangetic plains (Schaller, 1977). Prater mentions that their isolated distribution far south from the usual range of wild goats indicates the existence of temperature conditions during some previous epoch which could enable tahr to inhabit the area lying between the Himalayas and their present-day refuge temperate levels of south Indian hill ranges (Prater, 1987).

The molecular estimations of divergence times by Ropiquet and Hassanin indicate that the *Hemitragus hylocrius* and *Ovis* diverged in the Pliocene epoch around 2.7-5.2Mya in Central Asia and/or India (whereas *H. jayakari* and Ammotragus at around 4-7 Mya in North Africa and/or Arabia and *H. jemlahicus* and the various species of Capra at around 2.8-5.3 Mya probably in Central Asia) and this period was the onset of Northern Hemisphere glaciations, which resulted in a global change toward cooler, drier, and more variable climates (Peizhen et al., 2001) where the food resources availability became more seasonal which may have modified and diversified the feeding behaviour and pattern of aggregation of caprines (Ropiquet & Hassanin, 2005). This was also an intense period of diversification for sexually dimorphic characters such as horn size, horn shape, body size, and pelage (Ropiquet & Hassanin, 2005). Interestingly, there is also mention of an extinct species belonging to Hemitragus, *Hemitragus sivalensis* in Shivalik present during Pliocene (Blandford 1888).

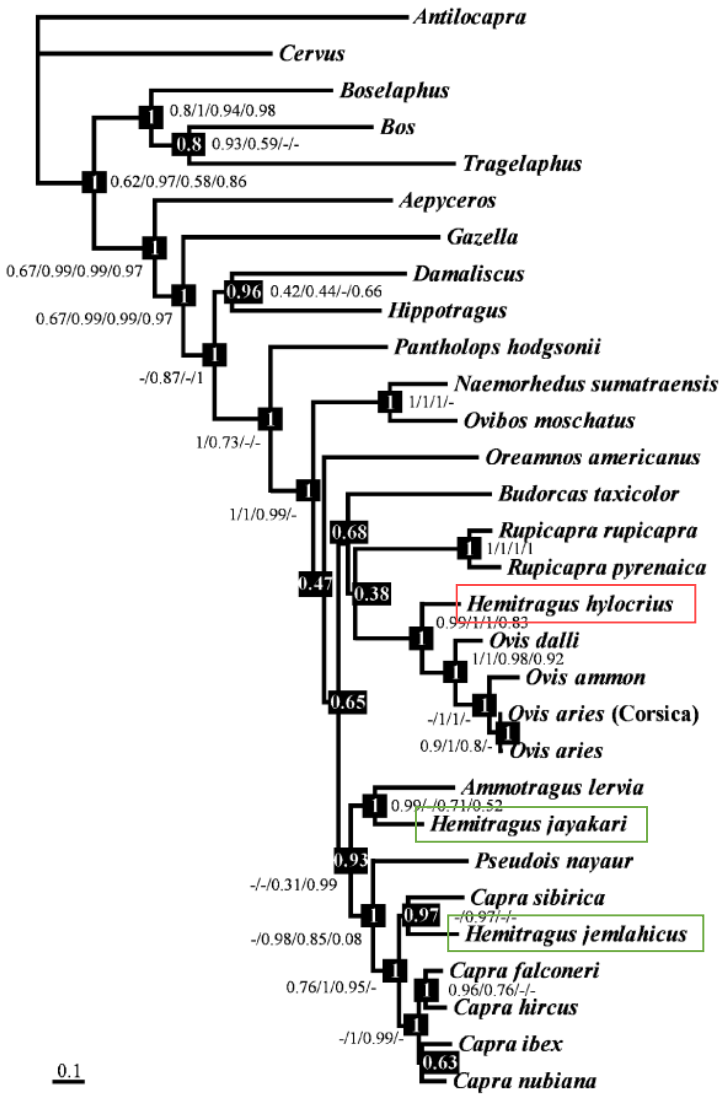

Figure 1 Dendrogram (Phylogenetic tree) of Nilgiri tahr *Nilgiritragus hylocrius* (old name *Hemitragus hylocrius*). Bayesian tree derived from the combined analysis of the four markers. (Source: Ropiquet and Hassanin, 2005)

1.2.1.2 Physical appearance

Genus Hemitragus is characterised by long and narrow skull and differ from Capra by having smaller horns where the male horns are not very much larger than that of females and the absence of beard and suborbital, inguinal or interdigital glands (Blandford, 1888-91, Lydekker, 1898). However, Nilgiri tahr has only a single pair of teats or mammae whereas Himalayan tahr and Arabian tahr have 2 pairs (Blandford, 1888-1891; Prater 1971; Rice, 1984).

Nilgiri tahr is slightly larger than Himalayan tahr standing to 39 to 42 in or 100 to 120 cm at shoulder (Blandford, 1888-1891; Lydekker,1917; Prater, 1971; Jerdon, 1984). They have short, thick, coarse, dark yellowish-brown hairs with paler underside and darker mid dorsal stripe which is more prominent in males (Blandford, 1888-1891; Lydekker,1917; Prater, 1971; Jerdon, 1984). Their legs are grizzled with white and are dark brown in front and paler in the rear with a black spot above the knees called carpal patch and a callous spot on the knee surrounded by fringe of hairs (Rice,1984; Jerdon,1984; Menon, 2023). They also have and buff patch around eyes and muzzle (Blandford, 1888-1891; Lydekker,1917; Prater 1971; Jerdon, 1984; Rice,1984).

Males are generally heavier and stockier than females and with age males get very deep brown, almost black with distinctively light or white saddle-shaped patch on the loins/ lumbar region which gives adult males their name “saddle backs” (Blandford, 1888-1891; Prater 1971; Rice 1984). Adult males also have distinct white facial stripes dropping from forehead towards the corner of the mouth anterior to eyes and have white carpal patch above the knee (Rice, 1984)

Nilgiri tahr horns almost contact in base, rise parallel for some length, then diverge and curve downwards with deep wrinkles and are covered with numerous fine crenulations (Blandford, 1888-1891; Prater, 1971; Rice 1984). Horns are nearly flat inner surface but rounder or convex outer surface and unlike Himalayan tahr it lacks the knotted keel (Prater 1971). The horns of adult male are heavier and slightly longer than that of females, reaching up to 16 inches for bucks and 11 inches for does and the largest horn recorded is of 17 inch long and 9 ¾ in girth (Blandord,1888-1891; Prater 1971; Rice 1984).

Fig 2 (d) Adult female with young one

Fig 2 (d) Light brown male (penis sheath visible)

Fig 2 (c) Saddleback (white colour in lumbar region)

Fig 2 (d) Dark brown male (note white carpal patch in for leg knee)

Figure 2 Age sex classes of adult Nilgiri tahr

Fig 3 (a) stouter and longer horn compared to female

Fig 3 (b) Horns very close at base

Figure 3 Horn and facial stripe in adult male (a) Saddleback and (b) Dark brown male

1.2.1.3 Population and Distribution

When most Caprini occupies temperate latitudes, with the exception of Arabian tahr (in UAE and Oman) and Abyssinian ibex (in northern Ethiopia), Nilgiri tahr inhabits the southern Western Ghats making them world's most equatorial wild Caprinae member (Lydekker,1898; Rice,1984). Historically distributed throughout the Western Ghats, Nilgiri tahr is currently restricted to few pockets of southern Western Ghats along a stretch of 400 km between 11°30'N and 8°20'N between Nilgiris in the North and Kanyakumari Hills in the south, across an elevational gradient of 900m to 2600m (Predit et al, 2015, Pandav et al, 2017). Some of the earliest survey of Nilgiri tahr population was carried out by Davidar (1963;1971;1978) and Schaller (1977). Population estimation by Davidar in 1978 estimated the population of Nilgiri tahr to be 2230. However, he also mentions about losing of population many areas due to poaching (Davidar, 1963).

As per 2015 study of WWF by Predit et al, total population size of Nilgiri tahr in the wild is 3122 and Eravikulam National Park with more than 700 individuals have the largest population of Nilgiri tahr (Predit et al 2015). Large population of more than 300 individuals were found in, Anamalai Tiger reserve and Mukurti National Park whereas population of more than 150 individuals were found in Kanyakumari Wildlife Sanctuary, Theni Forest division, Munnar forest division and Srivilaputhur Grizzled Giant Squirrel Sanctuary. Small population of less than 100 individuals were recorded form Palghat forest division, Tirunelveli Forest Division, Kalakkad-Mundathurai Tiger Reserve, Neyyar Wildlife Sanctuary and Parambikulam Tiger Reserve had and very small populations of less than 50 individuals were recorded from Ranni Forest Division, Chinnar Wildlife Sanctuary, Kodaikanal Forest division, Silent valley National Park, Periyar Tiger reserve, Vazhachal and Coimbatore Forest division (Predit et al, 2015).

Eravikulam national park conducts bounded count or block count population estimation, proposed by Reger and Robson (1966), every year towards the last week of April. The latest estimation of Nilgiri tahr population in ENP has recorded an increase in tahr population to 827 tahr including 144 young ones in 2024, compared to 803 tahrs with 128 calves in 2023.

Table 2 Nilgiri tahr population count in ENP (source ENP Management Plan 2022-2032)

SL.NO	YEAR	POPULATION
1	2012	789
2	2013	873
3	2014	894
4	2015	900
5	2016	664
6	2017	575
7	2018	643
8	2019	523
9	2020	723
10	2021	782

1.2.1.4 Habitat

Grass covered hills intermixed with stunned evergreen forest and rocky outcrops adjacent to granite cliffs is considered the preferred habitat for Nilgiri tahr (Schaller, 1977; Davidar,1978). Generally, tahr avoid entering woods (Blandford, 1888-91),

Study by KFRI found that the density of animal was found to be significantly higher in the blocks where the extent of cliff was more which indicates that tahr prefers habitat with sufficient extent of cliff for protecting themselves from the predators (Easa & Sivaram,2002). Habitat use study by Pandiyan suggests that Nilgiri tahrs were using undisturbed habitats for both foraging and resting, whereas the disturbed areas which had presence of predators like tiger, leopard or wild dogs were cautiously used by the animal for foraging (Pandiyan, 2018). Increase in the altitude and the availability of *Chrysopogon zeylanicus* and *Eulalia phaeothrix* has a positive relation with the density. (Easa and Sivaram,2002).

They are also known to have sexual segregation where males occupy open, forage rich plateau which improves their body condition after rutting whereas females prefer to stay near cliffs which provides an escape terrain and did not graze in the open (Madhusudan, 1998). Their habitat is covered with thick blanket of mist during most part of the year and hence they have highly developed sense of smell in addition to keen sight that is better than many herbivores (Davidar,1978).

1.2.1.5 Diet

They are primarily grazers but occasionally feed on forbs and shrubs (Davidar,1978; Rice, 1984). Study conducted in 2002 by KFRI in Eravikulam National Park observed tahrs feeding on 19 species of grasses, 12 species of herbs, three shrubs, licking one species of lichen (*Parmotrema grayanum*) and eating fresh shoots of the dwarf bamboo *Sinarundinara densifolia* and *S. walkariana* (Easa and Sivaram, 2002). In this study, *Chrysopogon zeylanicus* was found to be the major food species followed by *Eulalia phaeothrix, Arundinella ciliata, Sehima nervosum and Ischaemum indicum*.

According to Rice (1984) tahr in Eravikulam prefers the inflorescence of certain species like *Hypericum mysorense, Pedicularis perrotettii, Crotalaria clarkii, Anaphalis bournii, Anaphalis lawii* and *Eriocaulon brownianum* and also shows particular preference for some parts of certain plants like eating only inflorescence of *Anaphalis lawii* and only tender leaves of *Gaultheria fragrentissima* (Rice, 1984; Easa & Sivaram, 2002).

Cyanotis arachnoides, C. pylosa, Hedyotis anamalayana and *H.swertiodes* are the major herb species fed by tahr along with exotic weed *Ageratina adenophora* (Easa & Sivaram, 2002) Fresh leaves of endemic *Strobilanthes. kunthiana* are also eaten by tahr (Easa & Sivaram, 2002). Water requirement of tahr is found to be minimal compared to other wild ungulates (Davidar, 1978)

1.2.1.6 Social organisation

Like other caprinae, Nilgiri tahr associate in flocks of half a dozen or more animals which may assemble at to form much larger herds of more than hundreds were adult females outnumber males in 2:1 ratio (Blandford, 1888-91; Prater 1971, Davidar, 1978). Mature males do not always remain with the herd, forming two kinds of social groups among Nilgiri tahr: mixed group, consisting primarily of adult females and their sub-adult offsprings, and all male group or bachelor herd (Davidar,1978; Rice, 1984). Solitary males are not uncommon but lone females are very rare (Davidar,1978; Rice, 1984).

Figure 4 Bachelor Herd

There is no well-defined breeding season, however the main rutting of Nilgiri tahr is in monsoon from June to August and main birth season during January and mid-February, most of the young ones are born during winter months after an estimated gestation period of 179 days (Davidar,1978, Rice, 1988). Even though many older literatures mention twinning is the norm (Lydekker 1898; Blandford1899-91), one young per birth appears to be more usual (Prater, 1971; Schaller, 1973; Davidar,1978; Rice, 1984). However, several females

were found to give birth twice a year, especially when the first young one is lost, creating a secondary minor birth season during July to early August (Rice, 1984).

1.2.1.7 Behaviour and activity pattern

They feed on grassy slopes on early morning and again in late evening and rest on the cliff edges during the hot afternoon hours (Blandford 1888-91; Prater, 1971; Rice,1984) Usually, an older adult female acts as sentinel to the herd and they suspect danger from below, seldom looking above (Blandford, 1888-91; Lydekker, 1898). Their alarm call is a sneezy whistle (Davidar,1978). They spent night on or closer to cliff but in undisturbed areas they often bed away from cliff (Davidar, 1978). They do not have a territory and wander over large area (Davidar, 1978).

Study by Biju et al in 2018 on the activity budget of Nilgiri tahr between 7.00 am to 5.00 pm found grazing was the predominant activity observed (37% time) followed by resting (23.3%), walking (13%), standing (11.8%) and maintenance activities (11.4%) (Biju et al, 2018). During monsoon the percentage of resting increased to 31.1%, immediately next to grazing (32%) and also showed a difference in activity of animal based on their sex and age where adult males browsed and walked more in comparison to females (Biju et al, 2018). They concluded that the activity budget of Nilgiri tahr was similar to other ruminants where they find more time foraging to fill their rumen and then for resting and ruminating.

1.2.1.8 Threat

In 1963 Davidar had reported the dwindling population of tahr in Nilgiris and their disappearance in Glen Morgan Hills (Davidar,1963). The last repost of Nilgiri tahr in Karnataka was from Agumbe Ghat in 1954 (Davidar, 1978; Swengel; 1993). Uncontrolled hunting, conversion of tahr habitat to plantations of tea, eucalyptus and Pine and other anthropogenic pressures resulted in the decline of the tahr population (Davidar,1963;

Schaller, 1977; Davidar, 1978) and their habitat has reduced to less than one tenth of the historical range. (Schaller, 1977).

Hunting was the major reason for decline in tahr population. Shooting using guns was a common method, however snares and dogs were also used for poaching (Davidar, 1978). Tribals used to leave oil-stained plantain leaves near cliff and ambush the individual, making them slip over the oil and fall to death (Thyagarajan, Davidar,1978). Old males have strong odour of goats and its flesh is ranked unpalatable, however that of Doe and young males were considered excellent (Prater, 1971).

