# FORAGING AND HABITAT USE BY GOLDEN JACKALS (*CANIS AUREUS*) IN THE *BHAL* REGION, GUJARAT, INDIA[1]

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Home ranges of six Golden Jackals (*Canis aureus)* were estimated in and around Velavadar National Park, Gujarat using radio-telemetry, between November 2000 and December 2001. Classified LISS III digital satellite imagery in a GIS domain was used to determine available and used habitats. Each of the radio-collared Jackals was continuously tracked for 1-3 nights to determine their nocturnal ranging patterns. Jackal movement routes were plotted on a composite food index map. Mean 95% Minimum Convex Polygon (MCP) and 95% Adaptive Kernel home ranges of Jackals was 14.30 (SE 4.06) sq. km and 29.77 (SE 10.99) sq. km respectively. The mean core area (75% harmonic mean) was 3.97 (SE 1.62) sq. km. Compositional Analysis showed that Jackals preferred high cover habitats for their core areas during daytime and periphery of villages during night. Jackal ranges overlapped (15.7%, SE. 8.5; range 0.24-89%), but their core areas were exclusive. Food habits of jackals as determined by scat analysis (n=150) showed that they subsisted primarily on Blackbuck (33%) and cattle (32%). Jackals were observed to travel an average of 6.8 km (SE 1.05; range 0.4-12.1) per night and their routes tracked food resources. They often visited outskirts of villages to scavenge on livestock carcasses and garbage piles. This study highlights the importance of human generated resources for carnivores like Golden Jackals.

**Key words**: home range, Golden Jackal, *Canis aureus*, radio-telemetry, habitat use, ranging patterns, food habits

## INTRODUCTION

Golden Jackals (*Canis aureus)* occur in a variety of habitats from deserts to tropical evergreen forests and are also found in urban and rural areas. Their range extends from northern Africa, through the Arabian Peninsula and the Indian subcontinent, to Vietnam (Sheldon 1992; Jhala and Moehlman 2004). Jackals feed on small prey like hares, rodents, ground dwelling birds, and young of ungulates (Schaller 1972; Kingdon 1977). They also scavenge off kills made by large predators and on human garbage (Schaller 1972; Poche *et al.* 1987). Studies on the social organization, food habits, resource partitioning, economic damage, vocalizations, and co-operative breeding in jackals have been conducted primarily in Africa and Bangladesh (MacDonald 1979; McShane and Grettenberger 1984; Poche *et al*. 1987; Fuller *et al.* 1989; Jaeger *et al*. 1996; Jaeger *et al*. 2001; Moehlman 1979, 1983; Moehlman and Hofer 1997). Even though the Golden Jackal is the most common wild canid in India, little information is available on its habitat use, ranging patterns and food habits. In this paper, we present results of our study conducted between November 2000 and December 2001 on home range, habitat use, food habits and ranging patterns of Golden Jackals in Velavadar National Park and the surrounding *bhal* region of Gujarat, India.

## STUDY AREA

The *bhal* covers an area of about 2,590 sq. km along the coast of Gulf of Cambay in the state of Gujarat (Western India). The characteristic feature of the *bhal* is its flat terrain and thus the name, which means 'forehead' in the local language. The soil is alluvial, made up by silt deposits from the rivers flowing into the Gulf of Cambay and the Arabian Sea. It consists of a mosaic of croplands, grasslands, and saline marshes (Dharmakumarsinh 1978, Jhala 1997).

The *bhal* region is known for its large population of the endangered Blackbuck (*Antilope cervicapra rajputane*). Other important wild mammalian herbivores of the *bhal* region include the Nilgai (*Boselaphus tragocamelus*), the Indian Wild Boar (*Sus scrofa*) and the Indian Hare (*Lepus nigricollis)*. The Indian Wolf (C*anis lupus pallipes*), the Golden Jackal (*Canis aureus*), the Indian Fox (*Vulpes bengalensis*), and the Jungle Cat *(Felis chaus*) form the mammalian carnivore community in the area. Velavadar National Park is the only protected area in the *bhal* and covers an area of 34.52 sq. km (Pathak *et al*. 2002) comprising of grassland, scrubland, and saline marshes.

