JWLS
Volume 1, Issue 1 (April 2024)

TYPE Research Article

# There is no place like home: Den and rendezvous site selection of Indian wolves in the human-dominated landscape of Maharashtra

Shaheer Khan [1], Sougata Sadhukhan [1,2], Bilal Habib [1]*

[1]Wildlife Institute of India, Dehradun, Uttarakhand, India, 248001
[2]Bharati Vidhyapeeth Deemed to be University, Pune, Maharashtra, India, 411030

DIAMOND OPEN ACCESS Crossref

EDITED BY
Mewa Singh
Institution of Excellence, University of Mysore

*CORRESPONDENCE
Bilal Habib
✉ bh@wii.gov.in

RECEIVED 06 March 2024
ACCEPTED 17 April 2024

CITATION
Khan, S., Sadhukhan, S., Habib, B.(2024) There is no place like home: Den and rendezvous site selection of Indian wolves in the human-dominated landscape of Maharashtra. *Journal of Wildlife Science. 1* (1), 31- 39
https://doi.org/10.63033/JWLS.GHWH3024

FUNDING
Department of Science and Technology (DST) Govt. of India and Maharashtra Forest Department.



PUBLISHED BY
Wildlife Institute of India, Dehradun, 248 001 INDIA



## Abstract

Den-dependent species play a vital role in maintaining ecosystem balance, and understanding their den selection criteria is crucial for effective conservation. The Indian Wolf *Canis lupus pallipes* is found in various habitats, mostly human-dominated areas in India. They are social animals and use dens and rendezvous sites for rearing pups. We collected the data from 32 dens and 25 rendezvous sites in Maharashtra from 2016 to 2021. We measured 11 habitat and anthropogenic variables at den and rendezvous sites and 60 contrast random locations within the 95% MCP of all the collared wolves. Out of 32 dens and 25 rendezvous sites evaluated, the maximum dens and rendezvous sites were found in grassland and the lowest number of dens in agriculture. The den sites were positively associated with the presence of water (β=-4.55; p=0.006), vegetation cover (β=1.97; p=0.008), plantation (β=1.52; p= 0.001), presence of grassland (β=1.41; p=0.004), and scrub forest (β=1.09; p=0.02). The human footprint was negatively associated with the den sites (β=-0.88; p=0.05). The distance from escape cover (β=-5.17; p=0.02), presence of plantation (β=1.81; p=0.003), presence of grassland (β=1.46; p=0.01), presence of scrub (β=1.23; p=0.006) was positively associated with rendezvous sites and negative association with vegetation cover (β=-1.72; p=0.01). This study underscores the significance of understanding den and rendezvous site selection for the Indian Wolf in human-dominated landscapes. The identified factors provide essential information for conservationists, helping them design effective management plans to ensure the survival of Indian wolves and their coexistence with humans in the changing environmental context.

**Keywords:** Canid, conservation, denning ecology, grassland, habitat preference, homesite selection

## Introduction

Most large carnivores are endangered worldwide because of decreased prey, conflict with humans, habitat degradation and fragmentation (Fortin *et al.,* 2005; Karanth & Chellam, 2009). Carnivores that depend on dens for rearing their young are crucial for comprehending ecological dynamics and implementing effective conservation measures. Den-dependent species, such as wolves, foxes, bears, hyenas and small burrowing mammals, play integral roles in maintaining ecosystem balance. Understanding den selection criteria helps conservationists identify and protect critical habitats, ensuring the survival of vulnerable upcoming generations. Moreover, studying den and home site selection contributes to broader ecological knowledge, aiding in preserving biodiversity and ecosystem health. Ultimately, studying den-dependent species is imperative for informed conservation practices that safeguard both the species and the ecosystems they inhabit. Due to the dependence on conservation for large carnivore survival in increasingly human-dominated landscapes (Weber & Rabinowitz, 1996; Linnell *et al.*, 2001), identifying home site selection is necessary (Kenney *et al.*, 2014). For the prolonged survival of large carnivores in these landscapes, conservation strategies should prioritize protecting key breeding areas and home sites.

The Indian Wolf *Canis lupus pallipes* is found in various habitats, mostly human-dominated areas. They are social animals and use dens and rendezvous sites for rearing pups. Wolves survive with humans because of their ability to exploit human-modified landscapes (Habib, 2007). However, they also prey upon livestock, allowing the potential for conflict, especially with the shepherd community (Singh & Kumara, 2006). A persistent problem is the incidence and impact of human interference on wolf dens and rendezvous sites. Reducing disturbance is difficult for wildlife management across wolf's distribution range (Chapman, 1977; Darimont & Paquet, 2002), particularly in a country with a high population density like India (Habib & Kumar, 2007).