Leopard, tiger, wild dogs and jackals are considered to be natural predators of Nilgiri tahrs and birds of prey like Black eagle might be preying on newborns (Blandford, 1888-91; Schaller, 1977, Davidar,1978). Davidar mentioned about leopard becoming highly adapted in becoming expert in stalking and hunting tahr in Nilgiris (Davidar, 1978). The high predation rate by wild dogs were said to be a major threat by Thyagarajan in 1958 and suggested controlling the population of wild dog for protecting tahr (Thyagarajan, 1958). Schaller observed fewer than 25% of young ones dying between birth and the age of 1 year, but then around a third of the survivors disappeared before the age of 2 years (Schaller, 1977).

There has been reports of lump disease in Nilgiri tahr which is generally non-fatal. However, if the lump is in the mouth, it could affect the food intake and animal could starve to death and if the swelling is in the leg, it may not escape from predators. The Rajamalai group of tahr, which is having higher human interaction, is reported to be affected by worms of *Amphistoma and Fasciola* species and presence of cattle along the fringe poses the threat of rinderpest and foot and mouth disease (Saju, 2012). The catarrhal fever outbreak in Nilgiri tahr in San Diego Zoo where the death occurred within 5 days (Neilsen et al, 1988) should also be a concern especially for captive population and breeding centres.

1.2.2 Nilgiri tahr and tourism

1.2.2.1 tahr in captivity

Nilgiri tahr is considered moderately difficult to breed in captivity (Walker & Molur, 1999). Trivandrum zoo in Kerala, India is recorded to have Nilgiri tahr in the mid-1880s which is the earliest record of Nilgiri tahr in captivity (Swengel, 1993). Trissur zoo obtained their first pair of Nilgiri tahr in December 1959 from the game sanctuary of Kannan Devan hill Produce Co. Ltd, Munnar. The animals were hardly ten days old and were transported in a deal wood case padded with straw (Pillai, 1963; Potti, 1966; Swengel,1993). The pair (female named Bamby and male Cookei) produced first child on 27 April 1962 (Pillai,1963; Potti 1966) and since then the Zoo was able to successfully breed Nilgiri tahr in captivity till 1975 (Yalakki, 2014) where at least 21 births occurred between 1962 and 1970 according to International Zoo Yearbook records (Swingel,1993) and a total of 23 births till 1975 (Yalakki, 2014). Fresh cow milk diluted with water was given for the young ones in Trissur Zoo and later they started feeding on leaves of *Bridelia retusa*, Hibiscus and Ficus. They were also fed soaked Bengal gram, grass, leaves of jackfruit tree and ripe banana (Pillai,1963).

In 1899 itself, Berlin Zoo acquired Nilgiri tahr from German animal dealer Hagenbeck and on 27 August 1900 a young one was born which possibly might be the first captive bred individual (Swengel, 1993). Five Nilgiri tahr (two males and three females) were transferred to West Germany zoo from Trissur Zoo and Trivandrum Zoo (Swengel, 1993; Yalakki,2014) in 1971 from which one male and two females were transferred to Memphis Zoo and were the first Nilgiri tahr exhibited in North America. On 29 May 1974 in Memphis Zoo, first captive bred individual of North America was born and since then 169 Nilgiri tahrs were born in North American zoos till 1993 (Swengel,1993).

In North America, Apple valley/Minnesota Zoo, Baton Rouge Zoo, Cape May Zoo, Ferndale Zoo, Holiday Zoo, Knoxville Zoo, Memphis Zoo, Philadelphia Zoo, Roger William

Park Zoo/Providence Zoo and San Diego Zoo were reported to possess Nilgiri tahr and in Europe, Berlin Zoological Garden and Gelsenkirchen Zoo in Germany, Artis Zoo in Netherlands and London Zoo in UK had Nilgiri tahr (Swengel, 1993; Zootierliste, 2024). Sri Lankas National zoological Garden in Dehiwala also had few Nilgiri tahr (Swengel, 1993; Zootierliste, 2024). In 1980 and 1982 catarrhal fever, a unique malignant respiratory disease had killed 15 out of 16 captive Nilgiri tahr in the San Diago wild Animal Park in two separate outbreaks where none of them survived more than five days after initial symptoms (Nielsen et al, 1988).

As per Walker and Molur, the Zoos in the US had jointly taken a decision to stop breeding Nilgiri tahr as there was no ways to obtaining new individuals and had reached the limit which they could produce with the then existing genetic stock (Walker and Molur, 1999). There were 28 Nilgiri tahr in seven US institutions in 1993 (Swengel, 1993) which had reduced to 6 individuals in two institutions by 2004(ISIS online data base). Currently, there is no captive Nilgiri tahr in India and there is no information available on Nilgiri tahr in captivity from North America at present. However, a recent unofficial report suggests the presence of Nilgiri tahr in San Diego Zoo Safari Park and a private Ranch in Iron Mountain, Brewster County (Zootierliste, 2024; Zoochat, 2024). The under construction Puthur zoo in Thrissur have plan to start captive breeding of Nilgiri tahr in near future (Yalakki, 2014).

Figure 5 Picture of Nilgiri tahr is San Diego Zoo Safari Park,USA ; uploaded in ZooChat on 3rd May 2024 (Image credit 'Kudu 21' ,a member of ZooChat forum)

1.2.2.2 Eravikulam National Park, Kerala

Eravikulam National Park is the only protected area where there is tourism programme dedicated for Nilgiri tahr. The National Park has the highest number and density of Nilgiri tahr and was previously a privately owned game sanctuary which came under government control in 1971 (Saju,2012). The park is open to visitors in all days except in the months of February and March, when the park is closed for the calving season of Nilgiri tahr (Saju, 2012). Ecotourism activities are carried out in the tourism area where tourists are allowed for a short trek and a safari in minibus which brings annually around 3.5 to 5 lac tourists to the National Park (Vinod, 2024). From 2006 onwards involving 8 EDCs a visitor management system was created for efficient tourism management and private vehicles were stopped at the entrance of the park, except for the ones going to the Tribal Settlement (Vinod, 2024). An interpretation centre 'Story of the Park' provides tourists with information about the park as well as Nilgiri tahr (Vinod,2024).

1.2.3 Influence of tourism on wildlife

Wildlife tourism is ‘tourism based on encounters with non-domesticated animals occurring in either the animal’s natural environment or in captivity’ (Higginbottom, 2004, Gandiwa. 2011). As wildlife viewing has become a major industry, emphasis has been placed on animal sightings to the point where many commercial tour operators market their packages with the promise of close-up views (Knight,2009). Offering food (attraction) is practiced by people to see wild animals at a closer distance(Edington & Edington, 1986). Animals become accustomed to obtain food this way which could lead to animal begging for food even in aggressive manner which could cause harm to both humans and animals (Edington & Edington, 1986).

The wildlife viewing generally happens in sites where there is predictability of presence especially with exciting behaviour like social and courtship behaviour the animal’s response to external stimuli like the presence of tourists, is likely to vary over time (Hingham & Shelton,2011). Wildlife responses to non-consumptive recreation varies widely including avoidance of trails, use of trails primarily at night or increased use of trails (Oriol-Cotterill et al, 2015; Larson et al, 2016 (Coppes et al, 2017; Naidoo & Burton, 2020; Salvatori et al, 2023; Granados, 2023).

Not all biologists consider wildlife tourism as non-consumptive. Some like Lemelin and Knight considers wildlife viewing as “ocular consumption” and challenges the term “non-consumptive” as it conceals the potentially considerable impacts wildlife viewing can have on the animals being watched (Lemelin,2006; Knight,2009). Outdoor recreation like wildlife tourism have potential to disturb wildlife leading to higher energetic costs, altering interspecific interaction, avoidance of otherwise suitable habitat and impacts to animals’ behaviour and fitness (Taylor and Knight,2003). Wildlife tourism may have pronounced effects on individuals, populations, and communities and affect their behaviour, fitness and

interspecific interactions (Taylor and Knight, 2003, Boyle and Samson 1985, Knight and Cole 1995a). It could be short term negative impacts like change in physiology and behaviour or even long-term impacts like increased mortality or reduced breeding success, especially to cryptic or less 'exciting' wildlife which could further affect the population and ecosystem (Green & Giese, 2004). The severity of negative effects of wildlife tourism on wildlife varies with the animal, its age, sex, physical condition, stage of breeding, habitat, proximity, and previous encounters with wildlife tourism or other human activity (Swenson 1979, Cooke 1980, Poole 1981, Skagen et al. 1991, Holmes et al. 1993; Burger et al. 1995, Gabrielsen and Smith 1995, Knight and Cole 1995, Gill 2002) and also with type, frequency and intensity of wildlife tourism, distance between a person (or vehicle) and the animal, and stimuli such as sound, light and sudden movements (Green and Giese, 2004).

A UN study on impact of tourism in developed countries had noted that, whilst the tourism provides economic advantage it could cause environmental and social disruption (Edington & Edington, 1986).

1.2.4 Habituation

In order to make wildlife viewable, habituation and attraction strategies which necessarily changes the 'wild' quality of the behaviour of the animals are adopted (Knight,2009). Habituation could be defined as "a decrease in the strength of a response after repeated presentations of a stimulus that elicits that response" (Mazur, 2006) or as "any situation where wildlife come to tolerate the presence of humans without any obvious signs of physiological or behavioural response" (Shackley,1996; Hingham & Shelton,2011) where the waning of responsiveness could be temporary or permanent (Marler and Hamilton 1966) and gets replaced by tolerance of a human presence (Knight,2009).

Habituation makes it possible to approach, observe and study the animal which could provide information about their ecology and helps in conservation like Dian Fossey

habituating Gorillas (Fossey, 1983) and Clifford Rice habituating Nilgiri tahr (Rice, 1984). However, habituation is also carried out for the purpose of tourism like Gorilla groups in Uganda (Hanson, 2001) and chimpanzee groups in Uganda (Lloyd and Ajarova, 2005). Wild animals are generally human-averse and responds to any encounter by fleeing and retreating to cover. The habituation might reduce this predator avoidance behaviour and may have effects on their behaviour patterns like foraging. Habituation may have effects on the pattern of foraging due to the reduction of predator avoidance behaviour (Knight,2009). Habituated animals are also more vulnerable to poaching (Singer,1975; Boyle and Samson, 1985).

1.2.5 Human Shield Hypothesis

The Human Shield Hypothesis was proposed to explain the spatial responses by wildlife to human presence, where high human disturbance can displace large predators which benefits prey species by shielding them from carnivores and reducing predation risk, (Berger, 2007; Muhly et al, 2014; Granador et al, 2023). As per this hypothesis, human activity is expected to alter habitat use by ungulates by selecting areas with increased recreation as they are 'shielded' from predators or from hunting (Berger, 2007; Granador et al, 2023). However, this cannot be generalised in all landscapes and environmental contexts and multiple factors would influence the presence and absence of animals (Granador et al, 2023).

1.2.6 Purpose of this study

It is important to know how the human wildlife interaction in tourism area is affecting the wildlife for better management of wildlife tourism. In order to find ways to reduce the impacts while maximising the benefit of tourism, inputs from various disciplines including economics, sociology, architecture, engineering, geography and biology are needed (Edington & Edington, 1986). Studies of the short-term behavioural states of wildlife can provide scientific information regarding the impacts of wildlife tourism offering valuable

monitoring tools (Green & Giese, 2004). Understanding the influence of tourism on endangered Nilgiri tahr is essential for its proper conservation and effective management. Even though the behaviour and habitat use of Nilgiri tahr has been studied (Rice,1984, Easa & Sivaram, 2002), no study has been done on the influence of tourism or how tourism has changed the behaviour and habitat use of Nilgiri tahr.

1.3 Aim

To understand the influence of tourism on the behaviour and habitat-use in Nilgiri tahr (Nilgiritragus hylocrius) in Eravikulam National Park, Kerala.

1.3.1 Objectives

1. To study the differences in the behaviour of Nilgiri tahr in tourism and non-tourism area across tourism and non-tourism seasons.

2. To study the differences in the habitat-use of Nilgiri tahr in core and in tourism area across tourism and non-tourism seasons.

1.3.2 Research Question

1. How different is the behaviour of Nilgiri tahr in tourism area from that of core?

2. How different is the habitat use of Nilgiri tahr in tourism area from that of core?

3. How does the closing of tourism influence the presence and behaviour of Nilgiri tahr in tourism area?

4. What is the behaviour and habitat use Nilgiri tahr across different age sex class in tourism area and core?

5. How does the presence of predators (if any) affect the presence and behaviour of Nilgiri tahr in tourism area?

2. STUDY AREA

Figure 6 Eravikulam National Park board

Eravikulam National Park is located in the High Ranges (Kannan Devan Hills) of the Southern Western Ghats in the Devikulam Taluk of Idukki district, Kerala State between 10º 05' - 10º 20' N Latitude and 77º 0' - 77º 10' E Longitude. The area, which was managed as a Game Reserve by the erstwhile Kanan Devan Hills Produce Company through the High Range Game Association, came under the control of the Government of Kerala in 1971 when Kannan Devan Hill Produce (Resumption of lands) Act 1971 was passed. Subsequently, the Government of Kerala declared the area as Eravikulam-Rajamala Wildlife Sanctuary in 1975 for the protection of Nilgiri tahr and its habitat. It was elevated to the status of a National Park in 1978 (notification No. 92368/FM3/76/AD dated. 31.1.1978) (Saju, 2012).

Eravikulam National Park is spread across 97 km2 area with montane grasslands that are interspersed with shola forest. The National Park is bordered by Vaguvara tea estates and Munnar Reserve Forest in the east, Neymakkad and Kadalar Tea estates in the south, Munnar

and Malayatur Reserve Forest in the West, Indira Gandhi Wildlife Sanctuary in the north and Chinnar Wildlife Sanctuary in the north-east (Karunakaran et al, 1998).

Three major types of plant communities that are found in the park are grasslands, shrub land and shola forests (Saju, 2012). Weather of the area is predominantly influenced by the southwest monsoon. The annual temperature ranges from 80°F to 230°F with an average annual precipitation of 4050 mm. The average elevation of Eravikulam plateau is about 2000m and few peaks and knolls rise to an altitude of 2300m or more e.g., Anamudi (2695m), Kattumala (2478m), Kumarikkal (2449m) and Naikollimala (2332m) (Karunakaran et al, 1998).

The terrain above 2000 m is covered primarily by the grasslands with small patches of forest in gullies and hollows. Shrub lands are found along the bases of cliffs and intersperse in rocky areas (Rice, 1988a) The shola forests, classified as Southern Montane Wet Temperate Forest, are located mostly in the valleys (Chandrasekharan, 1962). Turner's valley, which splits the Park roughly in half from northwest to southeast, is the deepest valley (About 600m) and the Anamudi (2695 m) is the highest peak (Saju, 2012; Karunakaran et al, 1998). There are three mountain ridges radiating from Anamudi: Anamalais towards the north, Palnis to east and Cardamom Hills to the south-west

The fieldwork was carried out in two locations in Eravikulam National Park. Tourism zone towards the southern side of the National Park and area around Varattukulam camp site towards the eastern side. Both these populations are geographically isolated by Turner valley passing almost through the middle of the park which makes intermixing between these population is highly unlikely.

