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Den Site Selection by Golden Jackal (*Canis aureus*) in a Semi Arid Forest Ecosystem in Western India

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Abstract:
The availability of dens in habitat is essential for successful recruitment and it is confining factor for the distribution and abundance of den dependent species. Present study was conducted in Sariska Tiger Reserve, Rajasthan, India. To determine the most influential variable for selectivity of den sites by golden jackal (*Canis aureus*), data on habitat characteristics were studied at two scales. The physical structure and protective capabilities of dens were studied at small scale (microsite selection) by use-availability design along with discrete choice models. The selection of den in relation to environmental factors was studied at larger scale (macrosite selection) using binary logistic regression in generalized linear model. Thirty six jackal dens were observed in the study area (0.23 den / km^2). The hypothesis received support as a factor for den site selection was 'ease of excavation' at micro scale (314 m^2) and 'cover and resource' at macro scale (3.14 km^2). Areas with high cover were observed having less number of dens (r = -0.76, p =0.02) at significant level. Variables favoring natal den selection was no different than overall selected den sites. Jackal showed no significant avoidance for large carnivore presence where, rodent abundance and visibility were the important predictors for den-sites selection in the study area.

Keywords: Den, Micro site selection, Macro site selection, Resource, Disturbance.

INTRODUCTION

Ecology of widespread species like golden jackal is not much studied in the Indian subcontinent. We studied golden jackal population in semi arid forest area of Sariska Tiger Reserve, Western India, where species dwell along with sympatric mega carnivores including tiger and leopard. In the present study, emphasis was given to denning habitat of golden jackal, which is a crucial factor for successful recruitment and persistence of den dependent species. Golden jackal (*Canis aureus*) is as well known to use dens for both shelter and rearing of young. We intended to look at how structural characteristics and location of golden jackal dens establish to suit these functions under high predator pressure and stress caused by human habitations? Golden jackal excavates dens; as well adapt existing burrows from other species (eg. porcupine). They are regularly associated with dens unless if

they are hunting, which typically occurs during the late nocturnal hours and early dawn. Similar to observations recorded for Kit fox (*Vulpus macrotis*) (Egoscue 1975), golden jackal were observed reliant on dens for moderation of microclimate and security from large-bodied carnivores. Due to habitat alteration in human dominated landscape generalist species such as golden jackal may find greater denning opportunities compared to habitat specialist carnivores. The western part of India is largely arid and semi-arid has large, fast growing human and livestock population. To meet the human needs the region has been subjected to large-scale land use change, and consequent opening and conversion of habitats into scrub and agriculture in several areas over the decades (http://goidirectory.nic.in/fstateut.htm). Therefore, it is crucial to recognize factors that influence den site selection in such habitat and to propose management strategy designed to secure breeding conditions for the species.

In India, jackal den excavation begin from late April to May, where dens are primarily located in natural and man-made embankments usually in scrub habitat (Jhala and Moehlman, 2008). Den entrance characteristics such as the number of entrances, diameter of entrance, and orientation are referenced as important selection factors. The height of vegetation surrounding the den may play a larger role in den selection during pup-rearing season. Jackal generally uses the same den throughout a breeding season, unless disturbed, similar to the observations recorded for Arctic fox (*Alopexlagopus*) (Angerbjörn, Strömanand Becker 1997).

Several studies on jackal focused on distribution and use of dens in different habitat types, but only few have data on the den settlement in semi-arid regions in India (Aiyaduraiand Jhala, 2006; Patil and Jhala, 2008; Soni*et. al*, 1995). Jhala and Moehlman (2008) emphasized that jackal ecology needs to be studied in forested ecosystems. Hence, to join the thread between lacking information, present study was conducted in semi-arid forested area of Sariska Tiger Reserve, Western India.

The analysis of den selection was approached in two ways. First, the physical structure of the den and its protective capabilities (i.e. preventing detection and access by predators, and maintaining stable internal thermal conditions) was analyzed as micro-site selection; and second, den site selection in relation to environmental factors (structure of the vegetation, disturbance and prey availability) was investigated as macro-site selection. Besides collecting data on den structure and location, we also focused on following questions to understand how jackal dens' are arranged spatially. The questions are as follows:

1. What is the importance of vegetation cover for den placement?
2. Is site selection determined by predator avoidance or food availability at the time of denning?
3. Do denning pairs are favored (in terms of alternative food source) or disturbed (pups mortality) by human activities?

