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Research Article

Seasonal Distribution of Hoolock Gibbons (*Hoolock hoolock*) in Karbi Anglong District, Assam, Northeast India: Special Reference to the Marat Longri-Patradisa-Longnit Forest Complex

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ABSTRACT

This study provides a detailed seasonal evaluation of the population dynamics of the Western Hoolock Gibbon (*Hoolock hoolock*) within the Marat Longri–Patradisa–Longnit Forest Complex over a one-year period (September 2023 to August 2024). Systematic field surveys were conducted across four distinct seasons—post-monsoon, winter, pre-monsoon, and monsoon—covering seven Reserve Forests (RF) and District Council Reserve Forests (DCRF). Quantitative metrics including encounter rate, population density, group density, mean group size, sex ratio, and coefficient of variation were analyzed to assess temporal fluctuations in group composition and distribution. Disama RF consistently exhibited the highest population densities and reproductive activity, whereas Longnit RF showed a persistent absence of detections, suggesting possible local extirpation or habitat degradation. The pre-monsoon season registered the highest encounter rate and population density, likely facilitated by increased vocalization and detectability. Conversely, the monsoon season demonstrated the lowest mean group size amidst heavy rainfall and dense canopy cover. Sex ratios remained balanced throughout the study period. The high coefficient of variation (>70%) in group size highlights considerable variability in social structure, potentially influenced by ecological and anthropogenic factors. These findings emphasize the necessity of seasonally stratified monitoring to accurately characterize primate populations and inform effective conservation strategies within fragmented forest landscapes.

Key words: Hoolock Gibbon, Primate, Karbi Anglong, Seasonal Distribution, GIS

INTRODUCTION

Hoolock gibbons (*Hoolock* spp.), the only apes found in the Indian subcontinent; which inhabit tropical and subtropical forests across India, Myanmar, China, and Bangladesh (Kabir et al., 2025; Das et al., 2011). Classified as *Endangered* on the IUCN Red List, they are listed under Appendix I of CITES, affording them the highest level of international protection. In India, they receive strict legal safeguards under Schedule I of the Wildlife (Protection) Act, 1972 (Kumar et al., 2013 Aung et al., 2024). The genus comprises two recognized species the Western Hoolock Gibbon (*Hoolock hoolock*) and the Eastern Hoolock Gibbon (*Hoolock leuconedys*) distinguished mainly by pelage characteristics. Males of the Eastern species possess a silver-grey chest, whereas Western males are entirely black with distinctive outward-tapering white eyebrows. Females of the Western species exhibit uniform limb coloration, while Eastern females have slightly paler hands and feet, often interspersed with white or black hairs (Mootnick & Groves, 2005). Both species display prominent white facial hair contrasting sharply with dark cheeks. Ontogenetic color change follows a distinct pattern: infants are born light grey, turning black in juveniles of both sexes; females' later transition to pale brown and, ultimately, to copper-tan in adulthood (Biswas et al, 2016; Kashyap & Bose, 2024).

Karbi Anglong, the largest district in Assam, supports rich biodiversity within its protected areas, including five wildlife sanctuaries Marat Longri, East Karbi Anglong, Nambor, Garam Pani, and North Karbi Anglong. Karbi Anglong and West Karbi Anglong together encompass five of Assam's ten designated priority Hoolock gibbon conservation areas identified in the *Conservation Action Plan for Wildlife of Karbi Anglong* (CAPWGKA, 2016–2026).

Despite Karbi Anglong's status as a stronghold for hoolock gibbons, scientific knowledge of their seasonal distribution within the district remains limited. Available information is largely confined to scattered presence records, incidental sightings, and broad-scale distribution maps, which fail to capture seasonal variations in habitat use, movement patterns, and group locations. Long-term, systematic field studies are rare, and only a few have examined how gibbon spatial ecology shifts across the monsoon, post-monsoon, winter, and pre-monsoon seasons.