Although wolves are a generalist species that move over large areas and can survive in many different environments, tolerating various degrees of human disturbance (Mech & Boitani, 2003; Sillero-Zubiri *et al.*, 2004), they are conscientious at den and rendezvous site selection. The site selection for denning and rendezvous sites is crucial for survival. Their reproduction and denning behaviour have been studied extensively (Mech, 1970; Ballard & Dau, 1983; Fuller, 1989; Ciucci & Mech, 1992; Heard & Williams, 1992; Matteson, 1992; Unger, 1999). However, given the rapidly changing environment and habitat features, it is crucial to frequently study denning and rendezvous site selection behaviour. Wolves only use dens when young pups cannot travel with the pack (Boitani, 2000; Fuller *et al.*, 2003). Wolf dens are usually located near water and dug into well-drained soil or between rock splits (Mech & Boitani, 2003). They can be dug under a boulder, among tree roots, or in cut banks, hollow logs, or other sturdy natural structures. Wolves often enlarge existing fox or porcupine dens. The den and rendezvous sites are comparatively small areas where reproductive activities occur. Pups are born, fed, raised, and protected in the den sites and a series of rendezvous sites. Selection of these sites and activity around the den can have an impact on the ability of the pack to reproduce because the majority of pup deaths occur during the first six months (Harrington & Mech, 1982), and movements away from these sites are limited during the first six weeks after birth (Fuller, Mech & Cochrane, 2003; Mills, Patterson & Murray, 2008).

Many studies identified resource availability as the main factor determining Wolf reproductive success (Fuller, 1989; Fuller *et al.*, 2003), while others showed wolf human-caused mortality as an essential inhibitor of wolf reproduction and population recovery (Liberg *et al.*,2012). Homesite selection by wolf packs can be closely related to both these factors. It can directly influence access to food resources by reproductive wolf packs (Frame *et al.*, 2008) and disturbance to nurturing adults and pups from humans (Habib & Kumar, 2007; Argue *et al.*, 2008; Nonaka, 2011).

Anthropogenic and habitat characteristics associated with den and rendezvous sites have not been well documented for Indian wolves. However, wolf dens and rendezvous sites were well explored in other subspecies of wolves (Joslin, 1967; Unger, 1999; Theuerkauf *et al.*, 2003). Unger (1999) found wolves in Wisconsin and Minnesota, USA, selected wetland habitats for rendezvous sites and hypothesized that was because young pups cannot travel far and require ample water to process a diet high in protein. Unger (1999) also hypothesized that dense grasses in wet meadows decreased the detection of pups by intruders. Conceivably, wolves could also select wet meadows because they provide abundant small mammal and insect prey for pups.

Conservation of wolf populations is dependent on informed management of wolf habitat. We hypothesized that wolves in India would follow the same pattern as other wolf sub species. The goals of the present study were to 1) provide a general description of habitat type, substratum, number of openings, distance from the nearest human settlement, and topographic features, and 2) identify important factors associated with the den and rendezvous site selection. The increasing omnipresence of humans and associated disturbance within animal niches makes this research of broad significance. The information produced in this study will help devise a better management plan for the survival of the Indian wolves in human-dominated landscapes.

## Methods

### Field data collection for den and rendezvous sites:

Information on known and probable den and rendezvous sites, was collected from local villagers, Maharashtra Forest Department and from GPS locations of collared individuals. The sites were located and confirmed by scanning the site for wolf pugmarksand scats. The habitat feature, linear infrastructure, and human-induced parameters associated with den and rendezvous sites were collected in the breeding season (November to February) from 2016 to 2021. Probable den sites were integrated into the study only after confirming recent use by wolves as ascertained through the identification of freshly deposited scats and pug marks.

The data was collected after ensuring that wolves were not present, or often after waiting until wolves were vacating the den sites, to minimize our influence on wolf den sites. Since wolves often use the same dens in subsequent years (Ballard & Dau, 1983; Mech & Packard, 1990), we took precautions not to disturb the den and collected the data without altering the site. We collected data at 32 dens (4 in Ahmednagar, 1 in Gondia, 10 in Pune, and 17 in Solapur Districts, Maharashtra, India) and 25 rendezvous sites (4 in Ahmednagar, 1 Gondia, 2 Nagpur, 5 Pune, and 13 Solapur Districts, Maharashtra, India (Figure 1). The rendezvous sites were identified after sighting wolves with pups older than eight months at least three times. As a single pack can use the same rendezvous site for several years (Capitani *et al.*, 2006), we did not collect the data if the site was within 800 meters from any of our previously recorded rendezvous sites to avoid overestimating the important characteristics.

