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Factors Influencing the Seasonal Presence of Sloth Bear *Melursus ursinus* in Jambughoda Wildlife Sanctuary, Gujarat

VAIDEHI SHAH[1*] AND GEETA PADATE[2]
[1]Department of Environmental Studies, [2]Department of Zoology, The Maharaja Sayajirao University of Baroda, Vadodara, India
E-mail: vaidehishah202@gmail.com, vaidehi-envphd@msubaroda.ac.in, gs.padate-zoo@msubaroda.ac.in
***Corresponding author**

ABSTRACT
Sloth bears in Gujarat inhabit fragmented forest patches running across the eastern belt of the state from north to south. With most studies focused on its northern areas, more information is needed on sloth bears in central Gujarat. Previous studies show food availability as the critical factor influencing their presence, along with water, human activities, and forest cover. We aimed to understand the factors influencing sloth bear presence in Jambughoda Wildlife Sanctuary. We conducted grid-based surveys from 2020 to 2022 for direct and indirect evidences for the presence of bears for two seasons winter and summer**.** Simultaneously habitat **s**urveys were also carried out. We found 45 locations showing presence signs in winter, whereas only two in summer. This indicates a seasonal disparity in sloth bears' presence. The number of termite/ ant hills, water bodies, and sloth bear-preferred trees with their fruiting seasons were considered sample variables, while the vegetation types (woody, mixed, and undisturbed rugged) and the land use/ land cover patterns (dense, moderately dense, open forest; agriculture and barren land) were considered as the site variables. We studied the variables using the Euclidean distance matrix in RStudio. Our findings show that the vital sample variables included the number of termite/ant hills (0.03) and water bodies (0.05) during winter and summer, respectively. On analyzing the site variables in winter, sloth bears were closely associated with dense vegetation (0.02), while in summer; they preferred undisturbed/ rugged areas (0.02). Considering sloth bears as seasonal visitors to the sanctuary, these findings shall provide information on the habitat preferred by the bears and are expected to support long-term conservation strategies and management planning in the region.

Key words: Sloth bears, Termites, Seasonal variation, Euclidean distance matrix, Agglomerate hierarchical clustering.

INTRODUCTION

Sloth bears *Melursus ursinus,* the generalist species observed in various habitats, including dry deciduous forests, evergreen forests, scrublands, savannahs and grasslands (Lydekker 1907, Yoganand et al. 2006, Ratnayeke et al. 2007, Bargali and Sharma 2013) are endemic to the Indian sub-continent and spread across India, Bhutan, Sri Lanka, Nepal and previously also in Bangladesh (Islam et al. 2013, Dharaiya et al. 2020). A large population of sloth bears resides in the low-lying fragmented habitats of India (Akhtar et al. 2004). The habitat fragments of dry deciduous forests in the westernmost State of India, Gujarat, are the global western limits for sloth bears (Yoganand et al. 2006). Although Sloth bears have ecological significance as seed dispersers, they face threats of declining populations due to poaching and habitat loss (Garshelis et al. 1999, Sreekumar and Balakrishnan 2002, Kumar and Paul 2021, Kumara et al. 2023). The increase in human population has stressed the forest areas, leading to habitat degradation and deforestation, influencing sloth bear populations (Yoganand et al. 2006, Mallick 2019). Considering the threats and sloth bear's importance, they are placed in the status of vulnerable (VU) species under the IUCN Red List of threatened taxa (Dharaiya et al. 2020) and are included in Schedule-I of the Indian Wildlife (Protection) Act, Amendment 2022 No 18 of 2022, making it is an essential species that requires conservation.

Though devouring fruits, honey, and insects (Joshi et al. 1997, Sukhadiya et al. 2013, Rather et al. 2020, Philip et al. 2022), these myrmecophagy species depend largely on ants and termites for nutrition (Laurie and Seidensticker 1977, Dharaiya and Rabari 2022). Their strong claws primarily facilitate their feeding habit, simplified lower jaw, and flexible nostrils (Redford 1987). However, being opportunistic feeders, they are reported to show

seasonal variations in their food preferences based on available resources and the habitat. A study by Mewada (2015) in semi-arid regions of Gujarat indicated that sloth bears prefer insects over fruits as food. Likewise, a study by Philip et al. (2022) in semi-evergreen forests also reports that though sloth bears consume plant parts throughout the year, their dependency on insects is higher during summer. Seasonal dependencies of sloth bears on termites and fruits based on their availability in their habitat have been shown by other authors too (Joshi et al. 1997, Seidensticker et al. 2011, Palei et al. 2014, Palei et al. 2020, Rather et al. 2020). Although food is a major driving factor, various natural and anthropogenic factors also affect the presence of sloth bears in an area. An association with the type of forests, water bodies, and human activities, namely, cattle grazing, human settlements, and roads, have varying effects on the presence and distribution of sloth bears (Bargali et al. 2004, Ratnayeke et al. 2007, Ramesh et al. 2013, Das et al. 2014, Sharma et al. 2023).

Research on sloth bears for their feeding ecology, diet, habitat use, interactions with humans, distribution, and measures for their conservation has been comprehensively conducted in northern Gujarat (Sukhadiya et al. 2013, Mewada et al. 2019, Ketting 2020, Patel et al. 2020, Rot et al. 2023). However, in central Gujarat, limited information on sloth bear population estimates and habitat characteristics have been stated in detail (Pandya and Oza 1998, Jain and Prajapati 2012, Sugoor et al. 2014). However, habitat connectivity and potential corridors in the area have been proposed by Joshi et al. (2015), Dharaiya et al. (2021), and Malik et al. (2023).

A population of about 168 sloth bears has been reported in central Gujarat during the census of 2022, of which only 6 individuals were listed from the Panchmahal district that holds the Jambughoda Wildlife Sanctuary (Vadodara Wildlife Division, Government of Gujarat, 2022, personnel communication). However, studies on sloth bear distribution, occupancy, and habitat suitability are yet to be carried out in this area. The information regarding the factors influencing the presence and distribution of the species is crucial for habitat management and conservation (Servheen et al. 2001). Therefore, the present study has been conducted to understand the factors influencing the presence of sloth bears in the Jambughoda Wildlife Sanctuary, central Gujarat. The study focuses on the factors influencing the presence of sloth bears in Jambughoda. It is expected to assist in managing and conserving the bears in the area to ensure the long-term viability of their populations in the region.