The Marat Longri–Patradisa–Longnit forest complex one of the district's most critical habitats still lacks

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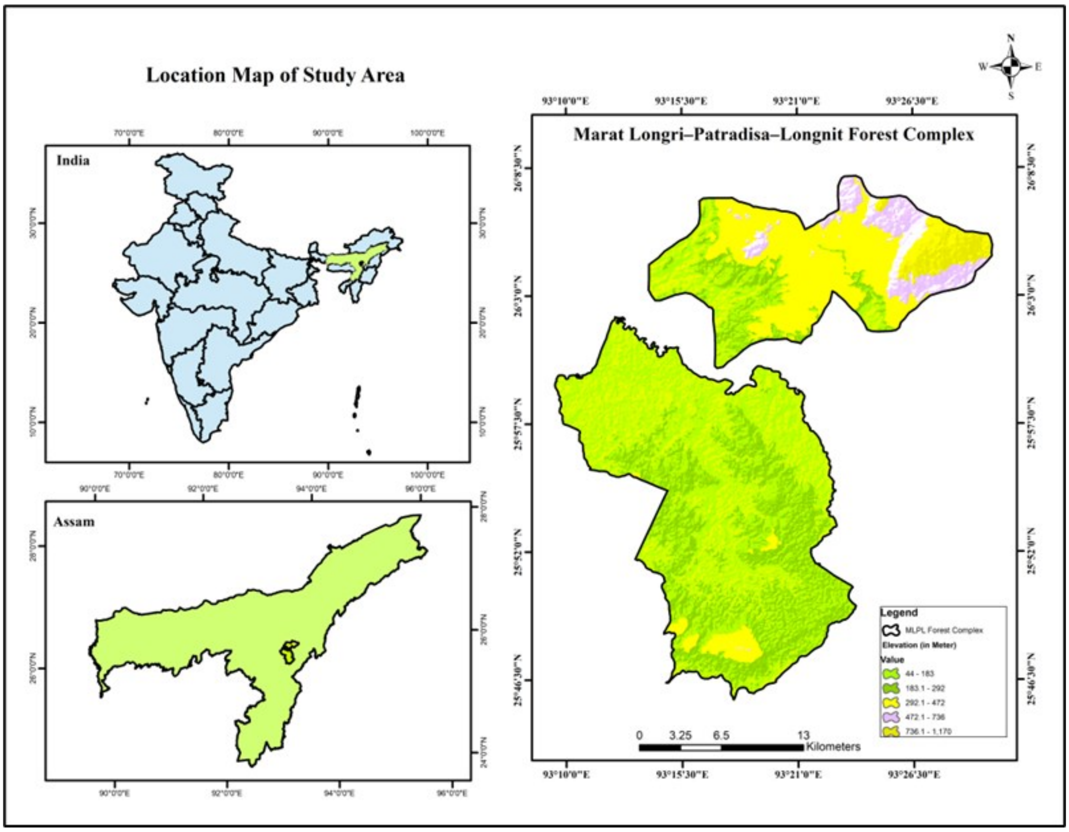

Figure 1. Location map of Study Area

a fine-scale, multi-season distribution map, despite its recognized conservation importance. This knowledge gap hampers the development of targeted management strategies, such as protecting key feeding areas during peak fruiting periods or mitigating seasonal pressures from resource extraction and tourism. Addressing these gaps requires a coordinated, multi-season research approach that combines standardized surveys, phenology monitoring, habitat mapping, and local ecological knowledge. Such an effort would generate the first comprehensive dataset on the seasonal distribution patterns of hoolock gibbons in the Marat Longri–Patradisa–Longnit complex, providing a robust scientific basis for season-specific conservation planning in Karbi Anglong.

MATERIALS AND METHODS

Study Area

The Marat longri-Patradisa-Longnit forest complex is located in Karbi Anglong district of Assam (Figure 1). The complex is lies between the geographical limits of 93^0 08' E and $93^0$30' E longitude and $25^0$45' N latitude and $26^0$10' N latitude. The total area of the complex is 802 Km^2. The Marat longri-Patradisa-Longnit forest complex comprises of seven important Reserve Forests (R.F.) and District council reserve forest (D.C.R.F) namely Meyungdisa (D.C.R.F.), Disama (R.F.), Kaki (R.F.), Englongkiri (D.C.R.F.), Patradisa (RF), Longnit (RF) and Khonbamon (D.C.R.F.).