We measured 16 habitat and anthropogenic variables at den and rendezvous sites and 60 contrast random locations (Figure 1) within the 95% MCP of all the collared wolves. This is referred to as third-order selection by Johnson (1980). In contrast to presence-absence models, we designed a use versus availability method with the advantage of not presuming that individuals never use certain places (Boyce *et al.*, 2002; Pearce & Boyce, 2006). This method assumes that the observed occurrences represent a sample of the locations that may contain information on animal preferences (Manly *et al.*, 2002). Moreover, while generating the contrast random locations, the points that fall on water bodies, human settlements, and roads were excluded from the analysis. Data were recorded for the den and rendezvous site for habitat type (agriculture, grassland, plantation, and scrub), terrain type flat, slope, steep and undulating), and vegetation cover in a 50 m radius circular plot centered on the den opening and rendezvous site. The vegetation cover was recorded through ocular estimation

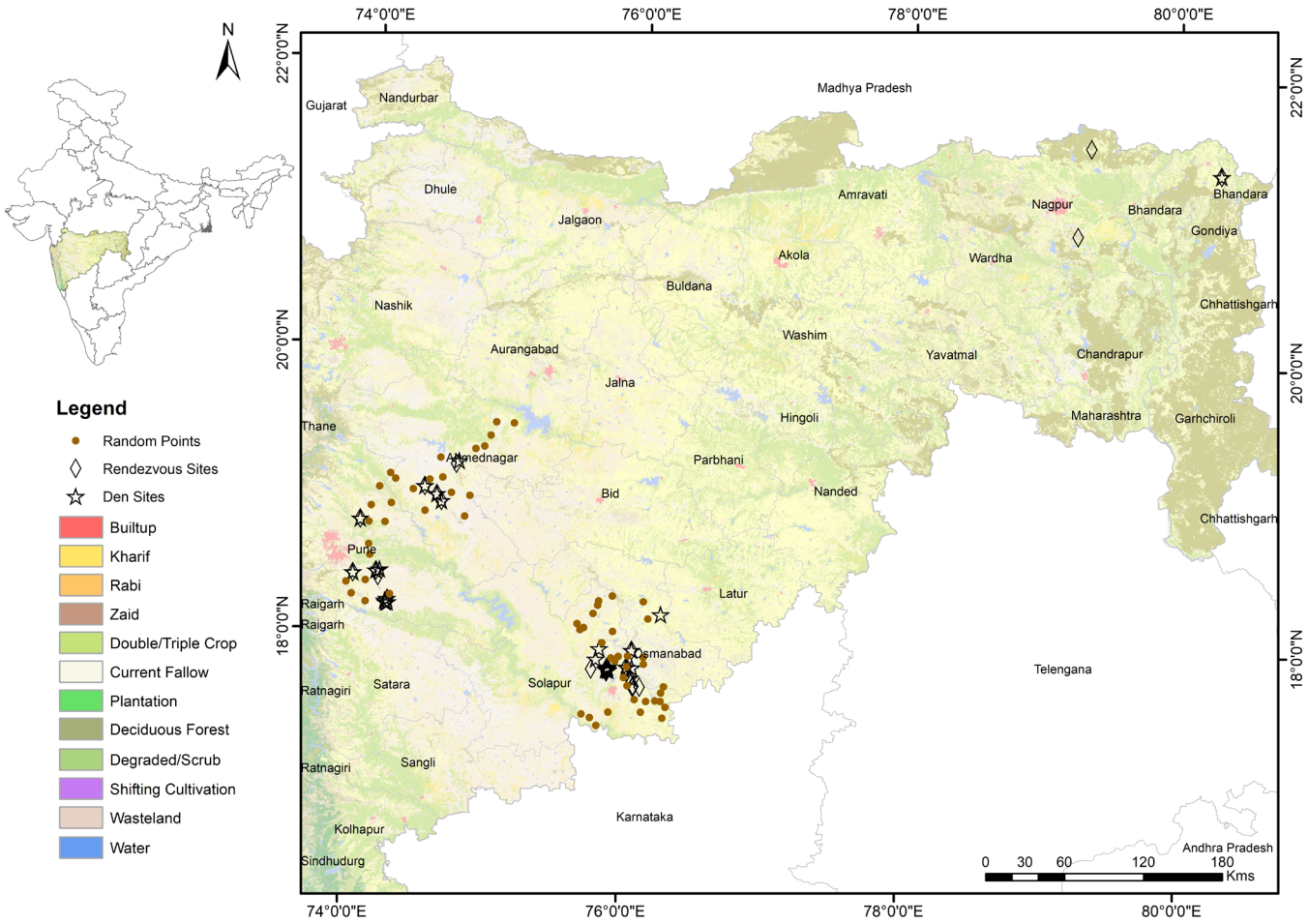


**Figure 1:** Study area showing den (star symbol), rendezvous sites (diamond symbol), and contrast random locations (brown dots) points in Maharashtra. Inset: Location of the study area in India. Land-use data were obtained from Bhuvan's NRSA LULC.

(Matteson, 1992). Distance from the nearest water source, cart road (dirt road used by locals and livestock), metal road (nearest tar road used for vehicular movement), and escape cover was recorded using google earth. The den substratum was classified into three categories *viz.* bund, rock crevices, and manmade structure. The total number of den openings were also counted at each den site.

### Data extraction using GIS for each den and rendezvous site:

The distance from the primary road, human population density, and human footprint were extracted using extract values to the point tool in ArcGIS 10.6. The primary road was acquired from open-source OpenStreet Map (OSM 2016) data. OSM road type shapefile was used to prepare Euclidean distance from the primary road. The human population density 2020 map (Stevens *et al.*, 2015) and human footprint 2009 (Venter *et al.*, 2018) and the tool extract values to raster were used to extract values in ArcGIS 10.6.