MATERIALS AND METHODS

Study area

The study was conducted in Sariska Tiger Reserve (Sariska TR) (27°05'-27°33' N; 76°15'-76°35' E) from April 2011 to March 2013. Sariska TR is situated in the Aravalli Hill Range in the semi-arid part of Western India. The total area of the Tiger Reserve is 881 km^2, of which 273.8 km^2 is notified National Park. The vegetation of Sariska corresponds to Northern tropical dry deciduous and Northern tropical thorn forests (Champion and Seth 1968). Plain areas are covered with scrub forests dominated by shrubs such as *Zizyphus nummularia, Capparis sepiaria*, *Capparis decidua*, *Adathoda vasica*, *Prosopis juliflora* and *Acacia sp.* The valleys are dominated by *Zizyphus mauritiana* mixed forest, gentle slopes are dominated by *Anogeissus pendula* forest and the steep slopes are occupied by *Boswellia serrata*

forest. Other than golden jackal, the park supports various carnivores and omnivores such as tiger (*Panthera tigris*), leopard (*Panthera pardus*), striped hyena (*Hyena hyena*), jungle cat (*Felis chaus*), common mongoose *(Herpestes edwardsii*), small Indian mongoose (*H. auropunctatus*), ruddy mongoose (*H. smithi*), common palmcivet (*Paradoxurus hermaphroditus*), small Indian civet (*Viverricula indica*), ratel (*Mellivora capensis*)(Sankar *et. al.* 2009). There were 30 villages within Sariska TR of which six are located in the intensive study area of 160 km². A large number of cows (*Bos indicus*) buffaloes (*Bubalus bubalis*), goats (*Capra hircus*) and sheep (*Ovis aries*) are kept by people living in villages in and around tiger reserve.

Den surveys

The study area was systematically searched on foot to locate active den sites of golden jackal. An approximate 1752 man hours were invested for searching jackal dens in ~ 160 km² study area using information obtained from jackal sightings, track marks, scats and also from secondary information from shepherds. Active dens were identified by signs of fresh digging, pup and adult scat deposition around the den site and tracks along the ramp of the den openings. The presence of pup scat deposition and pup tracks around the den site was used as sign to differentiate between active natal and resting dens. The number of active and inactive holes at the den-site was recorded. All the active dens of different pairs were monitored simultaneously. The distance between the two occupied dens was estimated using the global positioning system (GPS) and orientation of den openings was recorded.

Sampling methodology to characterize dens

On finding a den site, a circular plot of 10m radius was laid, keeping the den site at the centre, to measure surrogate variables at the micro scale. The same variables in similar size circular plots were also measured outwardly at distance of 100 m in four cardinal directions from the den site (Lesmeister *et. al.*, 2008). The observations on substrate type, terrain type, percentage of canopy cover, tree and shrub density were recorded in the 10m radius circular plot. Visibility was measured using percentage of shrub cover in terms of shrub volume around the den site by recording length and width of every shrub species and adding the results to amount for the percent of area covered by shrubs in 10m radius circular plot. All these observations were made during late mornings and afternoons to avoid disturbance to jackal inside the den. At the occasion when jackal were not present in and around dens, measurements on den openings and den temperature was recorded. The distance from each den site to nearest settlement, water source and road was measured, using spatial analyst tool in ArcMap software, using GIS land cover classification layer. In this study, den structures (the actual features jackal denned within) were described based on 15 natal and 21 resting den sites used by jackal. Out of 21 resting dens, those observed having less frequent usage (< twice; n = 6) were excluded from den site selection analysis.