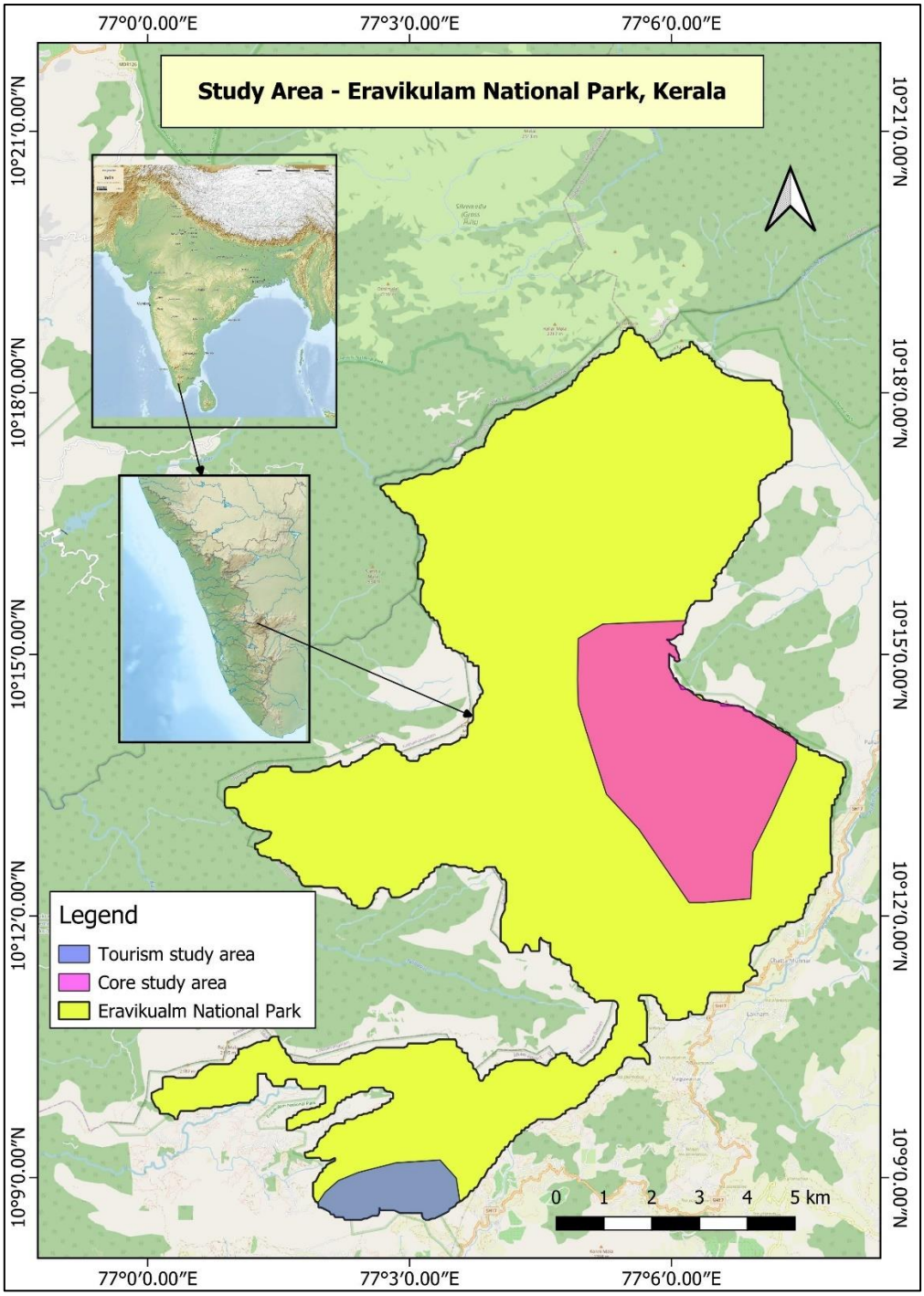

Figure 7 Study area map of Eravikulam National Park showing field sites in tourism area and core area (Varattukulam)

The tourism study area shown in the map includes tourism area where visitors are allowed to walk and see tahr up close, hills adjacent to the tourism area which the tahrs use, range office, wireless station and roads connecting all these locations. This covers an area of 2.725 km sq.

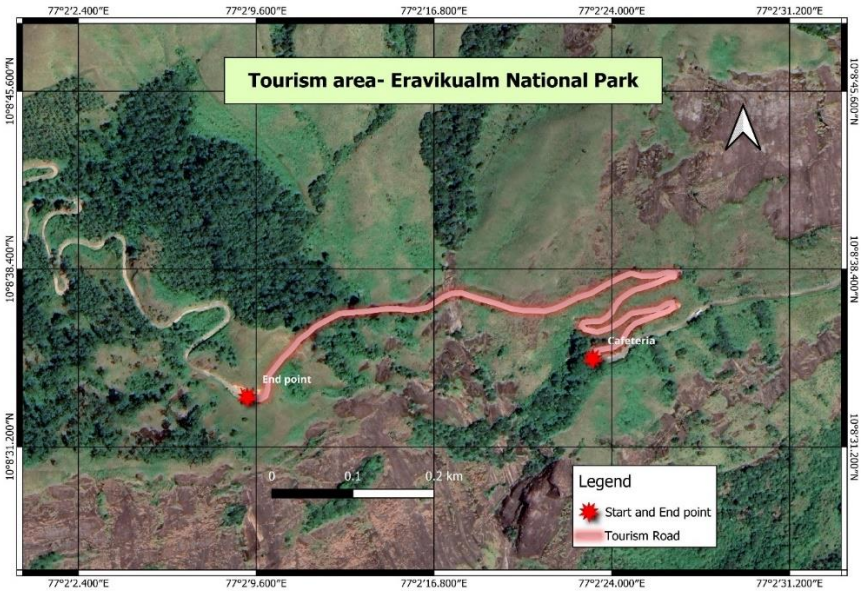

Figure 8 Tourism road – 1km road from the Cafeteria till the end point where tourists are allowed to walk and see Nilgiri tahr at a close distance.

In core area, sampling was done while staying in the Varattukulam camp site. 14 sq km area was searched for Nilgiri tahr and camera traps were deployed here to check for predator presence.

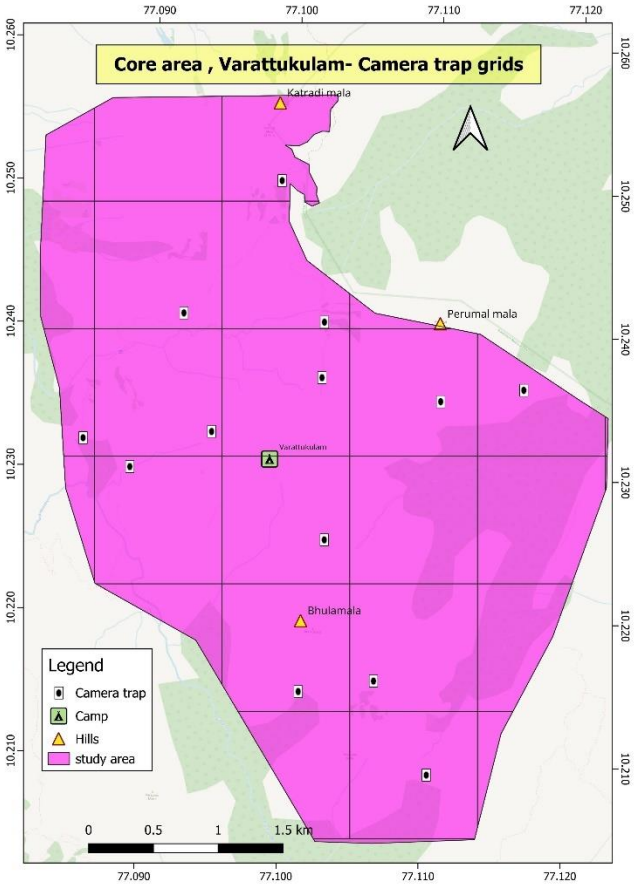

Figure 9 Study area in Core zone near Varattukulam camp site

Palani laughing thrush

Nilgiri Pipit

Nilgiri Flycatcher

White bellied sholakili

Black and orange flycatcher

Nilgiri wood pigeon

Figure 10 Some endemic birds seen in Eravikulam National Park

Brown palm civet

Nilgiri Martin

Leopard

Tiger

Sloth bear

Nilgiri striped squirrel

Figure 11 Some Mammals of Eravikulam National Park

3. METHOD

The field study was carried out from January 2024 to April 2024. This period was divided into three phases based on the tourism season. In Eravikulam national park, the tourism activities are closed during the months of February and March. So, the month of January is considered as preclosing season, February and March as closing season and April as reopening season. The study was focused mainly in the 1km tourism road where the tourists can walk and observe tahr at a very close distance and this is the area where there is maximum human-tahr interaction. Along with this data were also collected from range office and adjacent roads where human influence is present but direct interaction is comparatively less. The data collection for behaviour of tahr where there is no human tahr interaction was carried out in 14 sq.km area near Varattukulam camp in core area of Eravikulam National Park.

3.1 Habitat use

The objective 1 is to determine the differences in the habitat-use of Nilgiri tahr in wild and in tourism area across tourism and non-tourism seasons. For this, following factors were estimated when a group of Nilgiri tahr was spotted.

1) Sighting location
2) Sighting time
3) Habitat type will be determined as, Grassy slope, Rocky cliff, rock-grass interface, burnt grass, burnt rock-grass and other

Whenever a tahr is spotted in the tourism area addition to these factors, following information will also be collected

4) Closest distance to the humans
5) Distance from the road and other important anthropogenic structure.

6) Type of interaction the tahr – feeding, observing, teasing, touching

To measure temperature and humidity, Hobo dataloggers were deployed in tourism and core area (one in each location) and a hand-held thermo-hygrometer was also used. The Noise levels in both tourism and core area were measured using a hand-held decibel meter. Aspect, slope and nearest escape terrain of the sighting location were calculated using remote sensing.

3.2 Behaviour pattern

An ethogram was prepared for different behaviour specific for Nilgiri tahr was prepared before starting the behaviour sampling. The behaviours were broadly classified as Feeding, Resting, Standing and observing, Travelling, Social and Grooming. some of these behaviours were further classified. The detail ethogram is given in Appendix I.

Scan sampling was done every 15 minutes where behaviour at that particular moment of all the individuals in the sight were recorded (Altman,1974). Along with the behaviour, the habitat types on which the individuals were present were also recorded. The tahrs were classified based on their age and sex as adult female (AF), Light brown male (Lbm), Dark brown male (Dbm), Saddle back (S), young (yg) and yearling (yr).

a) Young (Yg): Age 0-1
b) Yearling (Yr): Age 1-2
c) Adult Female (AF): Age 2+
d) Light brown male (Lbm): Age 2-4
e) Dark brown male (Dbm): Age 5
f) Saddleback (S): Age 6+

Focal sampling was carried out till the animal is out of sight with 15 minutes break every 15 minutes. Activities will be classified as feeding, travelling, resting, standing and

observing, grooming, social and others. The social behaviour was further categorised like fighting, nursing, suckling, courtship and allogrooming, and feeding behaviour includes foraging, licking and drinking. Habitat or substrate on which the individual was present while performing each behaviour was also recorded. Observations were taken using Nikon 10x50 binocular. Data sheets, voice recorder and Epicollect software were used for data collection.

3.3 Flight distance

Flight initiation distance is the distance at which an animal responds to the approach of a person by moving or running away, or in other words the minimum distance a person could approach an animal before it moves, and flight movement distance is the distance the group subsequently moves before stopping and resuming normal feeding or grooming behaviours (Phillips 1993; Kandel et al, 2022). Alert distance, flush distance, approach distance and reaction distance are also terms used for flight distance by few authors (Taylor and Knight, 2003). Flight distance gives an understanding about the tolerance level of an animal or population towards the humans or other disturbances where the distance will be larger if the threat perception is higher and vice versa. Study by Kandel et al showed a considerable increase in the flight distance and vigilance of Blue sheep (*Pseodois nayaur*) in area where trophy hunting is practiced from where hunting is banned (Kandel et al, 2022).

To calculate the flight distance, the group was approached at a constant speed of around 1 m per second, and the distance to the centre of the group was measured continuously using a laser rangefinder (HAWKE LRF 400), as suggested by Taylor and Knight (Taylor and Knight, 2003).

3.4 Predator Presence

Camera traps were deployed in both tourism area and near Varattukulam camp site in core area for checking the presence of predator species, namely Tiger, Leopard and Dhole.

Fourteen 1x1 sq.km grids where created using QGIS in Core area where one camera trap was placed per grid. Predetermined locations used by forest department for camera trapping was used along with some other locations selected after sign survey. In the tourism area, where camera trapping was never been carried out before, strategic points were identified using sign survey and interacting with the local watchers. Here, camera traps were placed mainly along road, Fireline and nearby tea plantations where predator presence were suspected. Images were checked every two weeks and two of the camera traps in tourism area which did not show any predator presence were relocated to new sites where predator activity was suspected.

3.5 Analysis

Scan sample data was extensively used for the analysis of behaviour and habitat use. Generalised linear modelling was done to understand the relationship between habitat use and behaviour where habitat type is considered predictor variable and the behaviour as response variable. ANOVA was carried out to check whether there is significant difference in flight distance across tourism, core, range office and tourism adjacent hill areas. Chi sq. test and G test were done to check whether there is significant difference in behaviour across area and season. All the statistical analysis were carried out using R software version 4.2.1

4. RESULT

The field work was carried out from 8th of January 2024 till 19th of April 2024 which includes sampling for behaviour, habitat use and camera trapping for carnivore presence. In total 1414 behavioural observations core area, 5660 from tourism area and 131 from tourism adjacent area (which includes range office, wireless station, road before tourism zone and hill adjacent to tourism area) were collected using scan sampling.

Table 3 Scan sampling observation across tourism core and tourism adjacent areas

Sampling area	**Feeding**	**Resting**	**Travelling**	**Standing and observing**	**other**	**Total observations**
core	645	357	169	238	5	**1414**
tourism	2848	1403	644	609	154	**5660**
tourism adjacent	74	9	24	24	1	**131**
Total behaviour	**3567**	**1769**	**837**	**871**	**160**	**7205**

4.1. Tourism area behaviour

Table 4 Behaviour frequency of different age sex class in tourism area

Individual	**Feeding**	**Resting**	**Travelling**	**Standing and observing**	**other**	**total observation**
AF	1410	518	255	267	61	**2511**
yg	614	323	201	211	49	**1399**
Lbm	312	178	93	50	27	**661**
yr	351	126	64	50	11	**602**
Dbm	10	3	3	2	1	**19**
S	4	1	2	3	1	**11**
AF/Lbm	147	254	26	26	4	**457**
Total behaviour	**2848**	**1403**	**644**	**609**	**154**	**5660**

The mean group size in tourism area was 20.58 ± 2.25 (SE). Adult females and young ones were more frequent visitors compared to other age sex groups. Dark brown male and

saddlebacks were less frequent in tourism zone; however, they were present frequently in the road before tourism zone and in range office where limited human interactions were present.

Light brown males were hard to distinguish from adult females especially while resting or while feeding in distant hill. Individuals were categorised as Lbm only if their penile sheath or scrotum was seen; else put in AF/Lbm. Observation of adult female accounts for 44.36% of observation in tourism area followed by young one with 24.71%.