### Data Analysis:

Prior to formulating the candidate models, we did a Pearson correlation test between the 16 variables and eliminated highly correlated variables (>0.7). Thus, we finalized 11 variables for final analyses and removed human population density and three topographic features (flat, steep, and undulating parameters) from the analyses as they were correlated with the other variables. We used Generalized Linear Models (GLMs, McCullagh & Nelder, 1989) to obtain a mathematical description of site selection by wolves in an attempt to avoid the covariance of explanatory variables. GLMs allow for appropriate error formulations from the exponential family distributions, avoiding restrictions of traditional regression models. The error and link functions depend on the nature of the data. Since the den and rendezvous sites (a binary response variable: 1=presence, 0=absence) follow a binomial distribution, a logit link function was used (McCullagh & Nelder, 1989). The seven postulated candidate models were then fit to the den and rendezvous sites using GLM with probit link, and the best model was selected based on the lowest like-likelihood value (Tables 2 & 3).

All statistical analyses were performed using the R statistical software V. 4.1.0 (R Development Core Team 2023, Vienna, Austria), GLMs were fitted using the *MuMIn* Package (Barton 2023) and plots were created using *GGplot* (Wickham, 2023) and *SjPlot* (Lüdecke, 2021) packages.

## Results

### Den site characteristics and habitat selection:

Out of 32 dens evaluated, the maximum dens were found in grassland (n=15; 46.87% of total dens), followed by scrubland (n=7; 21.87%), plantation (n=6; 18.75%), and the

 https://doi.org/10.63033/JWLS.GHWH3024

**Table 1:** Log-likelihood (LogLik), number of parameters (K), Akaike's Information Criterion value (AIC), change in AIC value (ΔAIC), and Akaike's weight (ωi) of models for den site selection of Indian wolves, Maharashtra, India, 2016–2021.

| Model Description | LogLik | K | AIC | AICc | ΔAIC | *ωi* |
|---|---|---|---|---|---|---|
| Null Model<br>**Intercept only** | -59.44 | 1 | 120.88 | 120.92 | 64.79 | 0.000 |
| *Habitat Feature*<br>**Model 1: Slope + Grassland + Plantation + Scrub + Vegetation Cover** | -28.09 | 6 | 68.18 | 69.17 | 16.03 | 0.000 |
| *Distance to Water and Escape Cover*<br>**Model 2: Dist to Water + Dist to Escape Cover** | 39.98 | 3 | 85.96 | 86.23 | 33.10 | 0.000 |
| *Linear Infrastructure*<br>**Model 3: Cart Road + Metal Road + Primary Road** | -55.66 | 4 | 119.33 | 119.79 | 66.66 | 0.000 |
| *Anthropogenic parameters*<br>**Model 4: Human Footprint** | -51.52 | 2 | 107.04 | 107.18 | 54.04 | 0.000 |
| *Habitat feature, Linear Infrastructure and Distance to Water and Escape Cover*<br>**Model 5: Grassland + Plantation + Scrub + Dist to Escape Cover + Vegetation Cover + Dist to Water + Primary Road** | -19.46 | 8 | 54.93 | 56.66 | 3.53 | 0.146 |
| *Habitat, Distance to Water and Escape Cover and Anthropogenic parameters*<br>**Model 6: Grassland + Plantation + Scrub + Vegetation Cover + Dist to Water + Human Footprint** | -18.90 | 7 | 51.79 | 53.13 | 0.00 | 0.854 |

**Table 2:** Generalized Logistic Regression model predicting Indian wolf den sites vs. contrast sites in Maharashtra. The best model was selected based on the lowest Log-likelihood, and AICc values were used to summarize the results. The beta coefficients of the variables used for all the models and the standard errors, z value, p values, and VIF value (Variance Inflated Factor) are provided. The VIF value measures the amount of multicollinearity in a set of variables (VIF, 1:no correlation, 1-5: moderate correlation, >5: high correlation).

| | **Estimates** (±SE) | **p-value** | **z value** | **VIF** |
|---|---|---|---|---|
| **(Intercept)** | -2.101 (±0.63) | 0.001 | -3.297 | |
| **Grassland** | 1.416 (±0.49) | 0.004 | 2.868 | 1.558 |
| **Plantation** | 1.527 (±0.47) | 0.001 | 3.230 | 2.072 |
| **Scrub** | 1.090 (±0.46) | 0.020 | 2.323 | 1.166 |
| **Vegetation Cover** | 1.979 (±0.74) | 0.008 | 2.671 | 1.722 |
| **Water*** | -4.551 (±1.66) | 0.006 | -2.736 | 1.174 |
| **Human Footprint** | -0.888 (±0.46) | 0.054 | -1.928 | 1.086 |

* The water variable data was calculated as the distance from the den location. So here, the negative value of the estimate represents the association of the den site with water.