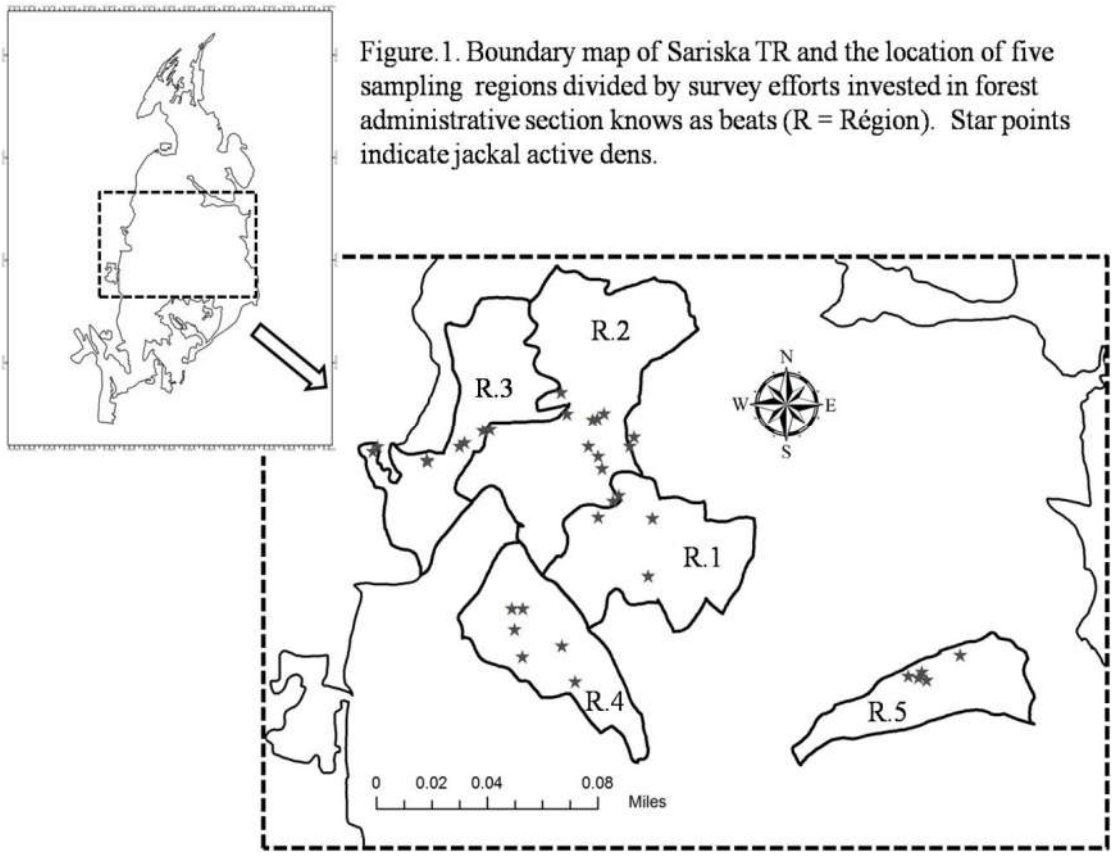

Figure.1. Boundary map of Sariska TR and the location of five sampling regions divided by survey efforts invested in forest administrative section knows as beats (R = Région). Star points indicate jackal active dens.

Figure 1:

Statistical analyses and Model Selection

The factors affecting den site selection in jackal was investigated at two levels; the selection scale at micro site and the selection scale at macro site. For micro site selection, use-availability design was used along with discrete choice models (Cooper and Millspaugh, 1999) using SPSS 16 (SPSS 2007) statistical package. The variables in consideration were i) substrate, ii) terrain, iii) tree number, iv) shrub number, v) vegetation composition, vi) grass cover and vii) distance to road, water and human settlement. For defining the vegetation composition, 'indicator species analysis' was done using program "PC.ord" (McCune and Mefford 2011). Variables with lowest AICs were tested in various model combinations and the model combination with lowest AIC was selected as a best model.

For macro site section multi models were constructed and analyzed using binary logistic regression in generalized linear model (GLM) using selected parameters of different variables with significant values. In the intensive study area where efforts for searching dens were invested, 60 random points were generated for 31 den locations, using Arc GIS tool. The buffer of 1 km radius was layered around each den locations and random locations. Variables in consideration in 1 km radius plot were i) proportional value of forest type, ii) proportional value of forest cover, iii) densities of various prey items, iv) elevation, v) slope, vi) ruggedness and vii) distance to road, water and human settlement. The values of the target variables were extracted from the 1 km radius buffer layer for both random and den locations using GIS land cover classification layer. Prey density for different prey species in 1 km radius plot was evaluated by exploratory analysis using DISTANCE 5.0 (Thomas *et al.*, 2010) software in conventional distance sampling (CDS) and multiple covariate distance sampling (MCDS) framework. For modeling detection function, forest type was used as a factor covariate.