MATERIAL AND METHODS

Study area

The forest of Jambughoda was established as a Wildlife Sanctuary in 1990 (The Gazette of India, February 24, 1990). Spread across an area of 130.38 km^2 it forms a continuity with the neighboring forests of the Pavi Jetpur range of the Chota Udepur reserve forest at the northeastern end, an ecological connectivity for the wild animals in the area (Fig. 1) (Dharaiya 2016, Malik et al. 2023). The sanctuary falls under the Vadodara Wildlife Division, located 70 km from the city. Judicially divided into two ranges - Jambughoda and Shivrajpur, it is located between 22°18'N and 23°30'N, 73°33'E and 74°45'E (Fig. 1). The area experiences three distinct seasons: winter- from November to January, summer from March to June, and Indian southwest monsoon- from July to October. The average summer maximum temperature rise is 38.7°C occasionally rising to 46°C, while in winter; the minimum temperature is 10°C, occasionally dropping to 7°C. The rainfall ranges from 800 to 1200 mm. The terrain here is undulating and hilly, with an elevation of 230-354 m (Jain and Prajapati 2012).

Champion and Seth (1968) state that the sanctuary has a tropical dry deciduous forest 5A/C1b. The vegetation here naturally occurs, along with cultivations for conservation and management by the forest department and economic benefits by the locals. The faunal composition consists of large predators like the flagship species - leopard (*Panthera pardus*), hyena (*Hyena hyena*), and sloth bear (*Melursus ursinus*); and herbivores like the blue bull (*Boselaphus tragocamelus*) and four-horned antelope (*Tetracerus quadricornis*). The area is interspersed with rural settlements accompanied by agriculture and influenced by sub-urban development from the neighboring town of Jambughoda. Hence, the habitat is dissected with rural roads and state highways in the low-lying regions.

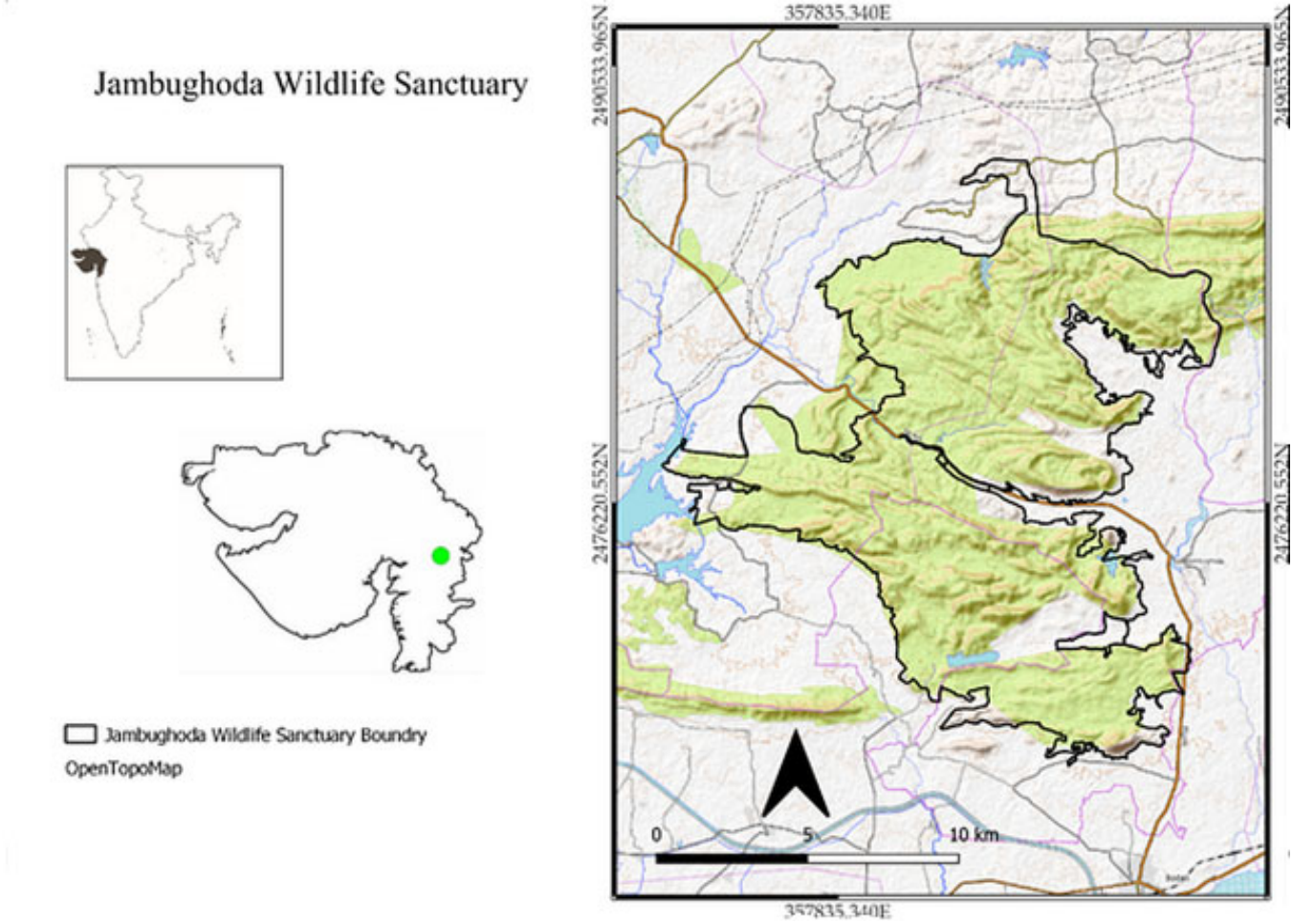

Figure 1. Location of Jambughoda Wildlife Sanctuary

Methods

We conducted field surveys to collect data on bear presence and assessed the habitat characteristics of the area. The field surveys were conducted for 25 days each in winter and summer from 2020 to 2022. Two field assistants and one forest personnel assisted with the surveys in the morning from 7:00 to 11:00 hrs to get fresh and intact presence signs, especially pugmarks, digging signs, and scats. This totalled to 100 days of field surveys and approximately 1200 man-hours over two years.