## MATERIAL AND METHODS

### Trapping and collaring

We trapped jackals using rubber padded foothold traps (Linhart and Dasch 1992) in Velavadar National Park during November and December 2000. A mixture of Ketamine hydrochloride (8-10 mg/kg) and Xylazine (0.2-0.3 mg/kg) was used to anesthetize the trapped jackals (Kreeger 1996). We

determined approximate age class of jackals from tooth eruption, tooth wear, teat size and genitalia. Four males (two adults, one sub-adult and one juvenile) and two females (one old and one juvenile) from different family groups were collared with Wildlife Material Inc. activity collars. The collars were <2% of the body weight of the jackals.

We monitored radio-collared jackals using Telonics TR-2 radio-receiver and a three-element hand held Yagi antenna by a 4-wheel-drive vehicle and on foot. The day was divided into four 6-hour periods and an attempt was made to obtain equal number of locations in each time period. Radio-fixes were obtained by homing-in and circling the jackals at a distance of 30-200 m, or by actual sightings (White and Garrot 1990). Errors on locations obtained by circling the jackal were estimated by verifying the actual position by homing-in and sighting the radio-collared jackal on several occasions. Care was taken not to disturb the radio-collared jackal while obtaining location data. We found this method to be most appropriate with least errors, on the flat terrain of the *bhal*. The coordinates of the locations were recorded using a hand-held global positioning system unit.

**Home range**

The location data were converted to Universal Transverse Mercator coordinates and used for estimating home ranges. Minimum Convex Polygon (MCP) home ranges obtained by ten cumulative sequential samples were plotted against number of locations to determine adequacy of sample size of radio-locations for home range estimation (Kernohan *et al*. 2001; White and Garrot 1990; Harris *et al.* 1990). Different percentages of harmonic mean isopleths versus the area of the home range were plotted; the point of inflexion of the home range curve was considered the isopleth defining the core area of the home range (Dixon and Chapman 1980; Harris *et al.* 1990). Ninety five percent adaptive kernel model and 95% MCP model were used for estimating home ranges (White and Garrot 1990; Worton 1989) using a computer program CALHOME (Kie *et al*. 1996*)*. Ninety five percent bootstrap confidence intervals (Krebs 1989) were generated for the 95% MCP home range estimates. The percentage overlap of home range of jackals was estimated by overlaying home ranges and areas of the overlap computed in Arcview GIS software (1996).

**Habitat Use**

Indian Remote Sensing Satellite imagery (IRS- ID/LISS III) of January 2001 with four bands (blue, green, infrared and near infrared) and 23.5 m resolution was used for analysis of availability and use of different habitats. Habitats were delineated into nine categories [grassland, medium *Prosopis*, dense *Prosopis*, village outskirts, saline wasteland, halophytic scrub, fallow fields, mud flat and others (road edges, canal etc.)] based on unsupervised and followed by supervised classification (Schowengerdt 1983) and ground validation. Areas of different habitats within the 95% adaptive kernel (AK) of each Jackal were considered available habitats for an individual Jackal. Radio-locations were plotted on the classified imagery and their percent frequency in each habitat category was computed and considered as 'habitats used' by that individual Jackal.

Habitat use was investigated at the following levels for each individual Jackal (Palomares and Delibes 1992):

1. All radio-locations (overall) within 95% AK as compared to habitat availability.
2. Core area selection within 95% AK home range.
3. Habitat selection during day (day locations) within 95% AK home range.
4. Habitat selection during night (night locations) within 95% AK home range

Compositional analysis (Aebischer and Robertson 1993) considering each Jackal as a sampling unit and individual locations as sub samples (Garton *et al.* 2001) was used to determine habitat preference. Normalized Difference Vegetation Index (NDVI) values were used as an index of vegetation cover (Jensen 1986) and NDVI values compared between entire home ranges and core areas.