Survey Period and Field Data Collection

A 12-month field survey (September 2023–August 2024) was conducted to document the distribution of Hoolock Gibbons across four seasonal phases: monsoon (June–August), post-monsoon (September–November), winter (December–February), and pre-monsoon (March–May) (Figure 2). All confirmed sightings were geo-referenced using a Garmin GPS eTrex (accuracy ±5 m), with supplementary photographs and videos for species verification and behavioral observations.

Foot surveys were carried out across forest interiors, edges, and adjacent human-modified landscapes during peak activity hours (05:30 am–11:00 am) to maximize encounter rates. Local forest guards and community members assisted in surveys, contributing valuable traditional ecological knowledge (TEK) for locating gibbon groups and recent activity hotspots.

For each sighting, the following information was recorded:

- Spatial coordinates: Latitude, longitude
- Date and time of detection
- Group size and age–sex composition: Males, Females, juveniles, infants

This participatory approach improved detection probability and enhanced data reliability.

Data Processing and Spatial Analysis

Geospatial data were compiled and analyzed using ArcGIS 10.3 and ERDAS Imagine 2014 to produce season-specific distribution maps. The process involved:

Organizing and geo-referencing all GPS-based sighting records.

Generating distribution maps for each season:

Post-Monsoon (September–November)
Winter (December–February)
Pre-Monsoon (March–May)
Monsoon (June–August)

The resulting distribution maps provide baseline information on the spatial ecology, habitat preferences, and seasonal movement patterns of *Hoolock hoolock* within the Marat Longri–Patradisa–Longnit Forest Complex, offering a foundation for long-term monitoring and conservation planning.

Quantitative Measures of Distribution and Population Parameters

Standard ecological indices were calculated following established primate survey methodologies (Choudhury, 2013; Kakati et al., 2010; Sarma et al., 2021):

i) Encounter Rate (ER)

Measures how frequently the species is encountered.

$$ER = \frac{Total\ Sightings}{Total\ survey\ efforts\ (sq.km)}$$

(ii) Population Density (D)

Indicates how many individuals per unit area

$$Density = \frac{N}{L}$$

Where,
N = Total number of individuals observed, L = Total surveyed area (km²)

(iii) Group Density (GD)

$$Group\ Density = \frac{FG}{L}$$

Where:
FG = Total number of Family Groups observed, L = Total surveyed area (km²)

(iv) Mean Group Size (MGS)

$$MSG = \frac{N}{FG}$$

Where:
N = Total number of individuals observed, FG = Total number of Family Groups observed

v) Sex Ratio (SR)

$$Sex\ Ratio = \frac{Number\ of\ Male}{Number\ of\ Female}$$

Vi) Coefficient of Variation (CV)

The Coefficient of Variation (CV) was calculated to quantify relative variability in wildlife distribution parameters such as group size, population density, or sighting frequency across transects.

$$CV = \frac{SD}{\bar{X}}$$

Where:

SD = Standard deviation of the dataset, $\bar{X}$ = Mean of the dataset
CV values, expressed as percentages, were used to assess the consistency of observations:
Low CV (<20%): Low variability, consistent distribution
Moderate CV (20–50%): Intermediate variation
High CV (>50%): High variability, indicating uneven distribution or habitat fragmentation effects.