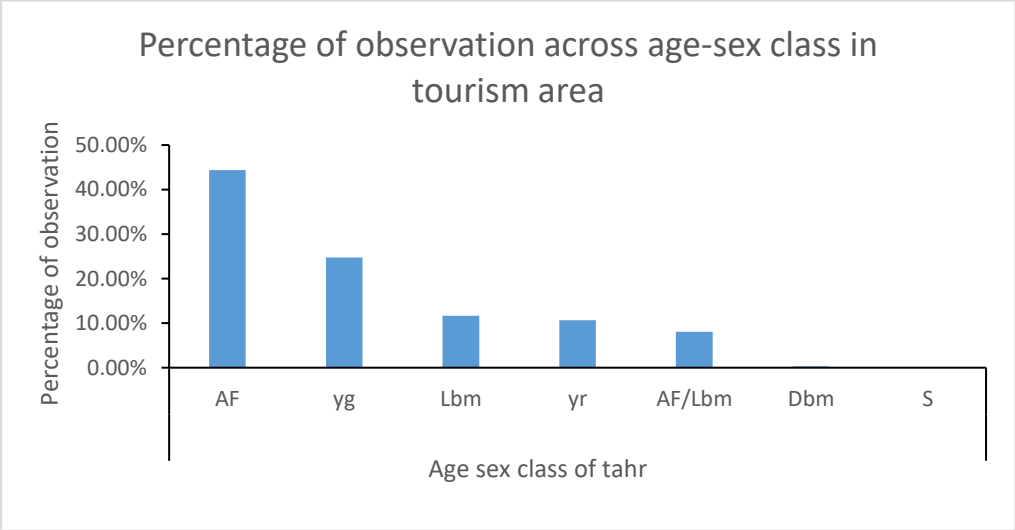

Figure 12 Percentage of age sex class observation in tourism area

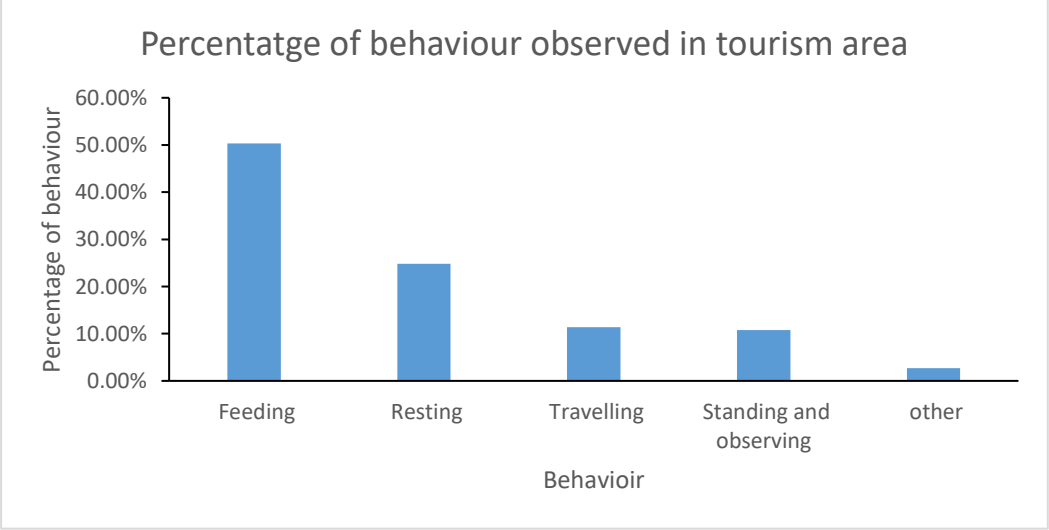

Figure 23 Percentage of behaviour observed in tourism area

Most frequent behaviour in the tourism area was feeding (50.31%) followed by resting (24.78%) and these two behaviours accounted for 75% of tahr behaviour in tourism area. Feeding includes drinking as well as licking. tahr used to lick on washroom walls and stones near to washroom due to the presence of salt. Travelling was 11.38% and standing and observing 10.76% of total activity.

4.1.1. Across tourism seasons

Feeding was the most frequent behaviour in all the three seasons followed by resting. The percentage of feeding increased from 40.88% in pre closing season (January) to 56.94% in reopening season (April) and the resting decreased from 31.37% to 21.07%. Feeding and resting together formed around 72-78% of observations across all the three seasons.

Table 5 Behavior occurrences in tourism area across tourism seasons

Seasons	**Feeding**	**Resting**	**Travelling**	**Standing and observing**	**other**	**total observations**
pre-closing	473	363	121	137	63	**1157**
Closing	1567	741	392	323	60	**3084**
Reopen	808	299	131	149	31	**1419**
Grand Total	**2848**	**1403**	**644**	**609**	**154**	**5660**

Table 6 Behavior percentage observed across tourism season

Season	**Feeding %**	**Resting %**	**Travelling %**	**Standing and observing %**	**other%**
pre-closing	40.88	31.37	10.45	11.84	5.44
closing	50.81	24.02	12.71	10.47	1.94
reopen	56.94	21.07	9.231	10.50	2.18

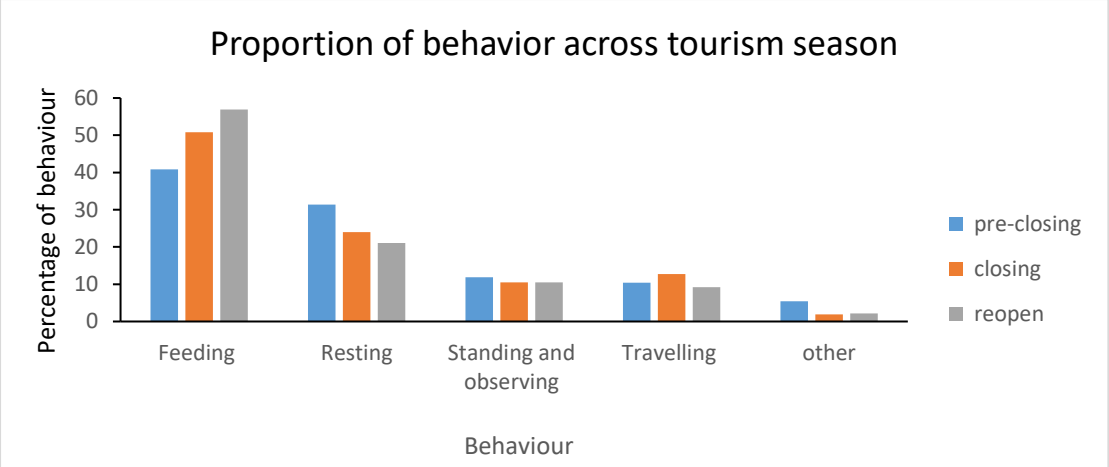

Figure 14 Proportion of Behavior across tourism season

To check whether the difference in the behaviour in tourism area across seasons, G test was carried out and it also showed significant difference in all behaviour across seasons.

Table 7 G-Test result on comparing the behaviour across season

Behaviour	**G**	**df**	**P value of G test**
Feeding	429.29	16	< 2.2e-16
Resting	304.79	16	< 2.2e-16
Standing and observing	88.126	16	5.532e-12
Travelling	6.592	16	5.598e-08
Other	30.547	16	0.01536

Chi sq test was also carried out between the behaviour across tourism season and p value was lower than 0.05 in all combination showing there was difference in behaviour pattern across seasons.

2. Behaviour in Core area

Table 8 Behaviour frequency of different age sex class observed in core zone

Individuals	**Feeding**	**Resting**	**Travelling**	**Standing and observing**	**other**	**total ind**
AF	82	35	46	73	1	237
yg	34	12	44	36	0	126
Lbm	8	17	2	4	0	31
yr	1	0	2	0	0	3
S/Dbm	31	26	4	14	0	75
Dbm/Lbm	141	104	8	31	1	285
AF/Lbm	348	163	63	80	3	657
Grand Total	**645**	**357**	**169**	**238**	**5**	**1414**

In core area, both mixed herd, which includes adult females, juveniles and light brown males, and bachelor herds were seen. The mean herd size in core was 15.46 ±2.73 (SE). Identifying the sex of the individuals were much difficult in core area compared to tourism area as the distance between observer and herd was higher. In core area also, feeding (45.61%) was major activity followed by resting (25.24%).here standing and observing was 16.8% and travelling 11.95%

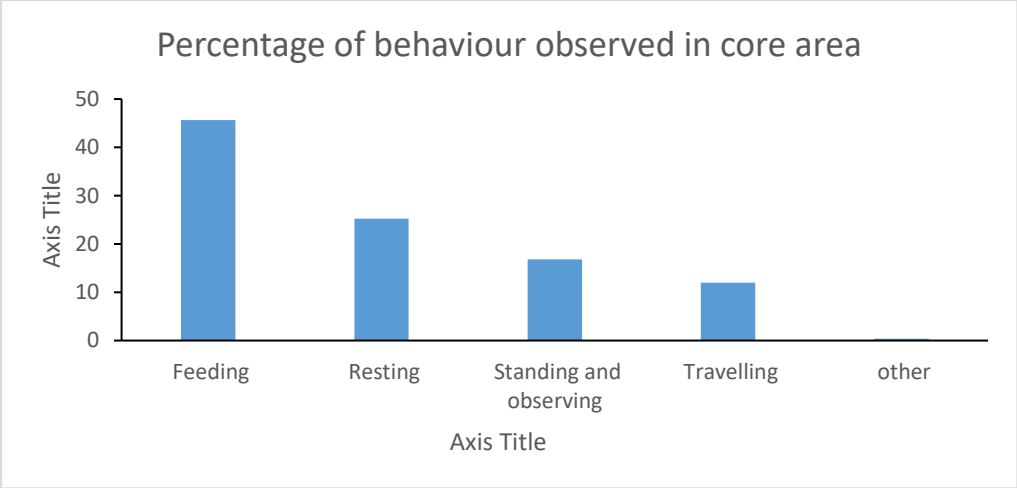

Figure 153 Percentage of Behaviour observed in core area

4.3. Activity pattern

The activity pattern in core area shows the animals spent more time feeding in the early hours of the day and towards afternoon resting increases. Peak afternoon when the temperature is high, they engage more time in resting. In the evening, they again start feeding and travels towards the cliff. This is the similar to the pattern described in most of the previous literature (Blandford 1899-91; Rice,1984;).

Table 9 Behaviour according to time of day observed in core area

Time of Day	Feeding	Resting	Travelling	Standing and observing	other	total ind
07	6	0	0	0	0	6
08	21	11	0	0	0	32
09	27	22	14	0	2	65
10	64	29	1	14	1	109
11	182	45	9	98	0	334
12	80	54	92	41	0	267
13	29	92	11	31	1	164
14	8	10	0	10	0	28
15	88	17	5	7	0	117
16	93	36	32	17	1	179
17	41	41	5	16	0	103
18	6	0	0	4	0	10
Grand Total	**645**	**357**	**169**	**238**	**5**	**1414**

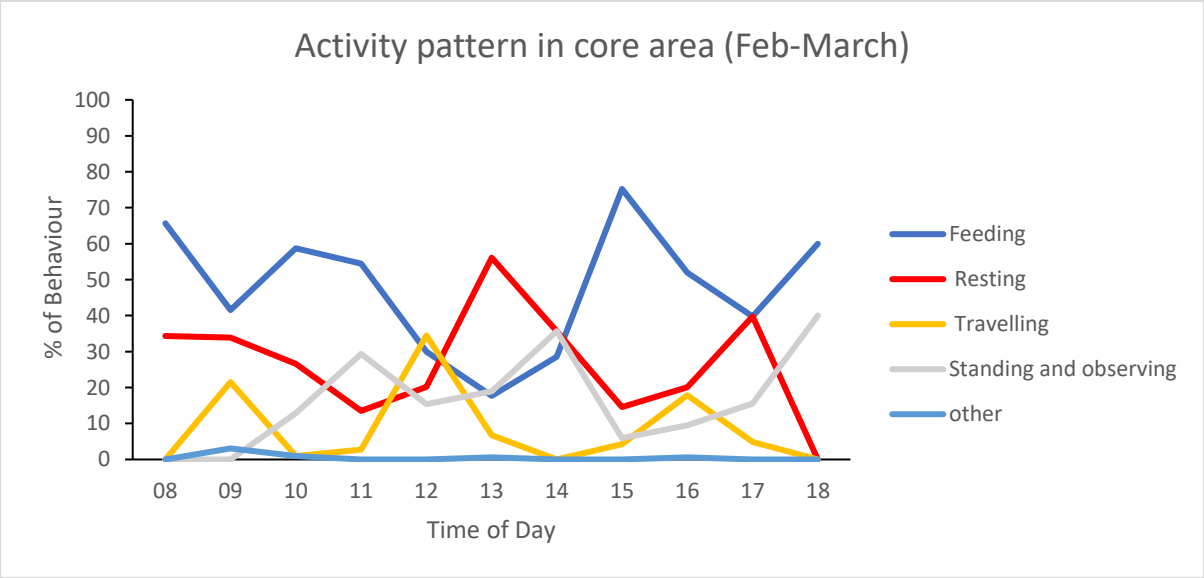

Figure 16 Activity pattern of core area

The activity pattern is found to be different in the tourism area from that of the core area. In all three seasons, Nilgiri tahr generally used to arrive at the tourism zone around 9 am from the Rajamalai-Naikolli hills in the Northern side. Upon reaching the tourism zone around they spent the initial hours resting and form 11 am onwards, percentage of tahr feeding were higher even during the peak afternoon till evening.

Table 10 Behaviour according to time of day observed in tourism area

Time of the day	Sum of Feeding	Sum of Resting	Sum of Travelling	Sum of Standing and observing	Sum of other	Sum of total ind
08	27	1	7	6	1	42
09	72	130	28	30	8	268
10	294	374	117	101	21	907
11	486	202	105	85	20	898
12	488	226	117	119	22	972
13	476	157	91	104	23	853
14	307	96	63	64	23	553
15	292	112	50	55	15	524
16	250	72	43	35	14	414
17	156	33	23	10	7	229
Grand Total	**2848**	**1403**	**644**	**609**	**154**	**5660**

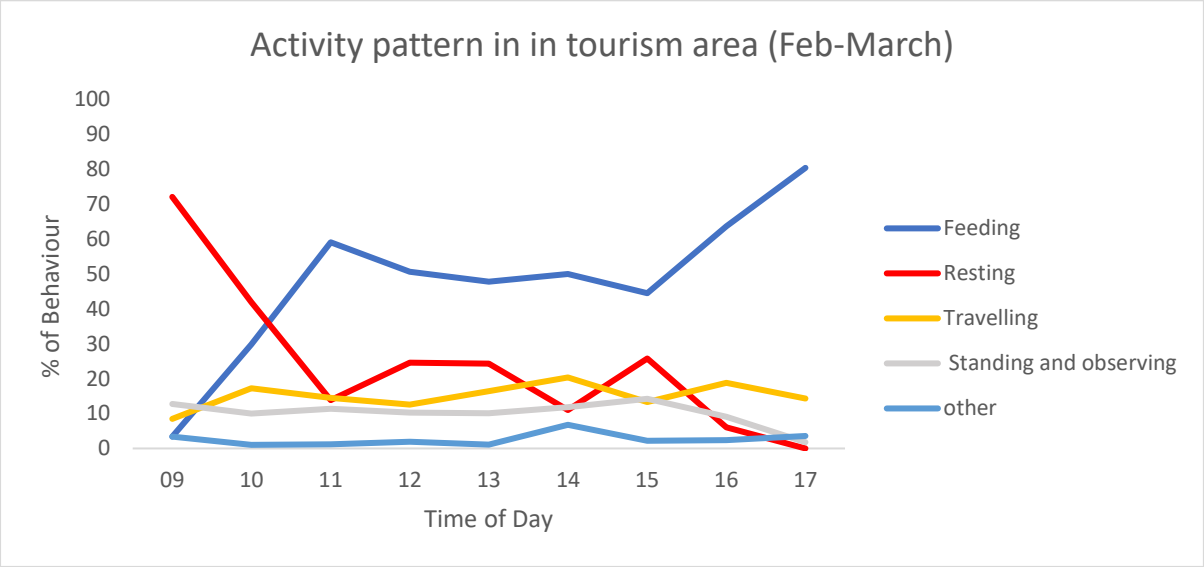

Figure 17 Activity pattern of tourism area

G test between the frequency of behaviour in tourism area and core area was carried out from the scan sample data. The result showed there is significant difference in the frequency of behaviour in both areas with p value less than 0.05