lowest number of dens were found in agriculture (n=4; 12.5%). We also assessed the substratum on which dens were formed and found that maximum dens (n=24; 75%) were in bunds (a mound used primarily in India to separate two agricultural lands or embankments to prevent water flow between the fields), followed by rock crevices (n=5; 15.62%) and manmade structure (n=3; 9.37%) such as pipelines. Of the total dens evaluated, 23 were found with single openings, seven with two openings, and one with three and four openings. We also calculated the nearest human settlement and water source from the den site and found that the maximum dens (n=13; 40.6%) were 1001-2000 meters away from any human settlement, followed by eight dens (25%) at 501-1000 meters. The maximum number of dens (n=18; 56.3%) were found within the 100 meters radius of the presence of water, followed by eight dens (25%) between 100–200 meters radius. The presence of the den sites was best predicted by model 6 with the lowest LogLik value (-18.90) and AICc value (51.79) (Table 1). The den sites were positively associated with the presence of water (β=-4.55 ± SE1.66; p=0.006), vegetation cover (β=1.97 ± SE0.74; p=0.008), plantation (β=1.52 ± SE0.47; p= 0.001), presence of grassland (β=1.41 ± SE0.49; p=0.004), and scrub forest (β=1.09 ± SE0.46; p=0.02). The human footprint was negatively associated with the den sites (β=-0.88 ±SE0.46; p=0.05) (Table 2, Figure 2).

## Rendezvous site characteristics and habitat selections:

Out of 25 rendezvous sites evaluated, the maximum number of sites was found in grassland (n=14; 56.0% of total rendezvous sites), followed by plantation (n=5; 20.0%) and scrubland (n=5; 20.0%) each, and the lowest in agriculture (n=1; 4.0%). We also assessed the topography

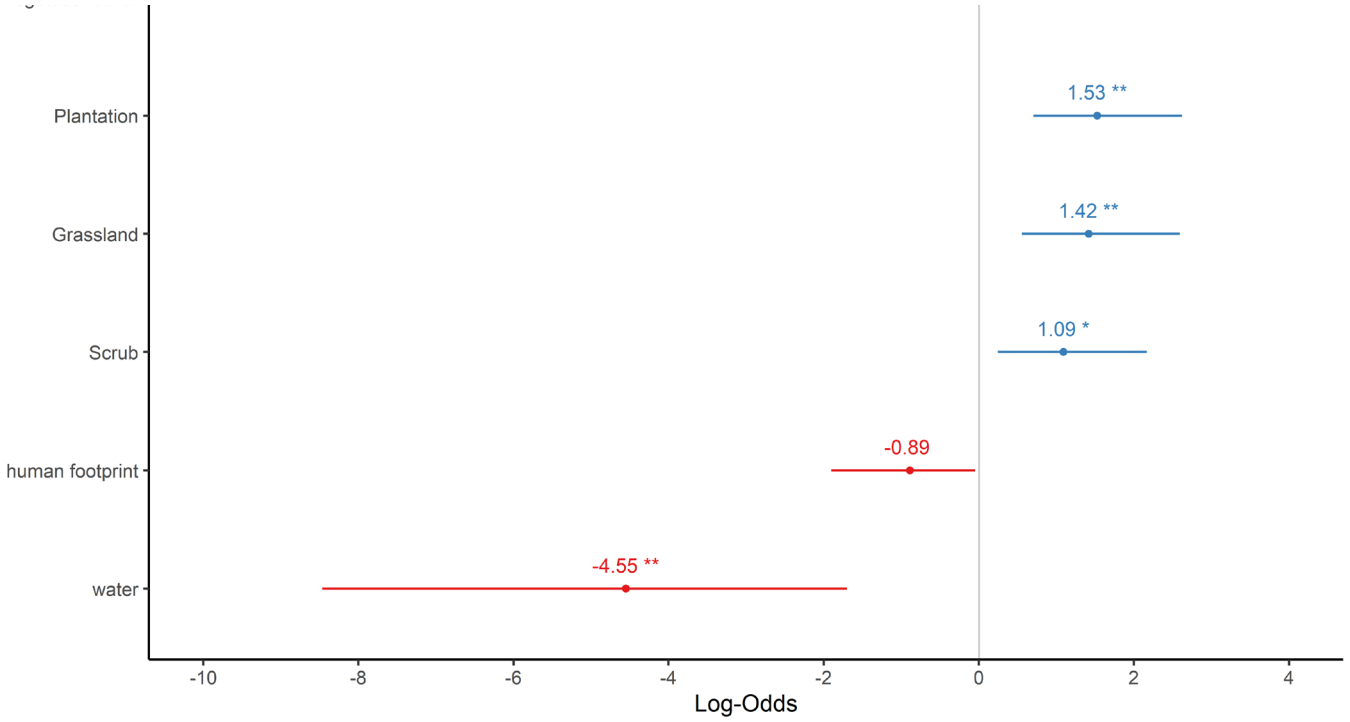


**Figure 2:** Scaled coefficients with a significance level of variables from generalized linear model estimates for the den site of Indian wolves. Horizontal lines depict the 95% confidence interval of each variable. Data for the water variable was calculated as the distance from the den location. So here, the negative value represents the association of the den site with water.