Land Use Land Cover Characteristics (LULC)

LULC images were downloaded from Landsat Thematic Mapper-8 of 30m resolution from the USGS for October 25, 2022. A supervised land use and land cover characterization was carried out with the help of semi-automatic classification in QGIS 3.26.2. The images with bandwidths from 1 to 8 were first stacked. The land cover and land use characterization included dense forests, moderately dense forests, open forests; barren land, agricultural land and water bodies (Cihlar and Jansen 2001). Following this, an accuracy assessment using the semi-automated classification was conducted to validate the classification with the ground situation (Chughtai et al. 2021).

Data collection

Data was collected from the Jambughoda range and parts of the Shivrajpur range in the sanctuary. Since high vegetation, soft soil, and faster withering of the signs follow the monsoon showers, the data from monsoon was not collected, and the surveys were conducted only in the winters (October-January) and summers (March-June mid) for two consecutive years. The study area was divided into 1 x 1 km grids with the help of QGIS (3.26.2), cumulating into 161 grids. Our surveys were initiated from a random point in the grid, preferably the more accessible one from the road leading to the interior grids of the forest. The grids either with intense human activity or those difficult-to-approach were not surveyed. An average of 2 km of transects in different directions were

walked per grid on the forest trails to make data collection more efficient for large mammals like the sloth bear (Ghimire and Thappa 2014). This made a sampling effort of about 322 km^2. During surveys, information was collected about the presence or absence of the animal with indirect evidence, mainly pugmarks, scat, claw marks on trees, and digging in the area (Fig. 7). Simultaneously, observations on the terrain, vegetation, and distance from human activity were recorded. Feeding preferences were studied by an in-situ analysis of sloth bear scat at its occurrence. Moreover, we gathered unpublished information from experts, locals, and forest staff about sloth bear presence (direct sightings or indirect signs) in the area before and during the field visits to support our findings.

Concurrent surveys were also conducted to note the habitat characteristics. At a distance of 500 meters, plots of a 10-meter radius were examined for vegetation type and floral composition, including the presence of sloth bear-preferred trees and other trees. The areas with human settlements and agricultural land were not surveyed, and the data was collected from 240 plots in the overall area as described by Potts et al. (2002). Other information, considering the dietary preferences and positively influencing variables like the presence of termites, ants, and water bodies (Laurie and Seidensticker 1977, Joshi et al. 1997, Akhtar et al. 2004) that influence Sloth bear presence were also recorded at every occurrence of the surveyed trails and tagged with GPS.

Selection of variables

The variables considered were categorized as sample variables and site variables. Based on the available literature, the resources that positively influence sloth bear presence were considered the sample variables (Joshi et al. 1997, Sukhadiya et al. 2013, Palei et al. 2014, Rather et al. 2020). This comprised active termite/ant mounds, active water bodies, sloth bear-preferred fruiting trees, and non-fruiting trees in the particular season. To avoid errors in data, termite mounds, and ant hills were considered one unit because of their occupancy on the same structure on several occasions. These variables were quantified per plot, and the values regarding sloth bear presence signs were evaluated. The sample variables were expected to show seasonal variation; hence, observations for both winter and summer were noted. The site variables that represent the habitat characteristics of the study area were the vegetation type (woody, undisturbed-rugged, and mixed) and the land use and land cover characteristics (dense forests, moderately dense forests, open forests, barren land, and agricultural land). The site variables were considered the same for both seasons and were recorded once. The vegetation type, i.e., woody, mixed, or undisturbed rugged, was reported as 1 or 0 from each habitat survey and was cumulated with the total plots in each grid. The land use characteristics per se forest cover were given values from 0 to 5 considering the area covered by each characteristic in each grid, with 0 having no area and 5 having maximum area. The presence or absence of sloth bears was considered as the sampling unit (Conner and Plowman 2001, Paudel et al. 2022), and further analysis was carried out concerning the quantified presence ($n >= 1$) or absence ($n = 0$) of the species for both the seasons.

Data analysis

An in-situ analysis of sloth bear scats was also carried out during the surveys. The scats were dismantled or broken at the site to check the undigested food contents and understand the bear's food preferences. These were then systematically recorded in the data sheets. The occurrence of undigested food items in the scats, like the exoskeleton of insects, seeds of fruits, etc., were considered and recorded as its 'desired food' (Bargali et al. 2004, Baskaran and Desai 2010, Sukhadiya et al. 2013, Rather et al. 2020). We broadly classified sloth bears' diet into ants, termites, fruits, and other items. The presence of sloth bear digging signs near termite mounds was also considered to be its preference for termites/ ants. Signs like claw marks on a particular tree were noted as its food preference. The indirect evidence were noted, along with their habitat characteristics at the location, for further analysis. The bear claw marks were old, so the season of its occurrence was not determined. Therefore, they were avoided from the seasonal analysis. However, the claw marks were found twice on the Mahua tree, indicating its preference for Mahua.

To understand the closeness of sloth bears to the variables, a generative hierarchical clustering (GHC) was run (McGarigal et al. 2013, Scholtz et al. 2014).

We used the Euclidean distance matrix (EDM) to develop the cluster. EDM is a multivariate statistical technique generally comparable to other similarity/ dissimilarity tools like principal component analysis, multivariate component analysis, etc. (Krislock and Walkowics 2011, McGarigal et al. 2013). For this study, a Euclidean distance matrix was performed in RStudio 2.8.2 (Chessel and Dufour 2012). This analysis was run for both summer and winter to assess the differences in favourable conditions for sloth bears. The Euclidean matrix was designed to understand the pairwise distance of the variables to the sloth bear's presence based on non-negative values in the matrix. This gave us information about the relation of sloth bear presence with the available resources. We tried to comprehend the variables' role; hence, matrices were designed for sample and site variables separately.