Pearson's correlation was used to evaluate correlation between different variable groups and among different parameters within the group. The high correlated variables were checked for AIC values and one with the high AIC value was dropped whereas other with lowest AIC value was retained for model construction.

To examine factors influencing den site selection by jackal, following four ecological hypotheses were used, that is - resource (habitat and prey availability), thermoregulation / ease of excavation (substrate and terrain), predatory avoidance (cover) and edge effects (distance to road, water and settlement) (Punjabi *et. al.*, 2013). These are represented by explanatory variables measured at each den sites and available sites. An information theoretic approach was used for testing *a priori* models by Akaike's information criterion (AIC) to assess model weights (ω_i) and ranked candidate models using Δ AIC (Burnham and Anderson 2002).

RESULTS

Physical attributes: Thirty six jackal dens were located in the intensive study area of Sariska TR (0.23 den / km^2) out of which information from 30 dens were used for data analysis (excluding less used dens, n = 6). Pairs of jackal observed to begin visiting dens with onset of conventional breeding season (March-April). Natal dens generally had young once present during the rearing season (May-July) and observed vacating dens with onset of monsoon showers (late July to mid August) depending upon the location of den. Four vegetation classes were identified using indicator species analysis i.e. NVD (*Zizyphus **n**ummularia*, *Adathoda **v**asica*, *Capparis **d**ecidua*), LJN (***L**entana camara*, *Prosopis **j**uliflora, Acacia **n**ilotica*), GPB (***G**rewia flavescens, Anogeissus **p**endula, **B**utea monosperma*) and EC (*Balanites a**e**geptiaca, **C**apparis sepiaria*). Vegetation classes NVD and EC were observed more in denning sites and more number of dens was observed in plain terrain. The term resting dens were used for all the dens other then natal dens. No significant difference was observed between natal and resting dens for the four vegetation classes.

Cover dependence: The average size of den opening was recorded 47.11 cm. The percentage cover for natal and resting den were not found different (F = 0.01, p = 0.92) however, in areas with high cover, significantly lesser number of dens were observed (r = -0.76, p =0.02). Natal den selection sites were indifferent to water availability (F = 1.02, p = 0.32) and other human induced disturbance such as distance to road (F = 1.45, p = 0.24) and human settlements (F = 2.53, p = 0.12).

Thermoregulation: The temperature for current period was recorded at intervals of 24 hours for each den. The minimum temperature range fluctuation inside and outside of den was recorded between 0.4°C and 3.6°C and maximum temperature range fluctuation was recorded between 0.1°C and 5.8°C. The ambient temperature was 2.8% to 4.7% higher than the temperature inside dens. To get an idea if den orientation is causing any variation in temperature inside dens, the temperature data was analyzed on the basis of various aspects. The temperature variation was not found significant among aspects (chi-square test: χ^2 = 5.49; df = 7; p = 0.60).

Den Orientation: No selectivity was observed for spatial orientation of den entrances in terms of physical aspect of landscape (χ^2 = 633; df = 7; p = 0.50).

Den placements: To study the position of dens in a landscape, the located den sites were divided into five regions. The 'regions' were defined as contiguous area occupied by jackal in terms of average experiential movement and habitat features such as vegetation type and topography (figure.1). The forest composition for each region was obtained from Sariska forest cover map. Out of eight known

forest types, the three dominant forest types were used for the analysis. There was a negative correlation observed at significant level between distance among dens and area size of the region (Spearman's rho correlation test; r_s = 0.89, n = 5, P < 0.04). The regions with large area extent had dens closely located to each other (≥ 1 km). The top three dominant forest types of five regions and variation among different forest types are given in table 1. The 'region two', having area of 28.11 km^2 was recorded having lower limit of 'maximum distance' between dens, where the composition of forest types were significantly different (One sample *t* test; t = 2.63, df = 5, p = 0.03). The 'region two' composed of high proportion of fellow land (10.62 km^2) followed by *Acacia* dominant forest (7 km^2) and barren land (5.64 km^2) (top three) suggesting the clumpy distribution of favorable habitat prevailing close allowance of dens with each other. No significant variation in forest types was observed for the region where maximum distance between the den was recorded relatively high (One sample *t* test; t = 1.89, df = 5, p = 0.10) (table 1).