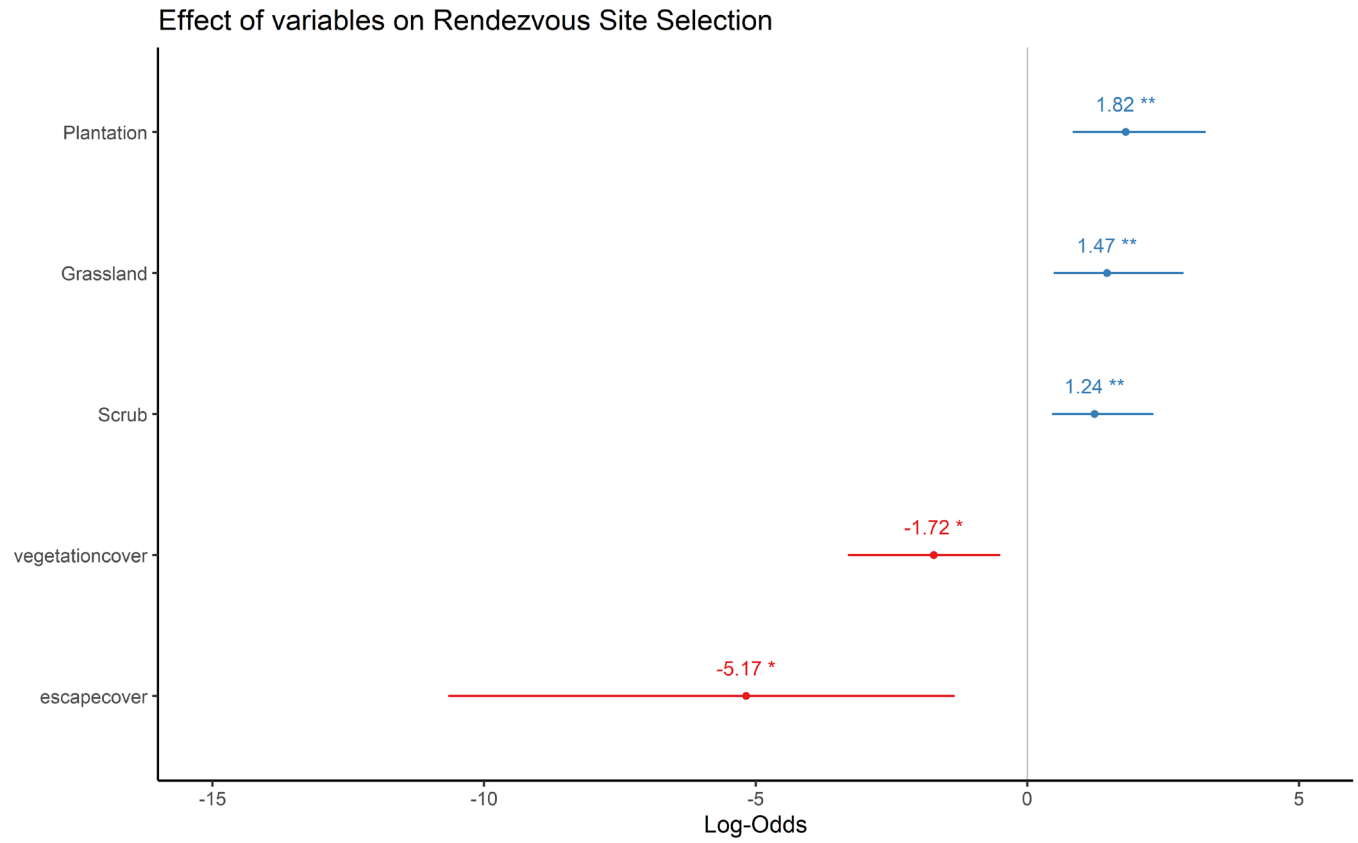


**Figure 3:** Scaled coefficients with a significance level of variables from generalized linear model estimates for the rendezvous site of Indian wolves. Horizontal lines depict the 95% confidence interval of each variable. Data for the escape cover variable was calculated as the distance from the rendezvous site location. So here, the negative value represents the association of the rendezvous site with the escape cover.

where the rendezvous sites were established and found that the maximum number of sites (n=18; 72%) were in flat areas, followed by the slope (n=4; 16.0%), and only three sites were in undulating terrain types.

The presence of a rendezvous site was best predicted by model 6, with the lowest LogLik value (-16.64) and AICc value (46.51) (Table 3). The distance from escape cover (β=-5.17 ± SE2.29; p=0.02), presence of plantation (β=1.81 ± SE0.60; p=0.003), presence of grassland (β=1.46 ± SE0.56; p=0.01), presence of grassland (β=1.46 ± SE0.56; p=0.01), presence of scrub (β=1.23 ± SE0.45; p=0.006) were positively associated with rendezvous sites and negative association with vegetation cover (β=-1.72 ± SE0.69; p=0.01) (Table 4, Figure 3).