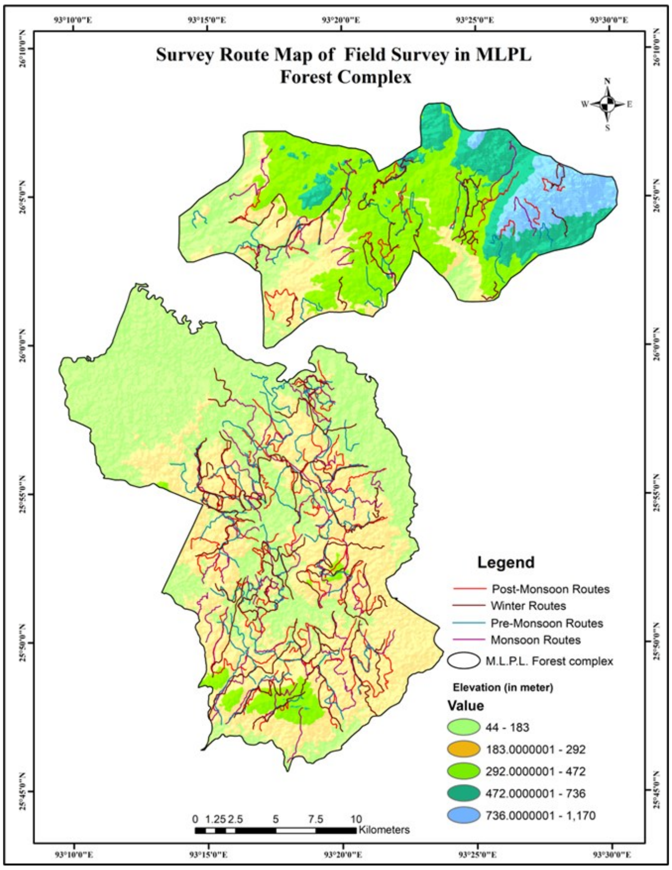

Figure 2. Survey Routes of Field Survey in MLPL

RESULTS AND ANALYSIS

Seasonal Distribution of Hoolock Gibbons across RF/ DCRF

Seasonal Analysis

Post-Monsoon (September–November)

The post-monsoon season, marking the transition from monsoon rains to drier conditions, provided favorable observation conditions with reduced canopy wetness and increased gibbon vocal activity. During this period, 13 gibbon groups comprising 28 individuals were recorded (Table 1). Disama Reserve Forest exhibited the highest group density with four groups totaling 11 individuals, including juveniles and infants, indicative of active reproduction and recruitment. Meyundisa followed with two groups of six individuals, also showing reproductive presence. Kaki Reserve Forest recorded two groups without younger age classes, possibly reflecting adult-only groups or seasonal absence of juveniles and infants. Smaller populations were observed in Englongkiri and Patradisa Reserve Forests, each with a single group of two individuals. No gibbons were detected in Longnit Reserve Forest (Figure 3). Khonbamon DCRF uniquely recorded three solitary individuals, each counted as a separate group, possibly representing dispersal or transitional social structures. The overall low encounter rate and population density reflect sparse distribution, while the equal sex ratio suggests balanced adult demographics. A high coefficient of variation in group size (83.45%) points to variability ranging from solitary individuals to larger family units (Table 2).

Table 1. summarizes the seasonal distribution of Hoolock Gibbon groups and individuals across different Reserve Forests (RF) and District Council Reserve Forests (DCRF) within the Marat Longri–Patradisa–Longnit Forest Complex.

RF/DCRF	Season	Total Groups	Family Members	Male	Female	Juvenile	Infant
Meyundisa D.C.R.F.	Post-Monsoon	2	6	2	2	1	1
	Winter	1	3	1	1	0	1
	Pre-Monsoon	2	4	2	2	0	0
	Monsoon	3	7	2	2	0	0
Disama R.F.	Post-Monsoon	4	11	4	4	2	1
	Winter	4	11	4	4	2	1
	Pre-Monsoon	4	11	4	4	3	0
	Monsoon	4	9	4	4	1	0
Kaki R.F.	Post-Monsoon	2	4	2	2	0	0
	Winter	1	2	1	1	0	0
	Pre-Monsoon	2	4	2	2	0	0
	Monsoon	1	2	2	2	0	0
Englongkiri D.C.R.F.	Post-Monsoon	1	2	1	1	0	0
	Winter	1	2	1	1	0	0
	Pre-Monsoon	1	3	1	1	0	1
	Monsoon	1	3	1	1	1	0
Patradisa R.F.	Post-Monsoon	1	2	1	1	0	0
	Winter	1	2	1	1	0	0
	Pre-Monsoon	1	2	1	1	0	0
	Monsoon	1	2	1	1	0	0
Longnit R.F.	Post-Monsoon	0	0	0	0	0	0
	Winter	0	0	0	0	0	0
	Pre-Monsoon	1	2	1	0	1	0
	Monsoon	0	0	0	0	0	0
Khonbamon D.C.R.F.	Post-Monsoon	1	3	1	1	0	1
	Winter	1	3	1	1	0	1
	Pre-Monsoon	1	3	1	1	1	0
	Monsoon	1	3	1	1	1	0

Table 2. presents key population metrics across seasons, including encounter rate (ER), population density (D), group density (GD), mean group size (MGS), sex ratio (SR; males to females), and coefficient of variation (CV) in group size.