**Food Habits**

We collected Jackal scats and analysed them by standard techniques to study the food habits of Jackals (Korschgen 1980; Haufler and Servello 1996). Identity of scats were ascertained based on location (e.g. Jackal dens), size of the scats and the presence of indirect evidences like scratch marks and footprints of the animals. Scats of ambiguous origin were discarded.

Mammalian hairs present in scats were identified by comparing their cuticular patterns and cross sections observed using a compound microscope with reference hair samples (Jhala 1993; Mukherjee *et al.* 1994; Jethva and Jhala 2003). Bird and reptile remains found in the scats were identified by the presence of feathers and scales. Species level identification for these was not attempted. Rodent remains were determined both by the presence of jawbones and by the cuticular pattern of hair (Korschgen 1980). Bootstrap analysis (Krebs 1989) was used to generate standard errors on percent occurrence of prey items in scats.

**Food Availability**

To quantify relative food availability, we classified habitats into five different types, namely grassland, saline

and mud flats, scrubland, crop fields and periphery of villages. We used different sampling methods for different prey species. Prey species quantified were Blackbuck, cattle carcass, hare and large grasshoppers. Hare abundance was indexed by quantifying hare pellets on 20-25 belt transects of 20 x 1 m in each habitat type (Cochran and Stains 1961). For comparative purpose, we assumed 1,000 hare pellets to correspond to one hare unit. The index was believed to scale relative hare abundance (not absolute hare numbers) between different habitats, since pellet persistence time was not likely to differ between habitats. We estimated grasshopper abundance by walking 10 one hundred metre transects in each habitat type (Austen 1997). A one metre stick was waved on either side to flush grasshoppers. Blackbuck numbers were estimated thrice in each habitat type by total counts. Information on domestic livestock carcass deposition rate near 12 villages was obtained by interviewing villagers and by counting the number of fresh cattle carcasses, skulls and other skeletal remains of cattle outside the villages. Since livestock carcasses and garbage were found within about 300 m of villages, this zone was considered as village peripheries for computing biomass availability index. A multitude of scavengers like village dogs, Wild Boars, Indian Wolves, birds of prey and Jackals were observed to feed on livestock carcasses. Most of the edible part of livestock carcasses was consumed within 2-6 days. Though Jackals visited carcasses several days old, their visit rates dropped after 4-6 days. There was very little edible portion left for Jackals to scavenge off a livestock carcass after the forth day due to the high density of village dogs and Wild Boars. Therefore, a livestock carcass was considered available to Jackals for 5 days after deposition.

**Ranging patterns**

We followed radio-collared Jackals continuously from early evening to late morning for a minimum of one night and a maximum of three nights to study ranging patterns in relation to food resources. During continuous monitoring, we obtained location of Jackals by direct sighting or by circling the animal at a distance (30-100 m).

**Jackal Food Index**

Each food item index was multiplied by the relative importance of that food item to the Jackal as estimated by percent occurrence in Jackal scats and a separate map of each food item index was then generated. A spatial composite food index was then developed by adding food index maps for each food item in a GIS domain. Thus, each pixel of the map had a value on a gradient of resource richness scale from low to high. The nocturnal routes taken by Jackals during the continuous night tracking were plotted on the composite food index map to understand the nocturnal movements of Jackals in relation to food availability. Random locations, equal to the number of locations used to map the Jackals' nocturnal routes, within the study area, were generated using Arcview (1996) software. Of these, 13 locations (same number as actual routes sampled) were randomly selected as starting points of random routes. A random movement path was generated by joining this random starting point to the closest random location and from that to the next closest location and so on. The route was truncated when the length of the random route matched that of an actual sampled route. Jackal routes and random routes were buffered on either side by a 20 m strip. Composite food index of buffered routes were compared between Jackal routes and random routes by a t-test (Zar 1984).