**Table 3:** Log-likelihood (LogLik), number of parameters (K), Akaike's Information Criterion value (AIC), change in AIC value (ΔAIC), and Akaike's weight (*ωi*) of models for rendezvous site selection of Indian wolves, Maharashtra, India, 2016–2021.

| Model Description | LogLik | K | AIC | AICc | ΔAIC | *ωi* |
|---|---|---|---|---|---|---|
| Null Model | -47.73 | 1 | 97.47 | 97.53 | 51.01 | 0.000 |
| **Intercept only** | | | | | | |
| Habitat Feature | | | | | | |
| **Model 1: Slope + Grassland + Plantation + Scrub + Vegetation Cover** | -20.68 | 6 | 53.36 | 54.60 | 8.08 | 0.013 |
| Distance to Water and Escape Cover | 39.32 | 3 | 84.65 | 84.99 | 38.47 | 0.000 |
| **Model 2: Dist to Water + Dist to Escape Cover** | | | | | | |
| Linear Infrastructure | -42.45 | 4 | 92.90 | 93.47 | 46.95 | 0.000 |
| **Model 3: Cart Road + Metal Road + Primary Road** | | | | | | |
| Anthropogenic parameters | -47.26 | 2 | 98.52 | 98.69 | 52.17 | 0.000 |
| **Model 4: Human Footprint** | | | | | | |
| Habitat feature, Linear Infrastructure, and Distance to Escape Cover | | | | | | |
| **Model 5: Grassland + Plantation + Scrub + Dist to Escape Cover + Vegetation Cover + Primary Road** | -16.58 | 7 | 47.16 | 48.84 | 2.32 | 0.235 |
| Habitat, Distance to Water and Escape Cover, and Anthropogenic parameters | -16.44 | 6 | 45.28 | 46.51 | 0.00 | 0.751 |
| **Model 6: Grassland + Plantation + Scrub + Vegetation Cover + Dist to Escape Cover** | | | | | | |

**Table 4:** Generalized Logistic Regression model predicting Indian wolf rendezvous sites vs. contrast sites in Maharashtra. The best model was selected based on the lowest Log-likelihood, and AICc values were used to summarize the results. The beta coefficients of the variable used for all the models and the standard errors, z value, p values, and VIF (Variance Inflated Factor) value are provided (VIF, 1:no correlation, 1-5: moderate correlation, >5: high correlation).

| | **Estimates** (±SE) | **p-value** | **z-value** | **VIF** |
|---|---|---|---|---|
| **(Intercept)** | -3.557 ±1.168 | 0.002 | -3.045 | |
| **Grassland** | 1.468 ±0.566 | 0.010 | 2.592 | 2.031 |
| **Plantation** | 1.816 ±0.604 | 0.003 | 3.005 | 2.268 |
| **Scrub** | 1.238 ±0.455 | 0.006 | 2.723 | 1.786 |
| **Escapecover*** | -5.173 ±2.290 | 0.024 | -2.259 | 1.130 |
| **Vegetation Cover** | -1.722 ±0.694 | 0.013 | -2.482 | 1.872 |

*the escape cover variable data was calculated as the distance from the rendezvous site location. So here, the negative value represents the association of the rendezvous site with the escape cover.

## Discussion

The results suggested that the presence of the grassland, plantation, and scrub forest were significantly important factors for den and rendezvous site selection. Moreover, vegetation cover (β=1.97; p=0.008) and proximity to the water (β=-4.55; p=0.006) were also significant factors affecting the den site selection. However, proximity to escape cover was significantly associated, and vegetation cover was negatively associated with the rendezvous sites. Most rendezvous sites (n=18) were also reported from flat topography. The findings were similar to that of the study of Sidorovich *et al.*, (2017), where they reported that wolves prefer small grassy areas for den sites and rendezvous sites are characteristically centered near open areas bordered by tree cover or thickets near the site (Pimlott *et al.*, 1969; Ballenberghe *et al.*, 1975). These open areas are generally less disturbed and are used for livestock grazing. The livestock grazing in these areas also allows wolves to depredate on them. Of total dens, 75% of dens were made on the bund. The bunds are pile foundations that line the edge of agricultural fields and are made of soil and

sometimes stones. Their advantage is that water is confined inside the field, which helps retain rich soil and maintains soil moisture for longer while reducing soil erosion in the low rain shed areas. The wolves use these bunds to build dens in the landscape. Most dens were found with a single opening followed by two openings. Two dens were found with three and four openings, corroborating the findings of Matteson's (1992) study in Montana. Of the total den sites observed, 13 dens were found 1000-2000 meters away from any human settlement, and as the distance decreases, the number of dens also decreases. As human settlement implies increased disturbance, den sites were located away from it, supporting results from studies in Greece (Iliopoulos *et al.*, 2014), Italy (Ciucci *et al.*, 1997; Capitani *et al.*, 2006), and Poland (Theuerkauf *et al.*, 2003).