4.4. Flight distance

The fllight distance was found to be very less in the areas with human interaction. The tourism zone had a mean flight fight distance of 1.87m with sd 2.05 where as range office area had a mean flight distance of 5.04m with sd 1.88. The value of flight distance for core area was almost 100 times higher than that of tourism zone with a mean flight distance of 118.5m with sd 25.88, in which the mininuum fligth distance was 75m and. However, the hills adjacent to tourism area (Naikolli, kurishmala and Irachippara) area which is connected to the tourism zone but does not have human influence showed a higher flight distance with mean flight distance being 81m with sd 27.44

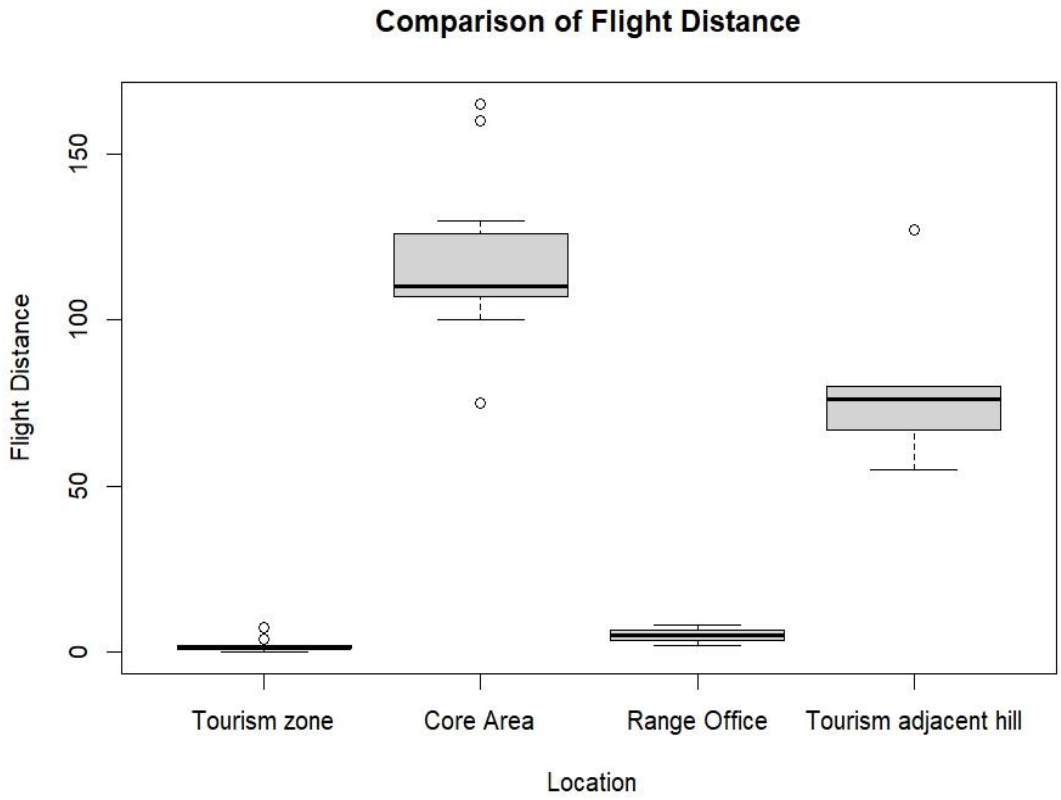

Figure 18 Flight distance of tahr group in different area

One way ANOVA was carried out using R program and the p value of 2e-16, which is less tham 0.05 showing the difference in flight distance is significant.

Post hoc test using TukeyHSD showed that the difference in flight difference between all areas are significant except between tourism zone and range office

Table 11 Result from TukeyHSD test showing significance in the flight distance difference across area

Area	diff	lwr	upr	p adj
range office-core zone	-113.549242	-132.09995	-94.99853	0.0000000
Tourism Adjacent hill-core zone	-37.590909	-61.56059	-13.62123	0.0008637
tourism zone-core zone	-116.715909	-135.26662	-98.16520	0.0000000
Tourism Adjacent hill-range office	75.958333	52.30282	99.61385	0.0000000
tourism zone-range office	-3.166667	-21.30962	14.97628	0.9651514
tourism zone-Tourism Adjacent hill	-79.125000	-102.78051	-55.46949	0.0000000

4.5. Habitat use

4.5.1 Tourism area

Major habitat types in tourism area included grassy slope, rock grass interface, rocky substrate adm roadside. Control burning in february, as part of the park management, created a new habitat; burnt rock grass interface. Rock- grass interface had highest activty followed by burnt rock grass interface and roadside.

Table 12 Behaviour across different habitat types in tourism area

Row Labels	**Travelling**	**Standing and observing**	**Feeding**	**Resting**	**other**	**total observation**
grass-shrub	4	2	33	0	0	39
grassy slope	120	91	685	55	29	981
roadside	165	161	450	380	47	1203
rock-grass	179	179	848	419	57	1683
rock-grass burnt	137	132	790	254	15	1328
rocky	39	44	42	295	6	426
Grand Total	**644**	**609**	**2848**	**1403**	**154**	**5660**

Rock-grass interface followed by burnt rock-grass interface had most number of observation form tourism area.

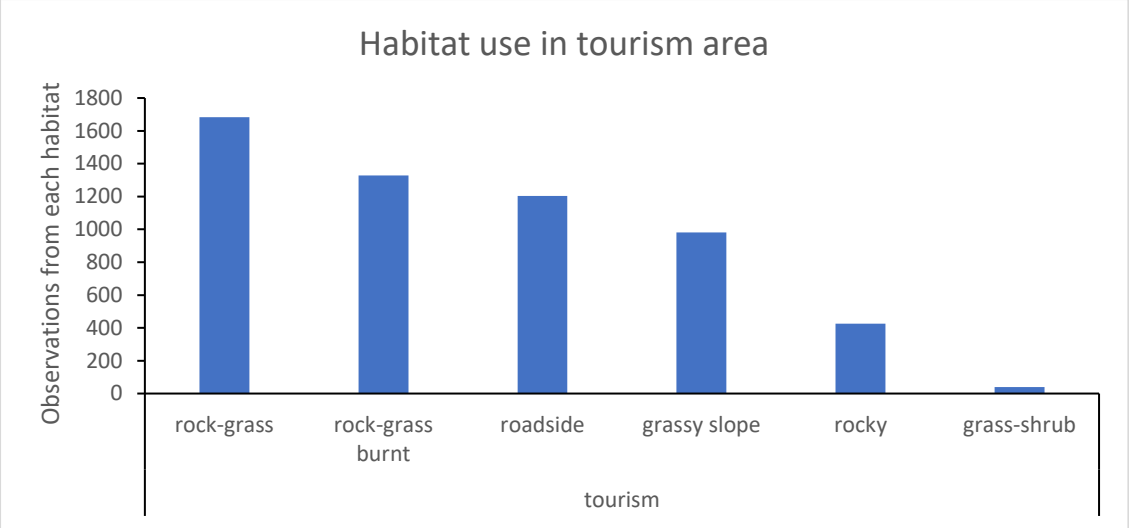

Figure 19 Number of observations form each habitat type in tourism area

Feeding was the most frequent behaviour in all habitat types except for rocky substrate where resting was more (69% resting).

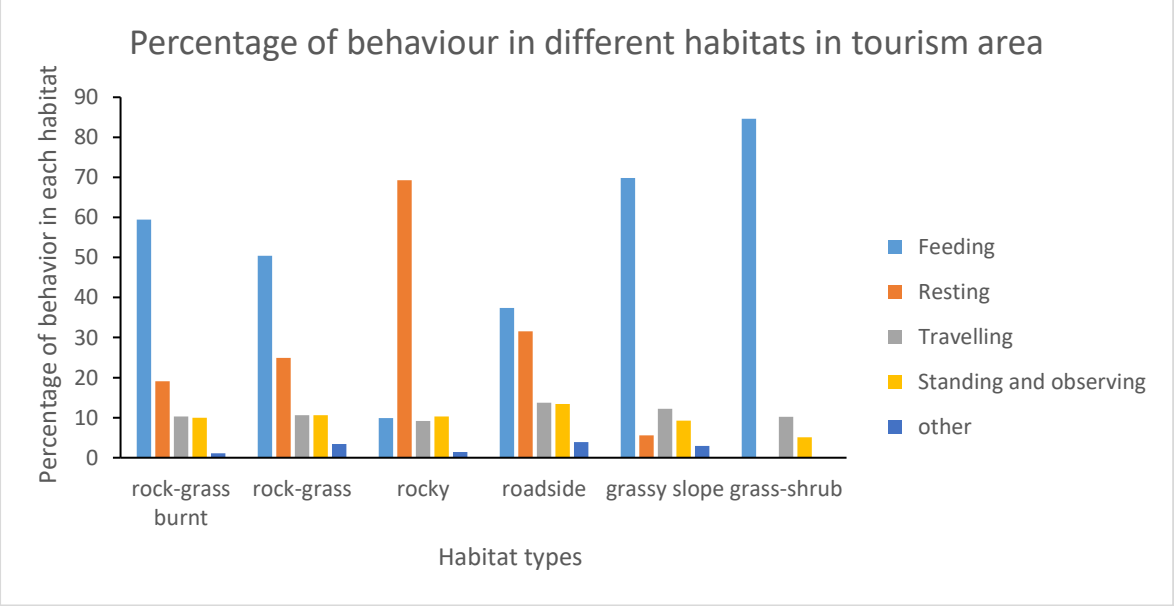

Figure 20 Percentage of behaviour in different habitat in tourism area

Rock grass interfsce had the highest proportion habitat used followed by roadside, except for feeding, where burnt rock-grass interface had more observation than roadside. No behaviour was restricted to any particular habitat.

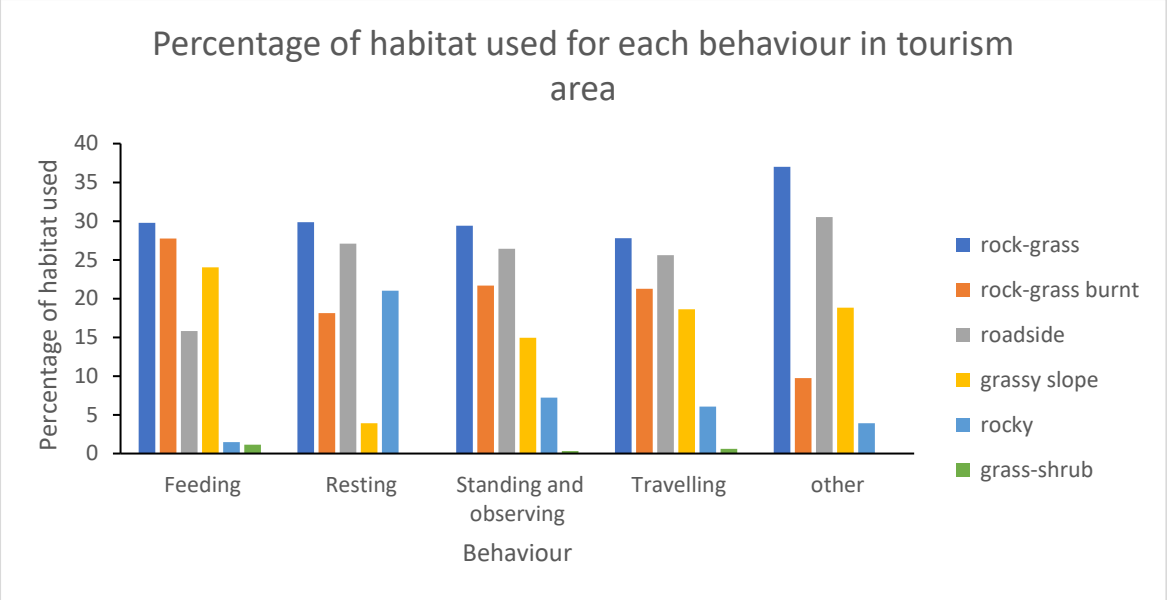

Figure 21 Percentage of habitat used for each behaviour in tourism area

Generalised linear modelling (Glm) was done to check for the factors influencing each behaviour. In tourism area, feeding and resting were seen to be having an interactive effect between habitat and Age sex class whereas standing and observing and travelling were seen to have an additive effect between habitat type and age sex class. Glm with habitat type being predictor variable and behaviour being the response variable showed that the feeding behaviour had a strong negative relation with rocky habitat and roadside and rock grass interface was shown to be having slight negative influence on feeding.

Table 13 Relationship between feeding and different habitat type in tourism area using Glm

	Estimate	Std. Error	z value	Pr(>|z|)
Intercept	1.60944	0.77460	2.078	0.03773 *
grass-shrub	0.09531	0.89273	0.107	0.91498
grassy slope	-0.77038	0.77771	-0.991	0.32190
roadside	-2.12426	0.77688	-2.734	0.00625 **
rock-grass	-1.59399	0.77613	-2.054	0.04000 *
rock-grass burnt	-1.23428	0.77663	-1.589	0.11200
rocky	-3.82241	0.79146	-4.830	1.37e-06 ***

Resting, standing and observing and travelling did not show any particular habitat preference. Animals were using all multiple habitats for these behaviours without any particular preference.

Table 14 Activity in different habitats with respect to time of the day

Time of Day	grass-shrub	grassy slope	roadside	rock-grass	rock-grass burnt	rocky	Grand Total
08		25		14	3		42
09		10	46	77	19	116	268
10		50	141	282	226	208	907
11	21	46	116	305	395	15	898
12		185	276	296	194	21	972
13	11	231	278	143	173	17	853
14	1	149	167	143	59	34	553
15		102	118	188	101	15	524
16	6	129	48	172	59		414
17		54	13	63	99		229
Grand Total	**39**	**981**	**1203**	**1683**	**1328**	**426**	**5660**

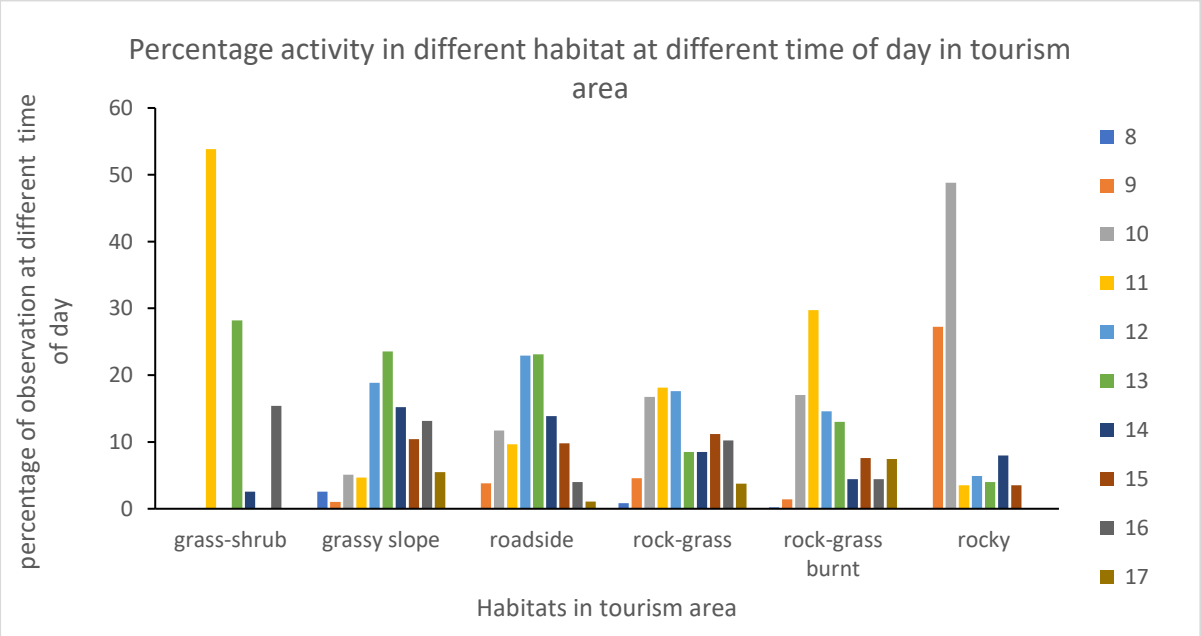

Figure 22 Percentage of activity in different habitat across time of the day in tourism area

Except for the rocky and the greassy shrub, in all the other habitats activities were higher dureing the afternoon hours.