RESULTS

Land use land cover classification

The land use and land cover classification with an accuracy of 87% was used for further analysis (Fig. 2). In Jambughoda Wildlife Sanctuary, the land cover, i.e., natural land characteristics, was found to be 46.8% dense forest, 15.1% moderately dense forest, and 7.55% open forest. In comparison, 12.3% of the area consisted of water bodies. Apart from this, the land use characteristics comprised 16.88% agricultural land and 1.24% barren land.

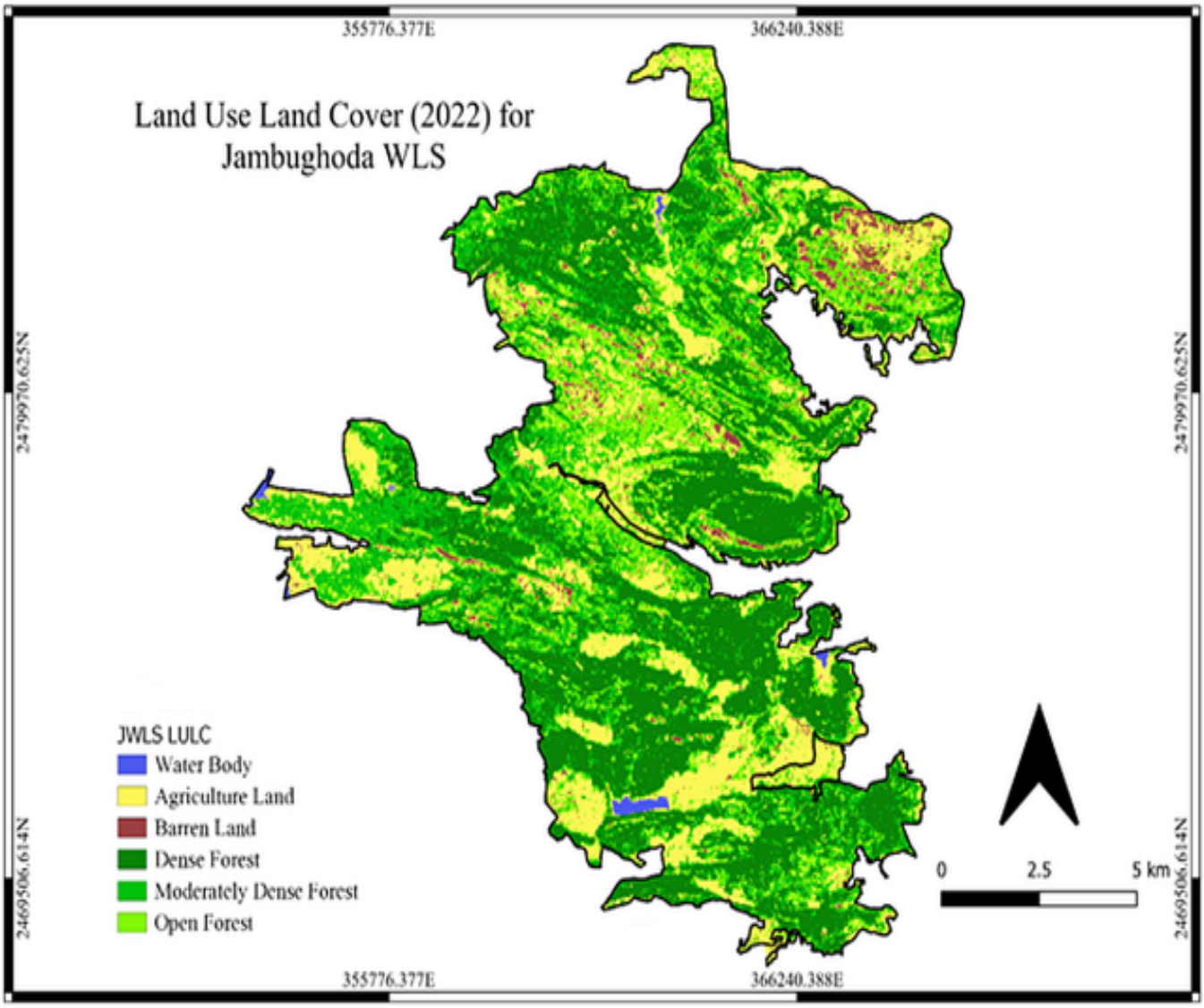

Figure 2. Land use land cover (2022) for Jambughoda Wildlife Sanctuary

Sloth bear presence

Among 161 grids, a significant difference in presence signs was found between winter and summer. In winter, 45 presence locations, including 11 secondary information, spread across the study area (in 25 grids), whereas, in summer, only 2 presence locations based on secondary information were noted only in the northern and northeastern regions of the study area (Fig. 3).

Euclidean distance matrix for sample variables

The seasonal observations for the sample variables revealed a ubiquitous occurrence of sub-terranean ant colonies for both seasons. However, more subterranean activity of ants was observed during summer (Table 1). However, a considerable difference in the number of termite/ ant hills and ants-colonized termite mounds was noted, though observed in both seasons, with 191 during winter reduced to 39 in summer. Further, water bodies, including dam reservoirs, check dams, artificial ponds, river streams, and puddles in the surveyed area, also significantly differed. The perennial and seasonal water bodies were active during winter, providing water from 140 sources. However, the seasonal water holes dried up during summer, limiting the water to only 30 perennial water sources. Based on the Euclidean Distance matrix (Table 3), the number of termite mounds/ ant hills (0.04) was the most influencing variable for sloth bear presence in winter. Following this, the availability of water (0.13) was found to influence sloth bear presence (Fig. 4a). In contrast, in summer, the availability of water (0.05) was the most influential factor for sloth