According to Karlsson *et al.*, (2007), the presence of humans close to den sites might cause wolves to avoid a particular area. In contrast to what we reported, Thiel *et al.*, (1998) recorded multiple cases of wolves establishing dens near human activity and explained the connection to human-induced subsidies. The proximity to the water source was also an important variable. Most of the dens (n=18) were within 100 meters of a water source. Similar results have been presented in many studies conducted on the den site selections in different regions (Joslin, 1967; Voigt, 1973; Carbyn, 1974; Unger, 1999; Habib & Kumar, 2007; Ausband *et al.*, 2010; Benson *et al.*, 2015). This demonstrates the significance of the water near the den sites. Proximity to water sources reduces the need for adults to travel longer distances and, therefore, leave the dens unattended for a longer duration to drink water. Because canid milk is relatively diluted and lactating female needs to consume sufficient water to make milk, proximity to water at this time appears to be a significant determinant (Habib & Kumar, 2007). The vegetation cover at the den site is an important factor. The cover at our den sites was 46.97 ±20.78%, which was lower than the study conducted in northwest Montana and southern Canadian Rockies (66.1 ± 27.3%) (Matteson, 1992), in northwestern Wisconsin and east-central Minnesota (70 ± 24%) (Unger, 1999) and Montana, Idaho, and Yellowstone areas (72 ± 24%) (Trapp *et al.*, 2008). Since our study area falls under the semi-arid landscape of Maharashtra, the low availability of vegetation cover in the area may explain the reason behind the use of low vegetation cover den sites.

The den provides a crucial function for the first few weeks of the pup's life by protecting the young from the environment and potential threats. Compared to the outside world, the den's temperature and humidity are typically moderate and steady (Paquet & Carbyn, 2003). Wolf dens continue to serve as the hub of activity after pups sneak out of the den and start to consume semisolid food that parents have regurgitated at 3–4 weeks (Mech, 1970). Followed by the use of the rendezvous sites, areas where pups are left, usually with a subadult, while pack members forage. Rest and play dominate the activities at rendezvous sites (Theberge & Falls, 1967).

Recently, several studies have related the choice of home sites by wolves to variables such as climate, soil type, vegetation type, tree cover, human disturbance, and prey availability. However, most of these studies have been in North America and Europe (Ballard & Dau, 1983; Norris female, 2002; Theuerkauf *et al.*, 2003; Capitani *et al.*, 2006). Also, there have been multiple reports of repeated use of established natal dens and rendezvous sites (Voigt, 1973; Carbyn, 1974; Paquet & Carbyn, 2003). According to Voigt (1973), one rendezvous site was used at least five times for nine years. In the given scenario, the identified den and rendezvous sites need to be monitored to ensure no changes in these sites and better species protection in the non-protected human-dominated landscape.

The increase in human population, habitat degradation, changing land use patterns, and low wild prey abundance have decreased the former range of wolves and even caused its local extinction (Jhala, 2003). In addition, the expansion of agricultural activities into marginal areas, including open plains, resulted in habitat loss and reduced their geographic range drastically (Mech, 1970). Studying the den site selection of the Indian wolf holds paramount importance for conservation efforts and ecological balance. Understanding the factors influencing den choices provides critical insights into the species behaviour, reproductive success, and population dynamics. By identifying preferred habitats and environmental conditions, conservationists can formulate targeted strategies to preserve and enhance these areas. Moreover, den site selection illuminates the intricate relationship between wolves and their ecosystem, aiding in establishing protected areas for securing den sites.

This is the first study where we presented an Indian wolf den and rendezvous site selection in human-dominated landscapes of India. However, researchers have observed frequent use of secondary dens sites (Chapman, 1977; Habib & Kumar, 2007), but our study only focuses on natal dens (Banfield, 1954). We presented the key characteristics of natal den and rendezvous sites to identify important features associated with these sites. However, our results are preliminary, and more research is required to understand these features more robustly with more data sets. This study serves as baseline information that could aid in Indian wolf conservation. Ultimately, this knowledge serves as a cornerstone for effective conservation policies, ensuring the sustainable coexistence of Indian wolves and their habitats while fostering biodiversity and ecological resilience.

## Acknowledgements

We thank the Ministry of Environment, Forest and Climate Change (MoEFCC) and Maharashtra Forest Department for the permission to conduct research. Department of Science and Technology (DST) Govt. of India and MFD are duly acknowledged for funding provided to carry out the research. We are also grateful to the Field Directors, DFOs, RFOs, and especially our field assistants for providing help in collecting the data. We thank the Director, Dean, and Research Coordinator of the Wildlife Institute of India for supporting the study. We thank Zehidul Hussain, and Hussain Saifi Reshamwala for their valuable comments and suggestions to improve the manuscript and Akash Aggarwal for his immense logistic support during the manuscript writing.

### CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

### DATA AVAILABILITY

The original contributions generated for the study are included in the article, further inquiries can be directed to the corresponding author/s.

### AUTHORS' CONTRIBUTION

BH conceptualized and acquired funding of the study. BH and SK conceived the idea of the study. SK and SS collected the data. SK analysed the data and drafted the manuscript; BH, SK and SS read and approved the final version of this manuscript.

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