On all the three seasons,when tahr were on rocky substrate they are found to engage more in resting behaviour; and when they were on grassy slope, feeding had highest

proportion of occurance. However, no behaviour was restricted to any particular habitat. There was very less observation from grass-shrub substrate.

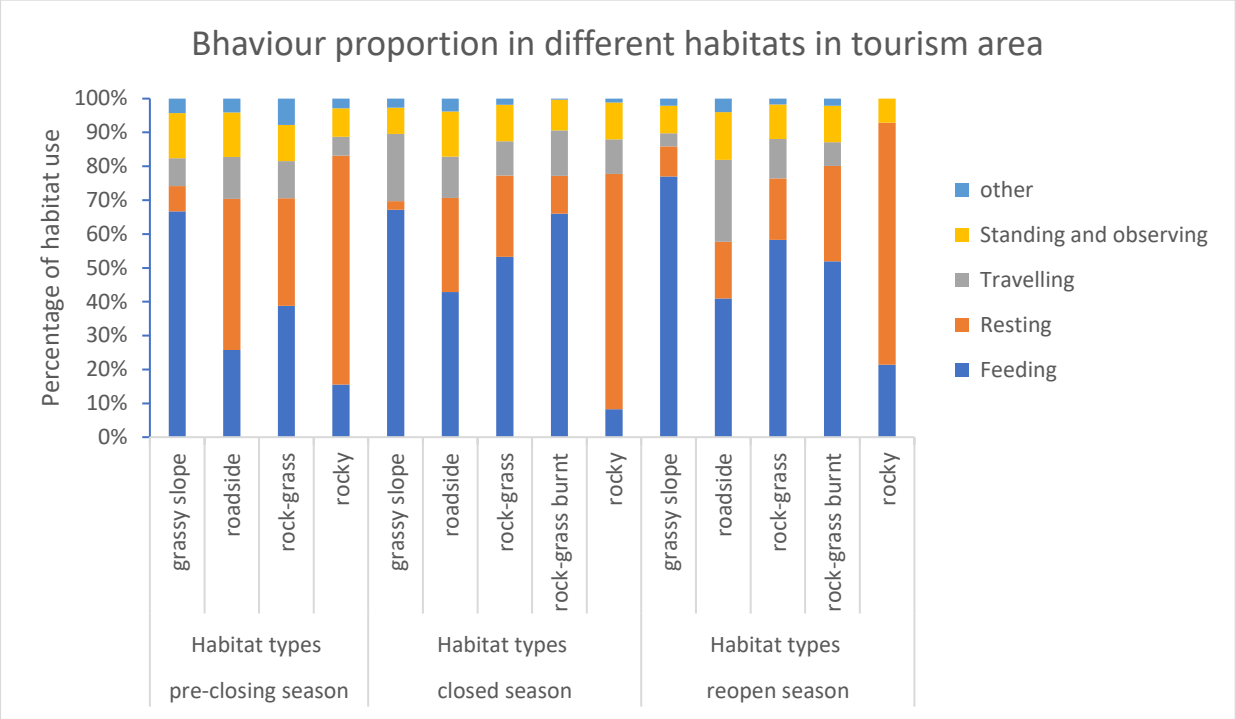

Figure 23 Behaviour proportion in each habitat types in tourism area across the tourims season

4.5.2 Roadside behaviour

Figure 24 Nilgiri tahr adult female and young one in tourism road

Nilgiri tahr were also active near the roadside. They travelled along the road along wihile feeding and resting by the roadside. Overall, feeding was the most common activity along the road which was followed by resting and travelling.

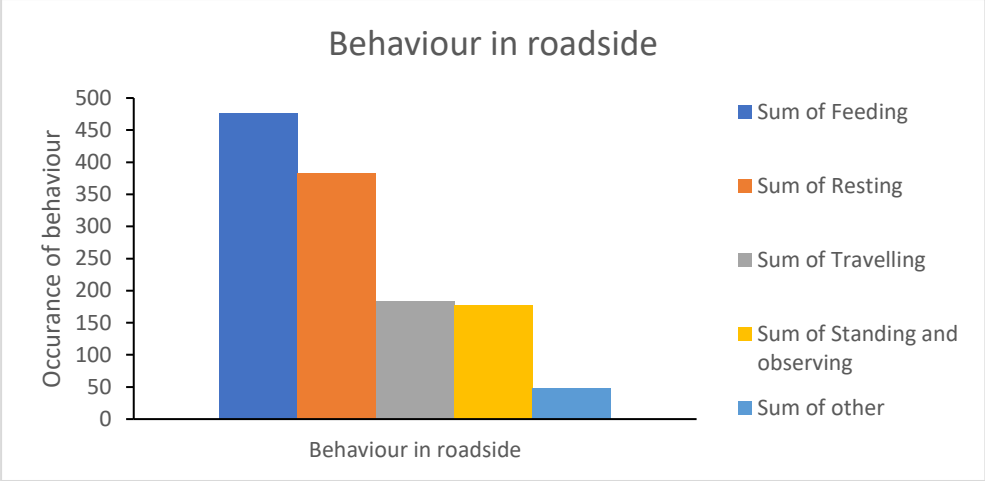

Figure 25 Behavior observed in roadside.

The grasses growing along the roadside and in between pavements were fed by the tahr and the washroom near the roadside was a regular liking site. For resting they prefer both road as well as the side wall made of rocks.

However, this varied in tourism and non tourism season. Tahr engaged in more resting behaviour near roadside during month of January when tourism was open while feeding was more during closing season. The control burning and absence of humans could have influenced this change.

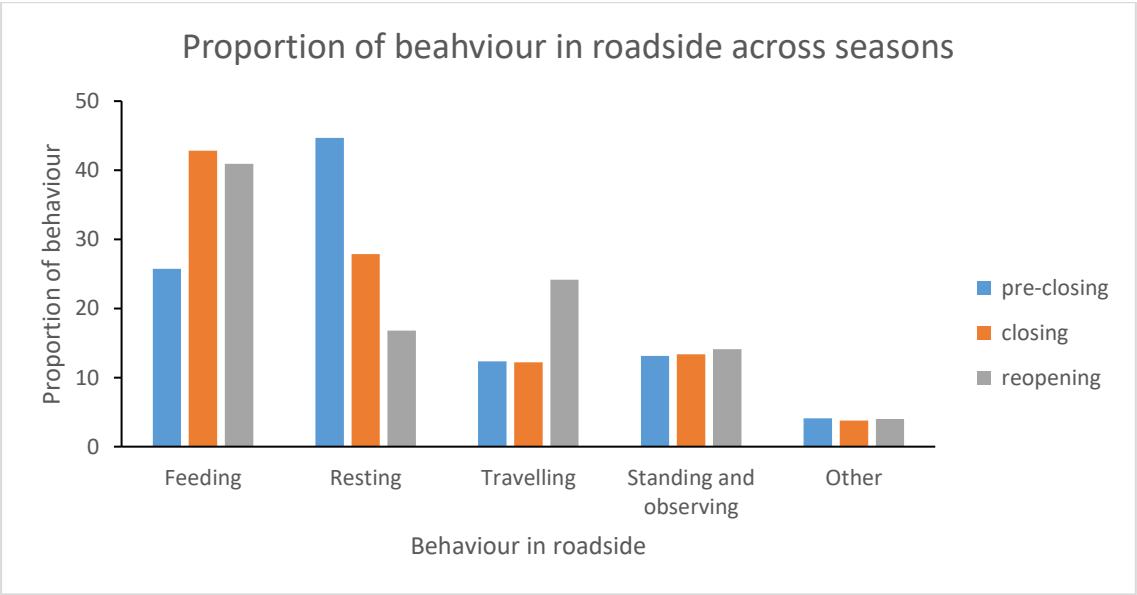

Figure 26 Proportion of behaviour in tourism road across tourism seasons.

4.5.3 Habitat Use core area

The study in core area was carried out after control burning and most of the observations from core area were from burnt grassy slope.

Table 15 Behaviour in different habitat types in core area

Row Labels	Travelling	Standing and observing	Feeding	Resting	other	total ind
grassy hill	3	51	44	37	0	135
grassy slope	102	86	112	1	0	301
grassy slope burnt	43	58	332	239	4	676
rock-grass burnt	5	32	155	33	0	225
rocky	16	11	2	47	1	77
Grand Total	**169**	**238**	**645**	**357**	**5**	**1414**

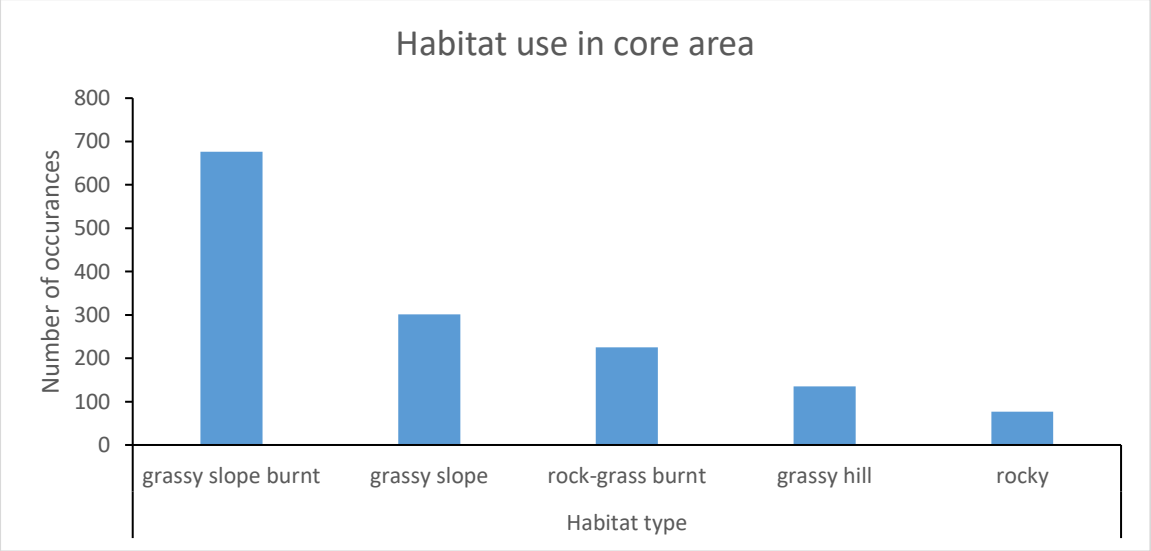

Figure 27 Habitat use in core area

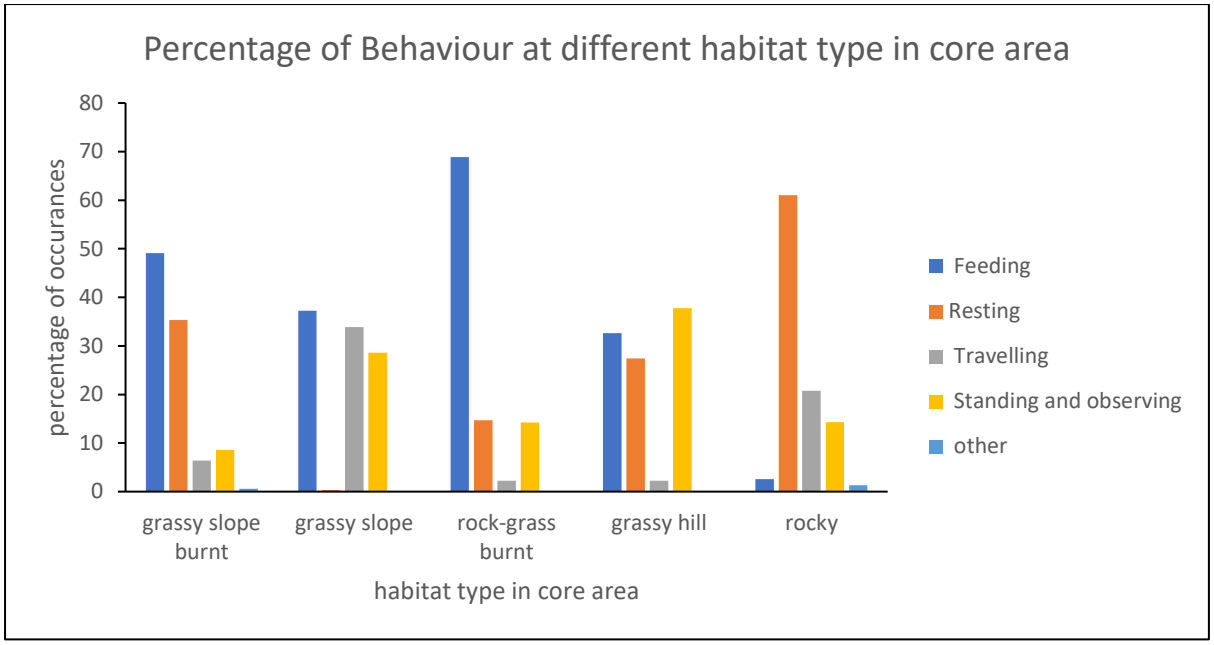

Figure 28 Percentage of behaviour at each habitat type in core area

In burnt grassy slope and burnt rock grass interface, feeding was the major activity. However, simillar to tourism area, rocky substrate had more resting behavior. Grassy slope had higher occurances of travelling and statnding and observing whereas grassy hill top had higher standing and observing occurances compared to other behaviours.

Glm analysis were carried out with Habitat type being the predictor variable and behaviour being the response variable. The result showed that burnt grassy slope and burnt rock grass were having high influence on feeding behaviour whereas rocky habitat had slight negative effect. Grassy slope was not found to have any significant influence.

Table 16 Relationship between feeding and habitat use in core area

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-0.7267	0.1836	-3.957	7.57e-05 ***
grassy slope	0.2034	0.2189	0.929	0.352832
grassy slope burnt	0.6912	0.1991	3.472	0.000517 ***
rock-grass burnt	1.5216	0.2334	6.521	7.00e-11 ***
rocky	-2.8977	0.7395	-3.918	8.91e-05 ***

For resting behaviour, grassy slope was showing negative association whereas rocky habitat was showing positive association.