Season	ER (groups/ km²)	D (ind/km²)	GD (groups/ km²)	MGS (ind/ group)	SR (M:F)	CV (Group Size %)
Post-Monsoon	0.0137	0.0349	0.0137	2.55	1.00	83.45
Winter	0.01122	0.02868	0.01122	2.56	1.00	99.89
Pre-Monsoon	0.01496	0.03616	0.01496	2.42	1.09	70.01
Monsoon	0.01372	0.03242	0.01372	2.36	1.00	78.41

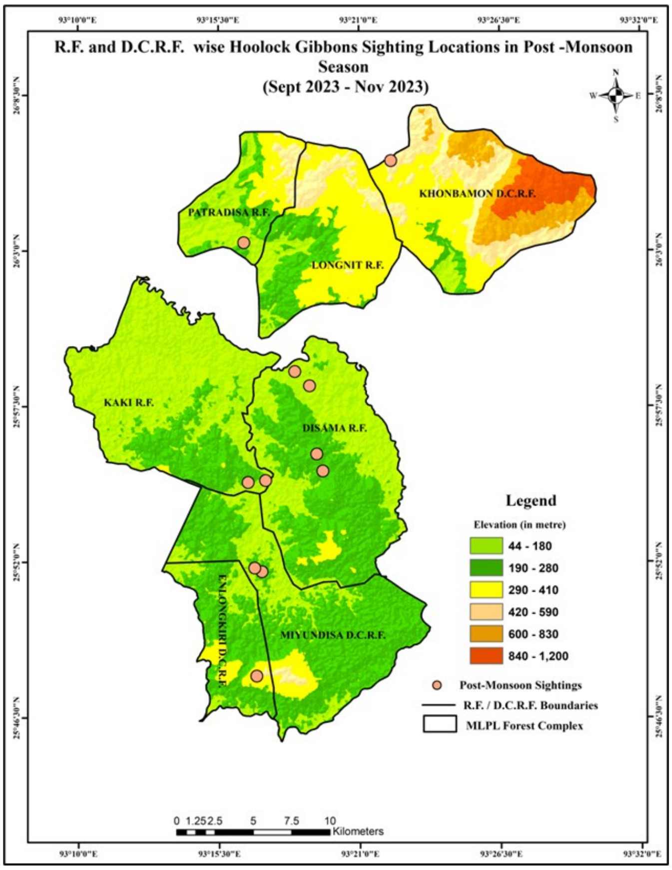

Figure 3. RF/DCRF wise Hoolock Gibbon sighting locations during the Post Monsoon Season