Table 1: Five regions surveyed for number of dens, area extent and three dominant forest type composing the region in relation to distance between dens and comparison using independent sample *t* test between regions

Region	Dominant Forest type	Area (Km^2)	Region area (Km^2)	Den distance (Km)	*t*	*p*
Region One	*Acacia* dominant	4.93	17.09	1.5	3.19	0.02
	Barren land	4.79				
	Fallow land	3.29				
Region Two	Fallow land	10.62	28.11	**1.2**	2.63	0.03
	Acacia dominant	7.00				
	Barren land	5.64				
Region Three	*Acacia* dominant	6.02	16.28	1.4	3.29	0.01
	Barren land	2.70				
	Anogeissus dominant	2.47				
Region Four	*Acacia* dominant	8.42	14.31	1.6	1.89	0.10
	Anogeissus dominant	1.88				
	Fallow land	1.65				
Region Five	Fallow land	4.30	11.03	1.5	2.83	0.03
	Scrub land	2.31				
	Anogeissus dominant	1.88				

Micro site selection: The modeled averaged parameter estimates at the micro scale (314 m^2) revealed that under physical structure dependence, the hypothesis 'ease of excavation' (substrate and terrain) received much support as the underlying factor for den site selection. The presence of suitable substrate (rock-mud; β = 4.82 ± 1.29, sum ω_i = 1 and mud-loam; β = 3.16 ± 1.04, sum ω_i = 1) in corresponding terrain were evaluated as the most influential factors (table.2). Variables favoring natal den selection were no different than that of overall selected den sites (Kruskal-wallis test, χ^2 = 5.00; p = 0.42).

Table 2: Most influential model-averaged parameter estimates of top models explaining den selection by jackal at the micro site scale at Sariska TR (2011-13)

Factor	Covariate	Mean β	SE unc	Sum ω_i
Substrate	Rock-mud	4.82	1.29	1.00
	Mud-loam	3.16	1.04	1.00
Vegetation composition	LJN	0.07	0.50	0.53
	NVD	1.05	1.03	0.53
Vegetation structure	Shrub-num	-0.01	0.00	0.21
	Tree-num	0.08	0.08	0.53

NVD = *Zizyphus **n**ummularia*, *Adathod a**v**asica*, *Capparis **d**ecidua*; LJN = ***L**entana camara*, *Prosopis **j**uliflora, Acacia **n**ilotica*;

Macro site selection: At the macro scale (3.14 km^2), the hypothesis 'cover and resource' received most support to infer the underlying factor for den site selection by jackal. On the basis of modeled averaged parameter estimates, favorable distance form settlements (DSET-KM; β = -1.597 ± 0.544, sum ω_i = 1), more distance from dense forest (ANOG; β = -10.396 ± 5.904, sum ω_i = 0.988) and presence of small mammal (RdntDnst; β = 0.050 ± 0.034, sum ω_i = 0.822) were evaluated as the most influential factors (table. 3).

Table 3: Most influential model-averaged parameter estimates of top GLM models explaining den selection by jackal at the macro site scale at *Sariska TR* (2011-13).

Variables		Mean β	SE unc	Sum ω_i
Cover - Resource	DSET-KM	-1.597	0.544	1.000
	ANOG	-10.396	5.904	0.988
	RdntDnst	0.050	0.034	0.822
Prey - Density	GrdBrdDnst	-0.001	0.001	0.008
	PreyD	-0.003	0.006	0.003
Resource - supplements	DRD-KM	-0.001	0.003	0.003

Dist SET-KM = Distance to settlement in Km;Dist RD = Distance to road; ANOG = *Anogeissus* dominated forest; RdntDnst = Rodent density; GrdBrdDnst = Ground bird density;PreyD = Prey density.