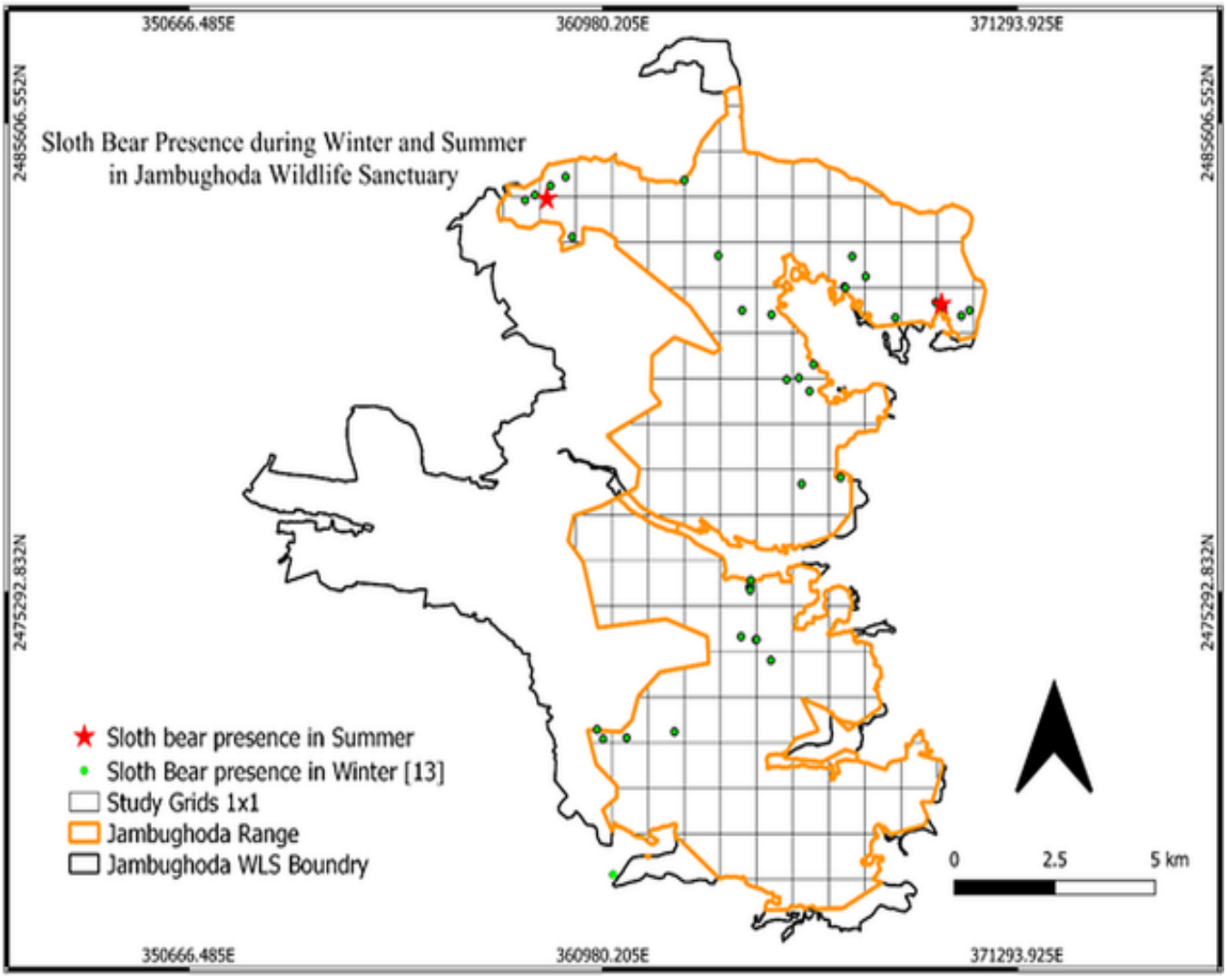

Figure 3. Sloth Bear Presence in JWLS (dot) winter and (Star) summer

Table 1. The observed difference in the sample variables for two seasons

Season	No. of Sloth Bear signs	No. of termite/ ant hills	No. of water points	No. Sloth Bear preferred Fruiting trees[#]	No. Grids with sub-terranean ant colonies
Winter	45 (34+11) *	191	140	22	85
Summer	2 (1+1) *	39	30	661	93

*Including secondary data; # Sloth Bear-preferred trees in the study area were listed with the help of available literature. These trees with their fruiting seasons were collated as sample variables for seasonal analysis (Table 2).

Table 2. List of Sloth Bear preferred trees in Jambughoda Wildlife Sanctuary[@]

Scientific Name	Vernacular name	Month of fruiting
Schleichera olesa (Malay lac tree)	Kusum/Kosimb	March-May
Alangium Salvifolium (Sage-leaved alangium)	Ankol	April-June
Miliusa tomentosa (Downy miliusa)	Umbh	April-May
Madhuca indica (Mango)	Aam, Keri	February-July
Cassia fistula (Golden shower)	Garmalo	Throughout the year
Diospyros melanoxylon (East Indian ebony)	Timroo	April-May
Buchanania lanzan (Char)	Charoli	April-May
Madhuca longifolia (Mahua) [$]	Mahua/ Mahudo	June-July
Aegle marmelos (Golden apple)	Bili/ Bael	April-June
Syzygium cumini (Black plum)	Jambu	March-July
Ziziphus mauritiana (Indian jujube)	Ghat Bor	October-November
Ziziphus nummularia (Wild jujube)	Bor	September- November
Ziziphus oenoplia (Chani Bor)	Chani Bor	September-October
Annona squamosa (Custard apple)	Sitafal	October-November
Ficus recemosa (Cluster fig)	Umber	June-September
Psidium guajava (Guava)	Jamfal	October
Cordia dichotoma (Indian cherry)	Gunda	May and October
Zea mays (Corn)	Makai	June-October/ February
Pterocarpus marsupium (Beo)	Biyo	December-March
Phoenix sylevestris (Khajuri)	Khajuri	March-June

$ Sloth bears are also observed to feed on the flowers of Mahua (*Madhuca longifolia*) from March to May.
@ Source: Bargali et al. (2004), Yoganad et al. (2005), Mewada and Dharaiya (2010), Mewada (2015), Rather et al. (2020), Palei et al. (2020), Kumar and Paul (2020), Kumara et al. (2023); their fruiting seasons Pandya and Oza (1998).

bear presence, followed by the availability of fruiting trees (0.13) (Fig. 4b). However, in winter, the presence of sloth bears showed an insignificant influence on bear-preferred fruiting trees (0.52) as well as non-fruiting trees (0.86). However, termite hills (0.32) and non-fruiting trees (0.25) did not show significant influence in summer.