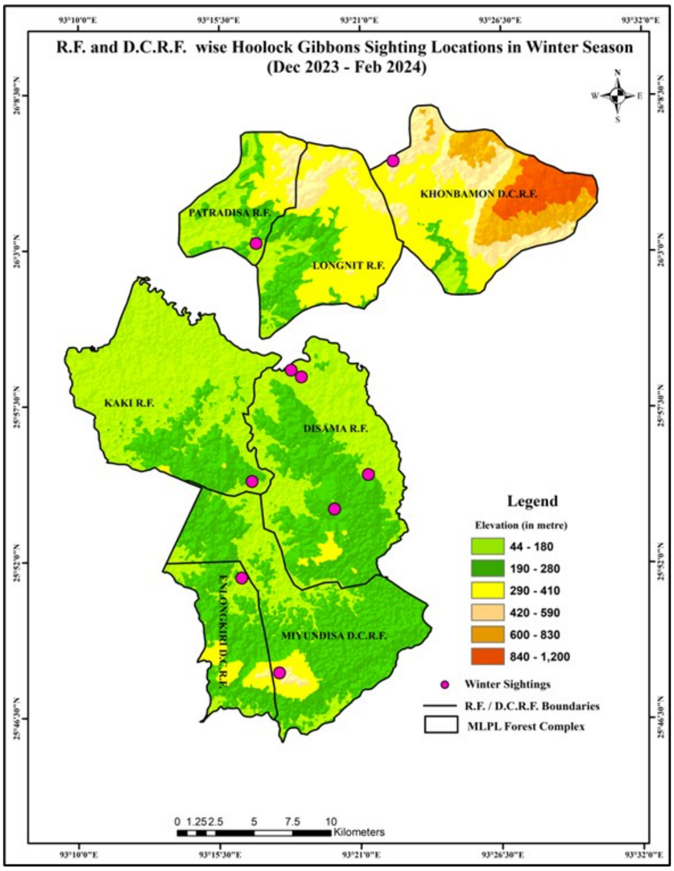

Figure 4. RF/DCRF wise Hoolock Gibbon sighting locations during the Winter Season

Winter (December–February)

Winter conditions featured cooler temperatures and reduced foliage, improving visibility for surveys. The number of groups and individuals in Meyundisa Reserve Forest declined to one group of three individuals, with the presence of an infant signaling recent reproduction. Disama remained the population stronghold with stable numbers (four groups, 11 individuals) and balanced demographic structure including juveniles and an infant. Kaki Reserve Forest showed a decrease to one group of two adults without juveniles or infants, suggesting potential reproductive inactivity or seasonal dispersal (Table 1). Englongkiri and Patradisa maintained small, stable groups of two individuals each without younger age classes. Longnit Reserve Forest remained devoid of gibbons (Figure 4), raising concerns over local extirpation or habitat degradation. Notably, Khonbamon DCRF's three solitary individuals formed a cohesive group, possibly reflecting social re-association. Encounter rate and population density slightly declined compared to post-monsoon, while mean group size remained stable. The high CV (99.89%) indicates considerable variability in group size and composition (Table 2).

Pre-Monsoon (March–May)

Characterized by rising temperatures and increased vocal activity stimulated by pre-monsoon showers, this season facilitated enhanced detection of gibbons. Meyundisa supported two smaller groups without juveniles or infants, suggesting a temporary recruitment gap.Disama continued to harbor the highest population (Table 1), with three juveniles recorded among 11 individuals, indicating strong reproduction. Kaki mirrored Meyundisa in group size and absence of young individuals. Englongkiri was notable for hosting a group with an infant, one of the few sites with direct evidence of births. Patradisa remained stable with a group of two adults, showing no recruitment. Gibbons were observed in Longnit Reserve Forest for the first time during the study, suggesting possible recolonization or dispersal. Khonbamon maintained a stable group size but with a juvenile present (Figure 5). This season recorded the highest encounter rate and population density across all seasons (Table 2), attributed to heightened vocalization and improved detectability. Mean group size was slightly reduced, with sustained high variability (CV 70.01%).

Monsoon (June–August)

Despite challenges posed by heavy rainfall and dense canopy cover, surveys revealed continued gibbon presence. Meyundisa showed increased group numbers compared to winter, with three groups totaling seven adults and no juveniles or infants, possibly reflecting seasonal dispersal or reduced juvenile visibility (Table 1). Disama remained the core population area, though total individuals declined slightly with fewer juveniles observed. Kaki supported a single adult pair without young, while Englongkiri had one group with a juvenile, indicating recent breeding activity. Patradisa's group size remained stable with no young observed. Longnit continued to lack detections, reinforcing concerns about population viability (Figure 6). Khonbamon recorded a