The negative beta values infer inverse relation with the variables where, larger the value more will be the avoidance for respective variable. Jackal showed no significant avoidance for large carnivore presence (tiger, leopard and hyena). All other models representing the predatory avoidance, vertical cover (tree number, canopy cover) and disturbance received no support. Neither any significant selection nor avoidance for any forest types (*Anogeissus* dominant forest, *Boswellia* forest, *Acacia* mixed forest, *Zizyphus* mixed forest, *Butea* dominant forest and Scrub forest) was observed.

DISCUSSION

Management of common species is often looked at coarse level and usually does not account for local `subtle' elements of the habitats, like what we are concerned herewith. We studied dens site selection of golden jackal, analyzing their presence using two different scales: the immediate surroundings of

dens and the potential denning areas at certain distances. The first scale allowed isolating physical structures of the den while second scale allowed investigating habitat characteristics and its configurations at wider context. It was hence used to compare the explanatory capability of each group of variables tested regarding den selection. This is the first study on den selection of golden jackal in semi arid 'forested ecosystem' and demonstrates that habitat configuration is important in resource selection (here den) in a mosaic setting such as Sariska TR. The results of the present study on jackal den site characteristics are in accordance with features observed in Bhal (Aiyadurai and Jhala, 2006) and Saurashtra (Soni *et. al*, 1995) region of western India.

The selection of particular dens is, in theory, influenced by their ability to satisfy the demands for raising pups successfully during their early growth stage. Thus, the placement of litters in canids and other denning carnivore has been related to a combination of factors, including security for young once and energy economy for the females (Laurenson, 1995a). In this regard, a widely accepted hypothesis deals with the demands of feeding optimization. This leads to an obvious question: what are the critical characteristics that makes certain location so worthy for den placements? We examined each factor separately to understand their dependency for denning.

Physical attributes: Golden jackals were frequently observed to overtake porcupine's dens (n = 6) (Habib and Kumar, 2007) modifying abandoned dens (n = 2), termite mounds (n = 3), man-made structures (3) and rock crevices depending upon the ease of excavation during the study. However, selectivity for natal den sites with small den entrance diameters (~23 cm; n = 15) supports suggestion that jackal preferentially selected such dens to reduce the potential of predation by larger-bodied carnivores (such as striped hyena) (Frafjord, 2003). Vegetation classes NVD and EC were observed more in denning sights of jackal in Sariska. The corresponding plant species in these indicator classes are *Zizyphus **n**ummularia, Adathoda **v**asica, Capparis **d**eciduas, Balanites a**e**geptiaca*and ***C**apparis sepiaria*. The predilection for den site amid above mentioned shrub species is acceptable since these arid plants bears feature like thick bush volume, protective thorns, summer fruit production and low water dependence, which may apparently favoring the jackal breeding pair at time of pup rearing.

Cover dependence: Lesser number of dens were observed in areas with high cover (r = -0.76, p =0.02). Primarily natal dens had low shrub cover close to 10 m radius of den, similar to the observation by Zoellick *et. al.* (1987) for natal kit fox dens. This could be to maximize probability of detecting approaching predators where, den itself was well camouflaged with bushes like *Capparis sepiaria*, *Capparis deciduas*, *Zizyphus nummularia* and *Adathoda vasica*.

Den Orientation: In our study jackal den entrance orientations were found random in general, similar to the observations on swift fox (Pruss, 1999 and Jackson and Choate, 2000) in Canadian prairies. Several studies on Arctic fox dens have discovered significantly larger number of den entrances oriented in a southerly aspect (Chesemore 1969; Smits *et.al.*1988: Prestrud 1992; Nielsen *et.al.*1994), which is hypothesized to provide thermal and microclimatic advantages. Moreover in present study it could not be concluded whether dens at certain aspect were inherently cooler than other aspects or it is governed by den construction style which is improving ventilation. More detailed study is needed to address this topic.

Den placements: The jackal dens were observed in clusters in the study area, similar to the observations recorded for Swift fox (Cutter 1958, Hines and Case 1991) and kit fox (O'Neal *et. al.*, 1987). Recorded minimum distance between two successively used jackals dens in Sariska were only 43.84 m apart. The den clusters were found to have two to four dens which were no more than an average of 424.3 m apart from each other. Den clustering may perhaps be valid as a fact that small

canids and the pups of the even larger species often run the risk of being killed by raptors and larger mammalian predators, especially when living in open habitats(e.g., Carbyn 1986, Thurber *et. al.*1992, Lindström *et. al.*1995, Ralls and White 1995, Palomares and Caro 1999, Macdonald *et. al.*, 1999). Hence, clusters of den provide an alternate refuge and protection from possible predators such as striped hyena, feral dogs and leopard in Sariska.