Euclidean distance matrix for site variables

In winter, woody vegetation (0.02) was the most influential variable, followed by dense forest (0.09) (Fig. 5a, Table 4). On the other hand, agricultural land (0.41) and barren land (0.38) had the farthest distance, indicating their lesser influence on the Sloth bear's presence. In summer, undisturbed, rugged

Table 3. Euclidean distance matrix for Sloth Bear presence and sample variables in winter and summer

	SB	TH	WP	FT	NFT
Winter					
SB	0				
TH	0.03790007	0			
WP	0.12799329	0.09009322	0		
FT	0.52658447	0.4886844	0.39859117	0	
NFT	0.86129284	0.82339277	0.73329954	0.33470837	0
Summer					
SB	0				
TH	0.32310907	0			
WP	0.05310381	0.27000526	0		
FT	0.13490096	0.18820811	0.08179715	0	
NFT	0.25861712	0.58172619	0.31172093	0.39351808	0

SB-Sloth Bear, TH-Termite/ ant hills, WP- Water bodies, FT- Sloth Bear preferred fruiting trees, NFT- Sloth bear preferred non fruiting trees

areas (0.02) and moderately dense forests (0.07) influenced sloth bear presence. However, like winter, agricultural land (0.45) was at the farthest distance in summer (Fig. 5b, Table 4).

Indirect evidence

We encountered 28 indirect evidence (excluding claw marks) of sloth bear presence in the study area during winter. These constituted pugmarks (5), scats (12), and digging (11) (Fig. 6). During the surveys, sloth bears, because of their crepuscular behaviour, were not observed directly. Apart from these, the forest field staff provided 11 GPS locations considered secondary information with 1 direct sighting, 10 diggings, and 4 scats for which GPS locations were unavailable.

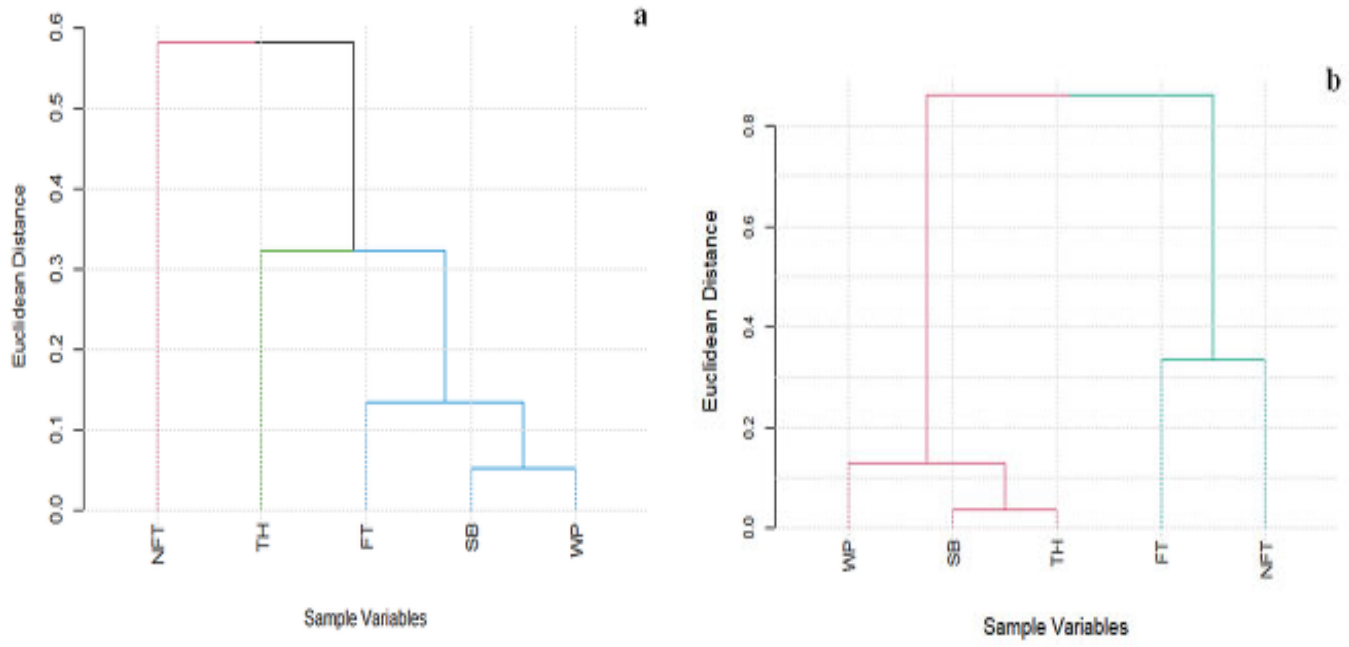

Figure 4. Agglomerate hierarchical cluster for sloth bear presence with sample variables for winter (a) and summer (b). SB-Sloth Bear, TH-Termite/ ant hills, WP- Water bodies, FT- Sloth bear preferred fruiting trees, NFT- Sloth bear preferred non-fruiting trees.