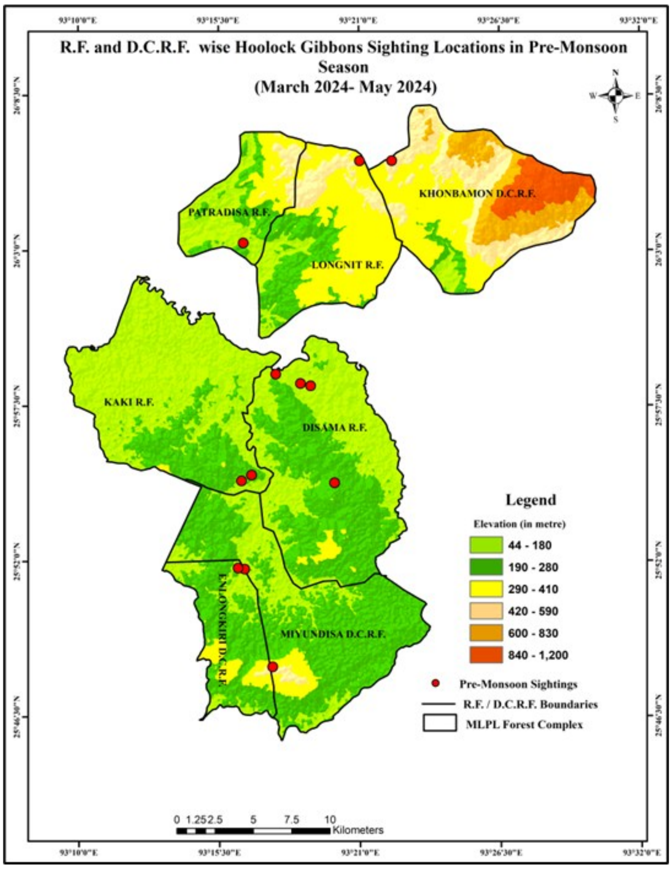

Figure 5. RF/DCRF wise Hoolock Gibbon sighting locations during the Pre Monsoon Season

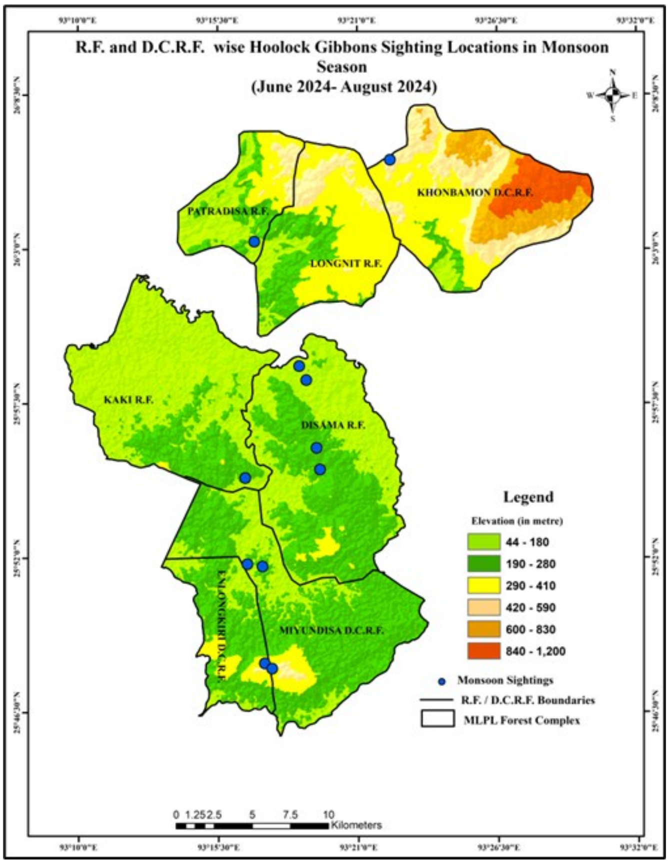

Figure 6. RF/DCRF wise Hoolock Gibbon sighting locations during the Monsoon Season

group with both juvenile and infant, suggesting successful breeding. Encounter rates and population densities were moderate, slightly below pre-monsoon levels. Mean group size was lowest across seasons, possibly due to seasonal dispersal and observational constraints (Table 2). The sex ratio remained balanced, while high group size variability persisted (CV 78.41%).