## RESULTS

**Trapping and radio-collaring**

Six Golden Jackals were trapped over one hundred and twenty six trap nights. Trapping success was low due to disturbance of traps by Wild Boars attracted to the bait. Forty-eight percent of traps set were disturbed by Wild Boars within 6 hours. Earlier trapping success in the same area in 1997 was one Golden Jackal in 4 trap nights. At that time no traps were disturbed by Wild Boars since their density was very low (Jhala unpublished data).

**Home range**

Errors in location estimates obtained by circling compared to actual sightings were less than 30 m. This error would be in addition to the inherent error of GPS units in recording position coordinates (considered to be about 1-5 m on the average). Most habitats patches were over one hectare in size, thus the location errors were small compared to habitat patches and were not likely to alter analysis of habitat use.

Home ranges of four Golden Jackals stabilized over the sampling duration, whereas home range of F1 and M3 did not reach an asymptote. Average number of locations required for estimating home range of Jackals was 65 (SE 5) spread over five months. Mean home range size (95% AK) of Jackals was 29.77 (SE 10.99) sq. km (Table 1).

On an average, harmonic mean isopleth graphs for Jackals showed an inflexion at 75% (SD 3.7%) and this isopleth value was used as an estimate of the core area of home ranges. The average core area for Jackal home range was 4 (SE 1.6) sq. km.

The home range of Jackals in Velavadar National Park overlapped, whereas their core areas were exclusive. The average percent overlap of home ranges of five adjacent Jackal ranges was 15.7% (SE 8.5 range 0.24 to 89%) for 95% AK and 14.5. (SE 1.17 range 2% to 25%) for 95% MCP.

**Habitat Use**

Jackals used nine different habitat classes, namely grassland, medium *Prosopis*, dense *Prosopis*, village outskirts, saline wasteland, halophytic scrub, fallow fields, mud flat and others (road edges, canal etc.). Compositional Analysis rejected the null hypothesis of no selection for all the 4 levels of habitat scales ($p < 0.05$). At the overall selection level, the selected habitats inside their home range were village outskirts, dense and medium *Prosopis* thickets. When comparing core areas to entire home ranges, major habitat types selected were grasslands, dense and medium *Prosopis*. None of the core areas included villages. NDVI values of core areas of Jackals' home ranges were significantly greater from the NDVI values of entire home range (t-test, df=11, $p<0.001$). There was a marked difference in the habitat selection of Jackals between night and day. Village outskirts were preferred at night, while grasslands and *Prosopis* thickets were selected during the daylight hours (Fig. 1).

**Food-habits and availability**

Scat analysis (n=150) showed that Blackbuck (33%) and cattle (32%) form the major food items followed by vegetation matter (24%) and hare (12%) (Fig. 2). Blackbuck and cattle remains combined, comprised more than 60% of the prey remains in Jackal scats. Grasslands, followed by scrublands and village peripheries, were rich in Jackal food resources (Table 2).

**Ranging pattern**

The average distance covered by Jackals in one night was 6.2 km (SE 1.01; range 0.4 to 12). Average rate of travel was 0.7 km per hour (SE 0.14). During the 13 sessions of continuous night tracking, Jackals were observed to visit 12 villages. The village close to the Park was visited often; the farthest village visited was 12 km from the Park (Table 3). The food index map showed that the Park and village outskirts were rich in Jackal food resources. Nocturnal movement