Table 17 Relationship between resting and habitat use in core area

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-0.9740	0.1930	-5.048	4.46e-07 ***
grassy slope	-4.7297	1.0201	-4.637	3.54e-06 ***
grassy slope burnt	0.3706	0.2091	1.773	0.07629 .
rock-grass burnt	-0.7869	0.2697	-2.918	0.00353 **
rocky	1.4230	0.3031	4.696	2.66e-06 ***

Standing and observing was very negatively correlated and wasless prominent in both burnt grassy slope and burnt rock grass interface. Rocky habitat was also negatively correalated

Table 18 Relationship between standing and observing and habitat use in core area

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-0.4990	0.1775	-2.811	0.004940 **
grassy slope	-0.4173	0.2186	-1.909	0.056275 .
grassy slope burnt	-1.8671	0.2244	-8.319	< 2e-16 ***
rock-grass burnt	-1.2980	0.2607	-4.980	6.37e-07 ***
rocky	-1.2928	0.3709	-3.485	0.000491 ***

Travelling was highly positively correlated with grassy slope and correlated poitively woth rocky substrate

Table 19 Relationship between Travelling and habitat use in core area

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-3.784e+00	5.838e-01	-6.482	9.07e-11
grassy slope	3.116e+00	5.964e-01	5.225	1.75e-07
grassy slope burnt	1.095e+00	6.047e-01	1.811	0.07020
rock-grass burnt	-4.691e-09	7.385e-01	0.000	1.00000
rocky	2.446e+00	6.479e-01	3.775	0.00016

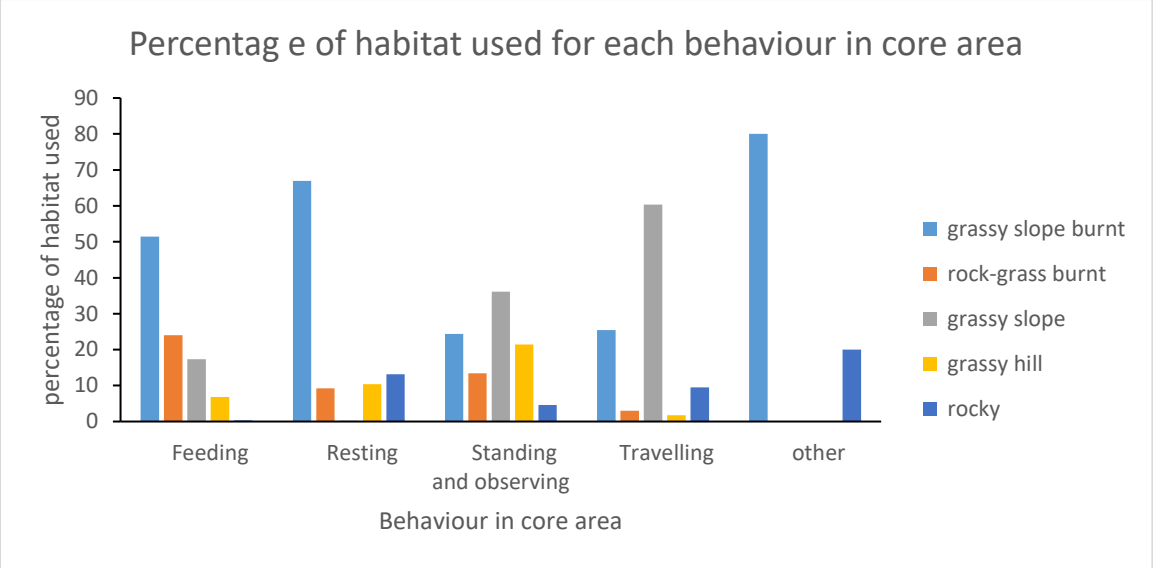

Figure 29 Percentage of habitat used for each behaviour in core area

Table 20 habitat use in core are with hour of the day

Time of Day	grassy hill	grassy slope	grassy slope burnt	rock-grass burnt	rocky	Grand Total
07			6			6
08			32			32
09			65			65
10	27		24	39	19	109
11	45	74	117	82	16	334
12	42	63	66	61	35	267
13	21	20	97	26		164
14		9	11	2	6	28
15		35	81		1	117
16		100	72	7		179
17			95	8		103
18			10			10
Grand Total	**135**	**301**	**676**	**225**	**77**	**1414**

4.4. Predator presence

The camera trap in tourism area road revealed the presence of 3 Tigers and 2 Leopards in the tourism and adjacent areas. The Tiger and leopards were seen in both nearby tea plantation as well travelling along the the tourism road. Tigers were caught in camera trap even during the tourism season. However, all the predator sightings occurred between dusk

and dawn from 8 pm and 6 am and interestingly, Nilgiri tahr never came in any camera traps during this time.

Core Area

In core area, along with tiger and Leopard, presence of wildfogs were also detected. Atleast 3 Tigers and 2 leopards are present in Varattukulam part of core area.

Figure 30 T1 - Resident with most number of images (23 pictures across 13 days within 3 months)

Figure 31 Predators present is tourism area

Figure 32 Predators present is core area

5. DISCUSSION

5.1. General behaviour observed in tourism zone

Nilgiri tahr were found to spend their day time in tourism zone. They used to reach the zone around 9 am but were hesitant to come to road immediately. They used to rest on the rocky boulder/ substrate or observe the area. They will also feed along the rock grass interface and around 11 am they start to venture to other parts of tourism zone as well. For most of the days, they used to be in and around tourism road, feeding or resting, till evening 4pm. Around 4 pm they start moving back towards the cliffs in Rajamalai hill. They will be feeding as they travel back to the cliff.

Figure 33 tahr spending their initial hours of the day in rock after reaching tourism zone

5.2. Group composition in tourism area

The group size arriving at the tourism zone varies from 3 to 48 with average group size of 20 individuals. The herd generally comprises of adult females, juveniles and light brown males. Observations of females accounts for nearly 45 % and young one nearly 25 %. Once in a while a bachelor herd with around 10 light brown males and dark brown males join arrive at the tourism zone increasing the herd size. There was another bachelor herd of 6

individuals comprising of saddlebacks and Dbm which used to stay around range office and road before tourism zone. They rarely came to tourism zone where tourists were present.

The young ones in their early days rarely down to the road, especially when humans are present. Adult females try to bring them down and after few days young ones also starts using the road. Generally, the young ones from a herd were seen travelling and feeding together and would sometimes even be away from adult females. On one occasion during closing season, ten young ones and two yearlings were seen feeding in tourism zone and no adult individuals were see anywhere near a 50m radius.

Figure 34 Young ones observing tourists from above

5.3. Group size and composition in core area

The average group size in core area is around 15 individuals, varying from solitary males to larger herd with 48 individuals. bachelor herd with 6 to 8 individuals were often spotted and they seemed to be much more tolerant to human presence than the mixed herd with young ones. Saddlebacks in bachelor herds were seen resting in front of us even when they saw, provided we were sitting. Once we start approaching towards them, they show flight response. Mixed herd with young ones were more cautious and gave alarm call (a whistle) when they spot us.

5.4. Human-tahr interaction in tourism zone

The Nilgiri tahr herd in tourism zone has become habituated to the presence of humans due to their constant interaction with tourists and nearby plantation workers for decades (Hingham and Shelton, 2011). While discussing with the staffs in the park, they mentioned how people used to provide food or salt to tahr during the earlier times, when tourism was not as organised as today, to see tahr at a closer distance. This practice might have initiated the habituation of Nilgiri tahr to humans. tahrs could be habituated to human presence by providing salt which was done by Rice for behavioural study of Nilgiri tahr (Rice, 1984). Habitation leads to reduction in response towards external stimulus (Mazur, 2006), in this case presence of humans (Shackley,1996; Hingham & Shelton,2011).

Figure 35 Tourists interaction with the tahr

Since Nilgiri tahr are habituated, tourists are able to go very close to them. Most of the tourists engage in observing and taking picture, however, in many instances people also touch the animals. The intensity of contact varies form touching and slightly patting to holding on horns and legs. The response by tahr towards touching by humans were found to be more individual dependent as well as activity dependent. One adult female was known to dislike any touch and showed aggressive display even though she was comfortably walking in between crowd of people. On the other hand, there was a male yearling which used to approach me while taking observation on multiple occasion and try to playfully hit my knees and shoes. Most of the individuals in tourism zone moved when humans try to touch them,

however, when they rest along the fence near the roadside, they showed little response to touch.

5.5. Food provisioning

The cafeteria in the tourism zone is often a feeding location for Nilgiri tahr. tahr were seen to be feeding on cakes, ice cream packets, tissue paper and paper packaging. The watchers and staffs constantly try to chase away them from the garbage bin, but they return undeterred. Upon informing the forest department, they have taken immediate steps to remove the ineffective waste bins and have started building fence to prevent tahr from accessing the cafeteria.

Figure 36- Food provisioning in cafeteria where tahr feeds on paper, food waste and at times plastic

Another major resource for tahr is the presence of salt near the washroom. Nilgiri tahrs spent a considerable amount of time licking the walls and stones near the washroom. tahr were found to lick on the side walls of the washroom for 3961 seconds or nearly 66 minutes across different focal and adult female were seen licking the most. Salt is known to attract tahr and other mountain ungulates which even make s them habituated to humans (Rice, 1984, Harris, 2023)

These food provisioning were considered as a leading factor which attracts tahr to the tourism area and if so, a decline in number of tahr were expected when the park closes for two months. However, tahr were present in good numbers in tourism season even when park

and café were closed and washroom was not used, proving the fact food provisioning by the cafe is not the sole reason for the presence of tahr.


vv

Figure 37- tahr licking the walls of washroom

Staff quarters near range office also witnesses Nilgiri tahr feeding on garbage and leftover food waste. there were also instances when Nilgiri tahr entered the kitchen of the staffs and was chased away by them. They also used to lick on a moist wall as well as near a washing stone most possibly for salt. One individual was seen licking and chewing on broken pieces of asbestos sheet.

Figure 38- Bachelor herd feeding in Range office

5.6 Difference in behaviour within tourism area across tourism seasons

Chi sq. test and G test showed a significant difference in behaviour across tourism seasons. Mainly two factors changed during these seasons. Tourism closing leading to lesser human tahr interaction and control burning in tourism area altering habitat use. The closing season also saw an increase in the number of young ones which could have also altered the behaviour.

The control burning was done as part of park management to ensure adequate forage availability within National Park (Saju, 2012). It would also prevent the tahr from venturing into nearby human dominated areas which might have led to poaching. After the control burning, the tahrs were seen to spent majority of their activity in and around the burnt area.

Figure 39 tahr behaviour in burnt habitat in tourism area

5.7. Difference in behaviour between tourism and core area

5.7.1. Flight distance

Habituation has caused a change in the tahr behaviour in tourism area and the most significant difference which could be observed is the change in the flight distance (Boer et al, 2003; Hingham & Shelton, 2011; Harris, 2023). Measure of flight distance can be considered as measure of shyness or sensitivity to disturbance (Boer et al, 2003).

The mean flight distance observed in the core area was 118.5 meter, whereas in the tourism zone, where tahr are interacting with humans in a daily basis, it is just under 2m. Many times, people could even touch the tahr (though it is not allowed). In the range office and the adjacent police wireless station also, the flight distance was found to be on an average 5m and very less compared to that in core.

However, the tourism adjacent hill, which is away from tourism zone and human interaction but still the continuation of the tourism hill, the mean flight distance was 75m. there could be few possibilities for this;

i. The tahr in the tourism adjacent zone might be a different population with minimal human interaction in the same landscape or
ii. They belong to the same population, however these individuals might be still pursuing humans as a threat and avoids interaction

This flight distance reduction in tourism area also poses a risk of poaching as the animal losing its fear of humans might not attempt to escape or be too late to escape (Hingham and Shelton, 2011, Harris, 2023).

5.7.2. Activity pattern

The activity pattern of Nilgiri tahr is showing a difference in tourism area and core area. The generally observed activity pattern of Nilgiri tahr is that they feed on grassy slopes on early morning and again in late evening and rest on the cliff edges during the hot afternoon hours (Blandford 1888-91; Prater, 1971; Rice,1984). Similar observation was obtained for the core area, however in tourism zone there was a deviation from this pattern. The tahr used to travel from the adjacent cliff and upon reaching they rest for around an hour.

Around 11 they start feeding and from then feeding has higher proportion of activity. This difference in activity pattern was seen across all the three tourism seasons. In both areas, feeding was major activity (45.61% in core and 50.31% in tourism) followed by resting (25.24% in core and 24.78% in tourism).

Core area has a higher proportion of standing and observing compared to tourism area. It could be due to the fact that tahr in tourism area feels safe from the predators due to the presence of humans in the area and hence spend less time and effort for vigilant behaviour and spent more on other behaviour.

5.8. Habitat use by tahr

In tourism area, rocky habitat was found to have negative correlation with feeding. This is true as the only feeding behaviour seen in the rocky substrate were occasional licking and drinking on moist rock. It also showed mild negative correlation for feeding in roadside, however in roadside feeding was the most frequent behaviour. This could be understood as, even though feeding is major activity in roadside, it has lesser proportion of feeding compared to other habitats. In tourism area, feeding was not found to be restricted in any particular habitat (Figure 17 and 18)

In core area also rocky substrate had negative relation with feeding, but burnt grassy slope and burnt rock grass interface had positive influence. This was also clearly observed during the filed work where Nilgiri tahr used to spend long time feeding on fresh sprouts and ashes the burnt habitat. There was an interesting observation where a tahr group from almost 2 km came to a burnt grassy hill for foraging and as soon as it spotted us the herd started running back to the cliff. The presence of fresh sprouts needs to be considered a s a very important factor influencing the tahr behaviour as the herd ventured grassy plains far away from escape terrain to feed them.

For resting behaviour in tourism area, there was no clear preference for any habitat type and they rested in almost all habitats and importantly, there was no negative correlation with any habitat. However, in core area, resting had positive correlation with rocky habitat and negative correlation with grassy slopes. This could be due to the predation pressure in core area, where grassy slopes might be used as a cover by predators to ambush and hence resting in avoided in these habitats. While taking samples, I was able to approach tahr in grassy slope much closer than other habitats as I was able to take cover behind the thick grass cover. Predators could also be doing the same and it could be the reason why tahr avoids grassy slope for resting. The travelling is found to be higher in grassy slope which also indicates the tahr prefers moving in grassy slope that resting.

In burnt area, the grass height is very less and hence tahr used to take rest here while feeding as there is no cover for predators. Hence it did not show any relationship with resting or travelling.

5.9 Predator presence and Human shield hypothesis

The tourism area was found to have the presence of Tiger and Leopard. Even then the area is being used by Nilgiri tahr means Human shield hypothesis is not as prominent in the tourism road of national park as the main concept of HSH is that the places with high human disturbance displace large predators which benefits prey species by shielding them from carnivores (Berger, 2007; Muhly et al, 2014; Granador et al, 2023). Not only the carnivores are present in the area, there is also spatial overlap between tahr and its predators.

Since the park was closed during February and March and humans' presence reduced, initial assumption was that the tahr would avoid coming to tourism area during this season. As expected, camera trapping revealed the activity of carnivores in tourism road at night time in tourism area. However, the tahr still came to the park and spent their morning hours there.

However, there was a temporal separation or avoidance adopted by Nilgiri tahr to survive in the tourism area. All the images of carnivores in tourism area (33 tiger images and6 leopard images) were captured during the night between 8 pm and morning 6 am. Even though the park was closed for the tourists, it still had human presence in the way of vehicular movement. Also, renovation works of tourism fencing were happening which also made the human presence visible. These might have deterred the Carnivores from coming during day time. tahr were never seen in the area during this time and they used to arrive at tourism area after 8 am and leaves before 6 pm. This way, tahr were able to maximise the benefit of being in tourism area in the day time, when carnivores are not active and could forage without any predation pressure and leaving to the cliff during night time for resting.