DISCUSSION

The present year-long study of the Western Hoolock Gibbon, *Hoolock hoolock*, over the Marat Longri-Patradisa-Longnit Forest Complex, Karbi Anglong, Assam, has indeed provided rich details on how an endangered primate negotiates the ecological challenges of a fragmented and seasonally dynamic landscape. This study, covering a period from September 2023 to August 2024, underlines marked seasonal variations in population metrics, which are influenced by rainfall, food availability, and resultant behavioural adaptations. Systematic surveys in seven RF and DCRF had shown pronounced seasonal variation: the highest encounter rates and population densities were during the pre-monsoon, which is very likely due to increased vocal activity and higher foraging effort in anticipation of the resource-rich monsoon months. The mean group size was smallest during the monsoon period, which reflects not actual demographic changes but lowered detectability due to heavy rainfall, thick foliage, and limited acoustic range. These findings resonate with the broader primate ecological studies that have shown that seasonality affects vocal behavior, diet, locomotion, and social interactions (Isbell & Young, 1993; Campbell, 2008; Zhou et al., 2022). In this context, earlier studies have documented that inclement weather reduces gibbon vocalizations, thus lowering the efficiency of auditory surveys (Cheyne, 2008; Rovero et al., 2012; Hasan et al., 2025).

Equally important is the impact of habitat fragmentation. The continuing absence of gibbons from Longnit RF reflects a global pattern whereby small, isolated forest remnants cannot support viable populations and ultimately result in local extirpation (Cheyne 2008; Rawson et al. 2011; Geng et al. 2025). Fragmentation impacts not only population persistence but also social and ranging behavior, as gibbons in constrained habitats must adapt to reduced resources and an altered canopy structure (Amsler 2009; Lappan 2008; Lehmann & Boesch 2003). The variability in group sizes, captured by a high coefficient of variation, may therefore indicate behavioral flexibility in response to both ecological constraint and anthropogenic disturbance (Herbinger et al. 2001; Reichard & Sommer 2000; Wallace 2008).

Food availability further emerged as a fundamental driver of spatial and seasonal patterns. Peak fruiting in several key species-Mangifera indica, Mangifera sylvatica, Artocarpus chama, Garcinia pedunculata, and Baccaurea ramiflora-occurs in the monsoon and post-monsoon seasons and coincides with increased gibbon activity and higher encounter rates in semi-evergreen and moist deciduous forests. During winter, when fruit abundance declines, gibbons switch to alternative resources, including leaves, flowers, and seeds from species such as Lannea coromandelica, Vitex quinata, Bombax ceiba, Ficus benghalensis, and Terminalia chebula. Seasonal shifts in diet probably explain variations in group movement intensity, forest patch use, and distribution in pre-monsoon, monsoon, post-monsoon, and winter periods. These findings therefore indicate that this seasonal ecological rhythm has great implications for conservation management. Identifying the timing and location of gibbon movement can be used to inform interventions-such as the installment of canopy bridges-to connect fragmented patches, already performed in Assam, for example (Huda, 2024). The identification of high-density zones such as Disama RF can act as important guides to targeted protection efforts and strategic resource allocation. Besides, long-term success in conservation will greatly depend on habitat restoration, strengthening of ecological corridors, and sustained community engagement-all key factors for sustaining viable gibbon populations in increasingly fragmented landscapes (Kabir, 2020; Kuhl et al., 2008).

CONCLUSION

This year-long examined of the Western Hoolock Gibbon (*Hoolock hoolock*) in the Marat Longri–Patradisa–Longnit Forest Complex highlights the critical influence of seasonal variation and habitat fragmentation on population dynamics. The study demonstrates that encounter rates, population density, and group size fluctuate across seasons, with pre-monsoon periods exhibiting the highest detectability and monsoon seasons showing reduced mean group sizes due to environmental constraints. Disama RF consistently supported the largest and most reproductively active populations, while the persistent absence of gibbons in Longnit RF emphasizes the vulnerability of small, isolated forest patches.

The high variability in group sizes and balanced sex ratios indicate both ecological adaptation and the potential resilience of gibbon populations within fragmented habitats. These findings emphasize the necessity of seasonally informed, long-term monitoring to accurately assess population status and guide conservation interventions. Effective strategies should prioritize habitat restoration, connectivity enhancement, and community engagement, with particular attention to high-density and ecologically significant forest patches.

Overall, the study contributes valuable, site-specific data for the conservation of India's only ape species and reinforces the need for adaptive management approaches to ensure the survival of Western Hoolock Gibbons in fragmented landscapes of Northeast India.

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Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this work.

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