The edge locale delimiting cultivated patches adjoining Sariska did not have any influence on the choice of denning places by jackal. Inversely, tarmac roads seem to persuade den settlements at levelheaded distance in the study area. Although the findings are contrary to expectation, it may infer that proximity to roads offer potential scavenging opportunities as road-killed reptiles, invertebrates, and rodents, offering suppliant food for jackal. Jackal may be denning closer to roads to avoid sympatric carnivores that may not be as tolerant to human-associated disturbance, which is similar to the observation recorded for red foxes towards coyotes in North Dakota and East-central Illinois, USA (Sargeant*et.al.* 1987; Gosselink*et.al.* 2003). Nevertheless, roads are certain threat to jackal in Sariska as there were five jackals observed killed by road accidents during the study period of three years.

Micro/Macro site selection: Feeding optimization has been proposed as an influential factor in the location of dens in several studies with carnivores (Hewson, 1986; Ciucci and Mech, 1992; Aldama, 1993; Laurenson, 1995a). The `central place foraging' (Orians and Pearson, 1979) pattern for searching food during denning, together with strong energetic stress and higher requirements due to breeding (Aldman, 1993), would constrain breeding pair to den in sites with optimal access to food. Our results did reflect such preference, as dens were situated at suitable distance from human settlements and dense *Anogessious* forest (Security), fair rodent abundance (food) and appropriate distance from road (security and optional food). However at exact den site, suitable depth for den construction was resolute by substrates for easy maintenance when reproductive costs are high.

From the present study, it can be inferred that in Sariska, where hyena and dogs (at the border of the reserve) are major interference competitors for jackal, it is important for the species to ensure early detection of approaching predator by avoiding dense areas have more horizontal cover. Consequently, vegetation cover did significantly influence jackal's den selection.

No straight avoidance for large carnivore presence (tiger and leopard) by jackal was observed however, denning close to roads and settlement may aid in avoiding sympatric carnivores that be not tolerant to human-associated disturbance. Relation with prey (rodent) abundance was fairly demonstrated and certainly influences site selection by jackal (table.3).

In extensive, jackal den selection were indifferent to distance to road (F = 1.45, p = 0.24) and human settlements (F = 2.53, p = 0.12). However, six of the dens in which pups were reported earlier, were altered by humans by means of dumping large stones and closing its opening. Weather such activities caused any mortality of pups was not known. Such dens were closely located to human habitation (~ 600 m). These activities attributed to the magnitude of disturbance on reproductive success of jackal in the study site. Despite the fact, jackals were observed to re-excavate the closed dens in next season instead of excavating in other locations. This infers that despite other denning sites are available to jackal; some dens are more preferred than others. The possible explanation could be either, agricultural region provide food accessibility (rodents, birds and crop) and may modify relative humidity and soil texture, favoring jackal building large dens or, such areas are the best sites available in animals' territory.

CONCLUSION

This study was carried out in an area relatively subjected to anthropogenic activity. Amid livestock, human, competition and predation pressure jackal were observed maintaining hold of its population by selecting hefty combination of habitat parameters ensuring successful breeding and rearing of pups. Forest is under stress and it is unclear how much alteration in habitat can jackal withstands or, whether the change condition will create more prospects for jackal population.

One consistent pattern emerges from across different models is that substrate and food availability is the key habitat variable structuring jackal den placements in Sariska. Moreover, It is suggested that more detailed study is needed using GPS collars that may enable us to determine territorial movement of jackals in relation to large carnivores and demarcate core of their territory. It would be more instructive to see den placements by jackals once their home range is well distinguished. It is suggested to promote jackal as rodent controlling agent in cultivated areas and hence improving its acceptance around adjoined human habitation. Change in forest condition determines the proportion and propagation of inhabiting species. It is edifying to see how jackal subsist in the protected area designated for tigers and the way they exploit human dominated as well as protected area at the same time for their very existence.

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