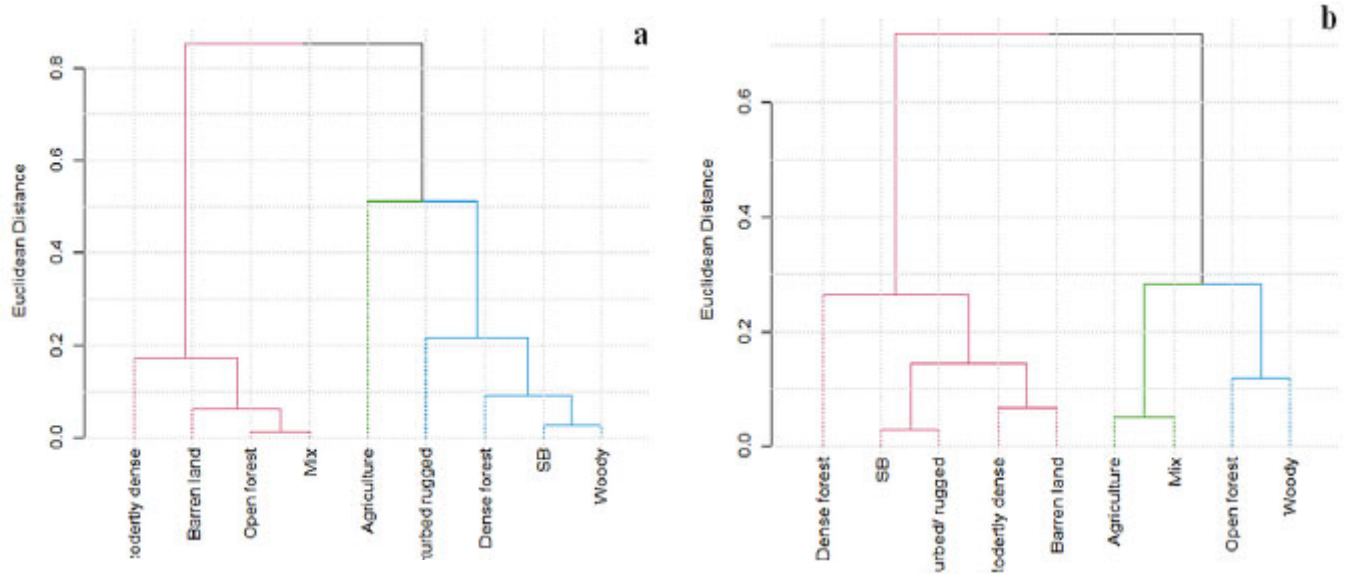

Figure 5. Agglomerate Hierarchical cluster for sloth bear presence with site variables for winter (a) and summer (b)

Dietary preferences

Sixteen scats were observed during the surveys in the Jambughoda Wildlife Sanctuary. These scats primarily comprised exoskeletons of black and red ants (10 scats), while others had *Ziziphus oenophilia* (Chani Bor) seeds (3) and remains of termites (2)

Table 4. Euclidean Distance Matrix for Sloth Bear Presence and site variables in winter and summer

	SB	Dense forest	Modertely dense	Open forest	Barren land	Agriculture	Woody	Undisturbed rugged	Mix
Winter									
SB	0								
Dense forest	0.09	0							
Modertely dense	0.26	0.16	0						
Open forest	0.38	0.29	0.12	0					
Barren land	0.43	0.34	0.17	0.051	0				
Agriculture	0.41	0.51	0.68	0.80	0.85	0			
Woody	0.02	0.06	0.23	0.35	0.40	0.44	0		
Undisturbed rugged	0.12	0.21	0.38	0.50	0.55	0.29	0.15	0	
Mix	0.36	0.27	0.10	0.01	0.06	0.78	0.34	0.49	0
Summer									
SB	0								
Dense forest	0.26	0							
Modertely dense	0.07	0.18	0						
Open forest	0.17	0.43	0.25	0					
Barren land	0.14	0.12	0.06	0.31	0				
Agriculture	0.45	0.72	0.53	0.28	0.60	0			
Woody	0.29	0.55	0.36	0.11	0.43	0.16	0		
Undisturbed/ rugged	0.02	0.23	0.04	0.20	0.11	0.48	0.32	0	
Mix	0.40	0.66	0.48	0.23	0.54	0.05	0.11	0.43	0

Figure 6. a) Sloth Bear Digging, b) Sloth bear scat with black ants, c) Sloth bear scat with *Ziziphus oenophilia,* and d) Sloth bear pugmarks.

(Fig. 7). Apart from this, scats with hair were found on one occasion. Along with these, sand and grass were also found in the scats. Further, 14 digging occasions were recorded in 2020-21 and 7 in 2021-22. From these 21 diggings, five incidences were found on or near termite/ant hills and 16 were noted to be subterranean.

DISCUSSION

Jambughoda Wildlife Sanctuary, in close vicinity to Chota Udepur and Ratanmahal Wildlife Sanctuary, with good populations of sloth bears, has shown frequent but not regular presence of sloth bears, suggesting that sloth bears visit the sanctuary occasionally (Pandya and Oza 1998). The bears may visit the sanctuary when resources like food, water, or shelter are available in plenty. Therefore, a study focusing on understanding the factors that attract sloth bears to the sanctuary during specific periods, i.e., winter and summer, was carried out. In the monsoon-dependent region of India, there is a vast difference in the availability of these resources during the two seasons (Sen-Sharma 1974).

The number of indirect evidence for the presence of sloth bears in Jambughoda Wildlife Sanctuary in winter compared to the same in summer indicated that summer is not a preferred season for bears to pursue the area (Fig. 3). The importance of food and shelter the two primary resources for the survival of any species, is a well-known fact. Our observations on the seasonal variations in the available resources indicated that the number of active termite/ant hills and water bodies is higher in winter compared to summer (Table 1). Rot et al. (2013) have also noted similar observations in Jessore Wildlife Sanctuary in North Gujarat.