6. CONCLUSION AND RECOMMENDATION

There is a significant influence of tourism on the wild behaviour of Nilgiri tahr. It is evident from its very small flight distance, which is almost non-existent in the tourism area, and its change in habitat use compared to the core area. The pictorial representation given below summarises the habitat use and behaviour in core and tourism area.

Table 12 Behaviour and habitat use relation in core area

Behaviour	Rocky	Burnt rock grass	Burnt grass	Grassy slope
Feeding				
Resting				
Travelling				
Standing and observing				

Table 13 Table 13 Behaviour and habitat use relation in tourism area

Behaviour	Rocky	Burnt rock grass	Rock grass	Roadside	Grassy slope
Feeding					
Resting					
Travelling					
St. observing					

Strong Negative mild negative No relation mild positive strong positive

The figure depicts the extend of change happened in the behaviour of tahr in the tourism zone. It seems like habituation has diluted the survival instincts of Nilgiri tahr in the tourism area and every behaviour is being observed in every habitat, except for feeding.

However, their temporal separation with carnivore activity hints that hey retain some wild behaviour and the behavioural change could be only directed towards human

Habituation could be a temporary or permanent waning of response; however, measures should be taken to ensure that it does not affect the survival rate of this endangered species. The high human tahr interaction might also carry a potential threat of disease and parasite transfer, especially because tahrs are licking the washroom walls. Study needs to be done on the parasitic load on the tahr in tourism area to check for any possible transmission of disease from humans or livestock to tahr.

APPENDIX I

Ethogram: Classification of Nilgiri tahr behaviour for the current study

Feeding (F) -Head bend down to the substrate and animal engaged in biting or searching for food.

Licking(L)- Rubbing tongue against a substrate to obtain water or salt.

Drinking (D) – Head bend down to a water body and intaking water.

Resting (R) - animal laying down with either folded legs and upright head, or straight legs and bended neck, with or without engaging observing the surrounding

Standing and observing (St)- Animal upright on all four legs and looking to any particular direction

Travelling (T) Moving from one place to other by walking, running or climbing cliff

Grooming (G) - cleaning or scratching body with legs, horns or tongue or scratching itself on to an object like fence, tree, rock or wall.

Social (Sc) – engaging in interaction with other individuals in positive or negative manner.

Nursing (N) adult female giving milk to young one or yearling

Suckling (Sk) Young one or yearling drinking milk from adult female.

Allogrooming (SG) scratching or cleaning the body of another individual using their tongue.

Aggression (SAg) displaying antagonistic behaviour towards another animal or human by fighting, headbutt, or display.

REFERENCE

Alempath, M. & Rice, C. (2008). *Nilgiritragus hylocrius*. The IUCN Red List of Threatened Species 2008: e.T9917A13026736. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T9917A13026736.en.

Altmann, J. (1974). Observational Study of Behavior: Sampling Methods. Behaviour, 49(3–4), 227–266. https://doi.org/10.1163/156853974x00534

Andersen, R., Linnell, J.D.C. & Langvatn, R. (1996): Short-term behavioural and physiological response of moose Alces alces to military disturbance in Norway. - Biological Conservation 77: 169-176.

Benirschke, K., Kumamoto, A.T. (1980). The chromosomes of the Nilgiri tahr. Int. Zoo yearbook 20, 274–275.

Berger, J. (2007). Fear, human shields and the redistribution of prey and predators in protected areas. Biology Letters, 3, 620–623

Blanford.W.T (1888-91) The fauna of British India, including Ceylon and Burma

De Boer, H. Y., Van Breukelen, L., Hootsmans, M. J., & Van Wieren, S. E. (2004). Flight distance in roe deer Capreolus capreolus and fallow deer Dama dama as related to hunting and other factors. Wildlife Biology, 10(1), 35–41. https://doi.org/10.2981/wlb.2004.007

Chandrasekharan, C. (1962). Forest types of Kerala. Indian Forester 88: 837-847

Coppes, J., Burghardt, F., Hagen, R., Suchant, R., & Braunisch, V. (2017).Human recreation affects spatio-temporal habitat use patterns inred deer (Cervus elaphus). PLoS One, 12(5), e0175134

Davidar, E.R.C. (1963). Census of the Nilgiri tahr Hemitragus hylocrius Ogilby in the Nilgiris. Journal of the Bombay Natural History Society 60: 251-252

Davidar, E.R.C. (1971). A note on the status on the Nilgiri tahr Hemitragus hylocrius Ogilby on the Grass hills in the Anamalais. Journal of the Bombay Natural History Society 68: 347-354

Davidar, E. R.C. (1978). Distribution and status of the Nilgiri tahr Hemitragus hylocrius 1975-1978. Journal of the Bombay Natural History Society 75: 815-844

Easa, P.S; Sivaram, M (2002). Habitual suitability index model for Nilgiri Thar in Eravikulam National Park. (KFRI Research Report No: 242: 42p)

Edington, J.M. & Edington, M.A (1986). Ecology, recreation and tourism. Cambridge University Press, Cambridge. 200 pages. ISBN 0-521-30646-9 (hardback), 0-521-31409-7

Fossey, D. (1983). Gorillas in the mist. London: Hodder and Stoughton.

Granados, A., Sun, C., Fisher, J. T., Ladle, A., Dawe, K., Beirne, C., Boyce, M. S., Chow, E., Heim, N., Fennell, M., Klees van Bommel, J., Naidoo, R., Procko, M., Stewart, F. E. C., & Burton, A. C. (2023). Mammalian predator and prey responses to recreation and land use across multiple scales provide limited support for the human shield hypothesis. Ecology and Evolution, 13, e10464. https://doi.org/10.1002/ece3.10464

Green, M. J. B. (1978) The ecology and feeding behaviour of the Himalayan tahr (*hemitragus jemlahicus*) in the Langtang valley, Nepal. Masters thesis, Durham University.

Green, R. & Giese, M. (2004). Negative Effects of Wildlife Tourism on Wildlife. In Higginbottom, K. ed., 2004. Wildlife tourism: Impacts, management and planning (pp. 81-97). Common Ground Publishing Pty Ltd

Haltenorth, T., 1963. KlassiWkation des Säugetiere: Artiodactyla. Handb. D. Zoologie, Berlin 8, Lfg. 32, 1–167.

Hanson, T. (2001). Th e impenetrable forest. New York: Writer's Showcase.

Harris, Richard B.; Aluzas, Kurt; Balyx, Laura; Belt, Jami; Berger, Joel; Biel, Mark; Chilton-Radandt, Tonya; Côté, Steeve D.; Cunningham, Julie; Ford, Adam; Happe, Patti; Lehman, Chad P.; Poole, Kim; Rice, Clifford G.; Safford, Kirk; Sarmento, Wesley; and Wolf, Laura (2023) "Habituated, Tolerant, or Salt-conditioned Mountain Goats and Human Safety,"

Heinmann,D (1968) Der tahr. In grzimeks Turleben 13:542-544. Zurich:Kindler Verlag

Higginbottom, K. ed. (2004). Wildlife tourism: Impacts, management and planning. Common Ground Publishing Pty Ltd

Higham, J. & Shelton, E. J. (2011). Tourism and wildlife habituation: Reduced population fitness or cessation of impact? Tourism Management, 32(6), 1290–1298. https://doi.org/10.1016/j.tourman.2010.12.006

Jerdon, T. C. (1984) Handbook on the Mammals of India , 288-290

Karunakaran, P. V., G. S. Rawat & V. K. Uniyal. (1998). Ecology and Conservation of the Grasslands of Eravikulam National Park, Western Ghats. Wildlife Institute of India, Dehra Dun, India.

Kandel, S., Ghimire, P., Silwal, T., & Low, M. (2022). Potential impact of trophy hunting on vigilance and flight behaviour in Blue Sheep (Bharal: Pseudois nayaur). Global Ecology and Conservation, 40, e02317. https://doi.org/10.1016/j.gecco.2022.e02317

Knight, J. (2009). Making wildlife viewable: habituation and attraction. Society and Animals, 17, 167e184.

Larson, C. L., Reed, S. E., Merenlender, A. M., & Crooks, K. R. (2016).Effects of recreation on animals revealed as widespread through aglobal systematic review. PLoS One, 11(12), e0167259.

Lemelin, R. H. (2006). The gawk, the glance, and the gaze: Ocular consumption and polar bear tourism in Churchill, Manitoba, Canada. Current Issues in Tourism, 9 (6), 516-534.

Lloyd, J. and Ajarova, L. (2005). Chimpanzee habituation for tourism. In J. Caldecott and L. Miles (Eds.) World atlas of great apes and their conservation (pp. 76-77). Berkeley: University

of California Press.Lydekker, R. (1913). Catalogue of the Ungulate Mammals in the British Museum (Natural History). London and New York: Johnson Reprint Company

Lydekker, R. (1898). Wild oxen, sheep & goats of all lands, living and extinct. https://doi.org/10.5962/bhl.title.885Madhusudan, M. D. (1998). Thinking like tahr, Nature watch. Resonance, 3(5), 43–47. https://doi.org/10.1007/bf02838841 In-Text Citation:

Marler, P.R., & Hamilton, W.J. (1966). Mechanisms of animal behavior. Wiley

Madhusudan, M.D., and Johnsingh, A.J.T. 1998. Analysis of habitat-use using ordination: The Nilgiri tahr in southern India. Current Science Bangalore 74(11): 1000-1003.

Mazur, J. (2006). Learing and behaviour (6th ed.). Upper Saddle River, NJ: Pearson Prentice Hall

Naidoo, R., & Burton, A. C. (2020). Relative effects of recreational ac-tivities on a temperate terrestrial wildlife assemblage. ConservationScience and Practice, 2(10), e271

Nielsen, N.O., Oosterhuis, J., Janssen, D., McColl, K., Anderson, M.P., and Heuschele, W.P. 1988. Fatal respiratory disease in Nilgiri tahr: Possibly malignant catarrhal fever. Canadian Journal of Veterinary Research 52: 216-221

Ogilby, W. (1838) Exhibition of the skins of two species of the genus Kemas. Proceedings of the zoological Society of London, '1837', 5: 81.

Oriol-Cotterill, A., Macdonald, D. W., Valeix, M., Ekwanga, S., & Frank,L. G. (2015). Spatiotemporal patterns of lion space use in a human-dominated landscape. Animal Behaviour, 101, 27–39.

Pandiyan, J. Sandeep, M & Desai, A. (2018) Habitat Use of Nilgiri tahr Nilgiritragus hylocrius in Western Ghats, India

Pandav, B., Goyal, S.P. & Nigam, P. (2018) Population Genetic Structure of Nilgiri tahr (Hemitragus hylocrius) in Western Ghats, India: Conservation and Forensic Implications.

Peizhen, Z., Molnar, P., Downs, W.R., 2001. Increased sedimentation rates and grain sizes 2–4Myr ago due to the in Xuence of climate change on erosion rates. Nature 410, 891–897.

Pillai, N.G. 1963. The Nilgiri tahr (Hemitragus hylocrius) in captivity. Journal of the Bombay Natural History Society 60: 451-454.

Potti, S.P. 1966. A note on the breeding of the Nilgiri tahr Hemitragus hylocrius at Trichur Zoo. International Zoo Yearbook 6: 206.

Prater, S.H. 1971. The Book of Indian Animals (Third Edition). Bombay, India: Bombay Natural History Society

Predit, P. P., Prasath, V., Raj, M., Desai, A., Zacharia, J., Johnsingh, A. J. T., Ghose, D., Ghose, P. S. & Sharma, R. K. (2015). Status and distribution of the Nilgiri tahr Nilgiritragus hylocrius, in the Western Ghats, India. Technical report, WWF-India.

Rice, C.G. (1984). The behavior and ecology of Nilgiri tahr (Hemitragus hylocrius Ogilby, 1838). Unpubl. Ph.D. Thesis, Texas A and M University, College Station. 254pp.

Rice, C. G. (1988). Reproductive biology of Nilgiri tahr, Hemitragus hylocrius (Mammalia: Bovidae). Journal of Zoology, 214(2), 269–284. https://doi.org/10.1111/j.1469-7998.1988.tb04721.x

Rice, C. G. (1988a). Habitat, population dynamics, and conservation of the Nilgiri tahr, Hemitragus hylocrius. Biological Conservation, 44(3), 137–156. https://doi.org/10.1016/0006-3207(88)90099-7

Ropiquet, A. and Hassanin, A. (2005), Molecular evidence for the polyphyly of the genus Hemitragus (Mammalia, Bovidae). Mol.Phylogen. Evol. 36: 154-168 https://doi.org/10.1016/j.ympev.2005.01.002

Salvatori, M., Oberosler, V., Rinaldi, M., Franceschini, A., Truschi, S.,Pedrini, P., & Rovero, F. (2023). Crowded mountains: Long-termeffects of human outdoor recreation on a community of wildmammals monitored with systematic camera trapping. Ambio, 52,1– 13

Saju, P.U. (2012) Eravikulam National Park Management plan (2012-2022). https://forest.kerala.gov.in/images/managementplan/eravikulam/2.mangementplan.pdf

Sony, R., Sen, S., Kumar, S., Sen, M., & Jayahari, K. (2018). Niche models inform the effects of climate change on the endangered Nilgiri tahr (Nilgiritragus hylocrius) populations in the southern Western Ghats, India. Ecological Engineering, 120, 355–363. https://doi.org/10.1016/j.ecoleng.2018.06.017

Schaller, G.B. (1977). The Mountain Monarch. Chicago University Press, Chicago, USA

Shackley, M. (1996). Wildlife tourism. London: Thomson Learning.

Skagen, S.K., Knight, R.L. and Orians, G.H. 1991. Human disturbance of an avian scavenging guild. Ecological Applications. 1(2): 215- 225

Swengel, F.B. (1993) Nilgiri tahr studbook Minnesota zoological Garden, USA

Swenson, J.E. 1979. Factors affecting status and reproduction of ospreys in Yellowstone National Park. Wildlife Management. 43: 595-601.

Thyagarajan, N. 1958. The vanishing ibex. Indian Forester 84: 188-191.

Taylor, A.R. and Knight, R.L. (2003), WILDLIFE RESPONSES TO RECREATION AND ASSOCIATED VISITOR PERCEPTIONS. Ecological Applications, 13: 951-963. https://doi.org/10.1890/1051-0761(2003)13[951:WRTRAA]2.0.CO;2Vinod,S.V (2012) Eravikulam National Park Management plan (2022-32).

Van den Bos, J.M. 1984: Terreingebruik en voedselselectievan het edelhert (Cervus elaphus) op de Imbos. – Landbouw Hogeschool, Wageningen, 52 pp. (In Dutch).

Walker,S & Molur,S (1999), Endemic Mammalsin Indian zoo

Yalakki,C.S (2014). Master plan of the Trissur Zoological Park at Puthur, Kerala (relocation of State Museum and Zoo, Trissur). https://cza.nic.in/uploads/documents/zoos/plan/english/MP_thrissurzoo.pdf

Zoochat (2024). https://www.zoochat.com/community/media/nilgiri-tahr-herd.722010/

Zootierliste (2024). https://www.zootierliste.de/en/?klasse=1&ordnung=121&familie=12124&art=50901259&subhaltungen=1