Termites mix their saliva with soil and water to build mounds (Zachariah 2016, 2020). The moist soil after the monsoon provides a suitable condition for

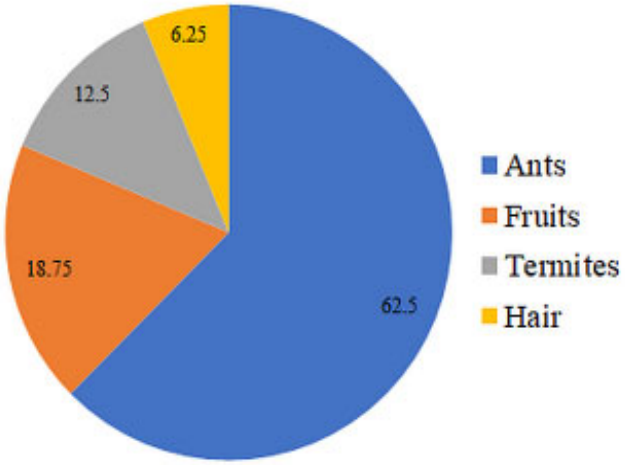

Figure 7. Dietary composition of Sloth bears from scat analysis in Jambughoda WLS

constructing termite mounds, especially near water bodies. Additionally, ants in ant hills and subterranean colonies were more prevalent during winter (Table 1). Hence, more termite/ ant hills in post-monsoon continued to sustain themselves into winter, alluring bears to the habitat. Further, as winter ends and the temperature rises, the evaporative loss of soil moisture increases in this semi-arid region, leading to the subduction of termite hills.

Apart from myrmecophagy, the sloth bears are observed to consume a plant-based diet too, feeding on several fruits per se, *Miliusa tomentosa*, *Madhuca longifolia*, *Diospyros melanoxylon*, etc. (Kumara et al. 2023). These trees are distributed in and around the sanctuary (Pandya and Oza 1998), which can provide suitable food resources for bears in the absence of termites or ants. Nonetheless, these trees mainly fruit during summer, limiting their availability for sloth bears in winter.

Correlatively, the significant difference in the number of occasions of sloth bear presence between the two seasons in the study area indicates sloth bears' preference for the resources available in winter. Seasonal differences in distribution and dietary preferences are common in the case of sloth bears. Previous studies have discussed bear presence influenced by the availability of food and water (Joshi et al. 1995, Garshelis 2022). Although Sloth bears show opportunistic behaviour for food preferences, their main preference has more often been found for termites and ants, followed by fruits in their absences (Chhangani 2002, Sukhadiya et al. 2013).

The Agglomerate hierarchical clustering based on the Euclidean distance matrix for sloth bear presence and resources indicates termite hills and water bodies impact sloth bear presence in winter (Fig. 4a). Along with this, our analysis showed dependencies of sloth bears on fruits during summer, even though their presence was measurably low (Fig. 4b). Thus, though fruiting trees are available in the sanctuary during summer, lack of water resources as well as termites restrict sloth bears from exploring Jambughoda Wildlife Sanctuary in summer. This indicates that the presence of sloth bears was not significantly influenced by the fruits but by termites or ants; highlighting its myrmecophagy. Our results based on scat analysis also suggest its dependency on ants (62%). Although the presence of ant colonies was ubiquitous in the area, sloth bear presence was predominately observed in winter, perhaps because of the feasibility of digging the soil for ants when some moisture is retained (Sukhadiya et al. 2013).

Along with food preferences, habitat characteristics also play a vital role in the distribution of sloth bears. Studies by Akhtar et al. (2004) and Bargali et al. (2004) have shown sloth bear distribution in rugged and undisturbed areas. Studies in disturbed and fragmented areas have shown the occurrence of species near human settlements. However, certain studies have observed sloth bears avoid human activities and encroachments (Rot et al. 2013, Ghimire and Thappa 2014). Sloth bears tend to forage near human settlements and agricultural areas for easy food and water or when suitable resources are not adequately available in their natural habitat (Akhtar et al. 2004, Rot et al. 2023). The Euclidean distance matrix in the current study for the site variables or habitat characteristics has resulted in the closeness of sloth bear presence with dense and moderately dense forests. In contrast, there is an insignificant distance with agricultural land in both seasons (Fig. 5). The observations based on human-sloth bear conflict information provided by the Vadodara Wildlife Division indicate no recorded cases in the last 20 years supporting our results for their insignificant use of agricultural land and settlements. However, the study area is protected where human movements are expected to be low, especially at night when bears are supposed to be active. Previous studies in Jambughoda WLS have

implied the seasonal visits of Sloth bears in October, especially in the northern regions (Pandya and Oza 1995). Also, the sloth bears were observed on a forest hilltop during the winter of 2000, as noted by the co-author (unpublished).

Our findings on the seasonal differences in the sloth bear's habitat use may be coherent with other studies. In semi-arid regions, captive bears were observed to spend more time walking in winter while resting in summer to protect themselves from the heat (Prajapati and Koli 2018). Similarly, a study by Yoganand (2005) in the wild showed variability in activity patterns for cold and dry seasons with longer activity duration in winter for foraging. Further, the cubbing period may restrict the mother's movement during late summer. Hence, we speculate that the sloth bear reduced their activities during summer Yoganand (2005). However, because of the habit of delayed implantation and postpartum confinement by the female, the exact breeding status of sloth bears is difficult to assess. From the present study, we conclude that the presence of sloth bears in Jambughoda WLS shows a seasonal pattern. The bears' presence is highly dependent on their diet, myrmecophagy, i.e., the availability of termites/ ants, water during winter, and the woody and undisturbed rugged areas in the sanctuary.

CONCLUSIONS

The sloth bear, a vulnerable species (Dharaiya et al. 2020), holds ecological significance as a seed disperser. The species is a flagship species for the Jambughoda Wildlife Sanctuary, attracting tourists. The conservation of this species is crucial not only for the ecosystem but also for the rural upbringing via eco-tourism. We suggest a few conservation and management practices for sloth bears in Jambughoda WLS:

1. We speculate an increase in anthropogenic activities, such as agriculture and settlements in the regions outside the protected area, degrading the natural bear habitat. This may restrict its accessibility to Jambughoda from the nearby forests. We suggest restricting habitat encroachment in the forests, especially on the northeastern end of the sanctuary, which the bear may use to enter the area.
2. Restoring these areas with extensive spread of water sources during summer.
3. Based on the literature review, lacunae of scientific research can be observed for the study area. Strategic and extensive research on the population, abundance, ecology, and species behaviour of sloth bears will help make species-specific and area-specific conservation strategies and management plans for the area.

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