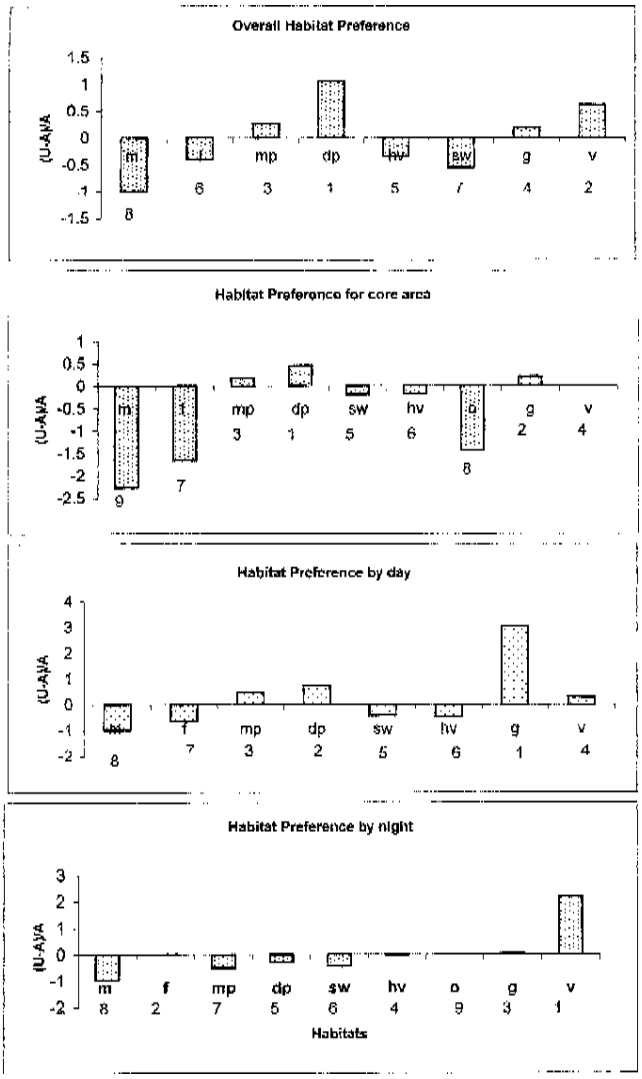


Fig. 1: Order of habitat selection by Golden Jackals in the *bhal* region of Gujarat. Habitats are plotted on a preference index (U-A/A) (Aebischer and Robertson, 1993) scale. The number shown above each bar are the ranks obtained by Compositional Analysis. (m-mudflats, f-fallow fields, mp-medium dense *Prosopis* scrub, dp-dense *Prosopis* scrub, sw-saline wasteland, hv-halophytic vegetation, g-grassland, v-village periphery, o-others (road edge, canal, etc).

**Table 1**: Home range (sq. km) of Golden Jackals as estimated by 100% Minimum Convex Polygon (MCP), 95% MCP (± Bootstrapped 95% Confidence Interval), 95% Adaptive Kernel (AK), 75% Harmonic Mean (HM) and number of radio-location (N)

| Jackal | Sex | Age group | 100% MCP | 95% MCP | 95% AK | 75%HM | N | Months Tracked |
|---|---|---|---|---|---|---|---|---|
| F1 | Female | Adult | 48.13 | 29.80 ± 1.56 | 16.79 | 11.51 | 79 | 5 |
| F2 | Female | Juvenile | 34.92 | 19.11 ± 0.94 | 32.68 | 3.76 | 104 | 6 |
| M1 | Male | Adult | 41.54 | 10.40 ± 3.03 | 77.22 | 3.58 | 109 | 23 |
| M2 | Male | Juvenile | 7.77 | 5.60 ± 0.27 | 5.33 | 0.70 | 121 | 22 |
| M3 | Male | Sub Adult | 20.78 | 17.63 ± 1.72 | 39.34 | 3.60 | 41 | 20 |
| M4 | Male | Adult | 5.60 | 3.0 ± 0.33 | 7.24 | 0.67 | 79 | 11 |
| Average | | | 26.46 | 14.26 | 29.80 | 3.97 | 89 | 14.5 |
| (SE) | | | (7.3) | (4) | (11) | (1.6) | (12) | (3.3) |

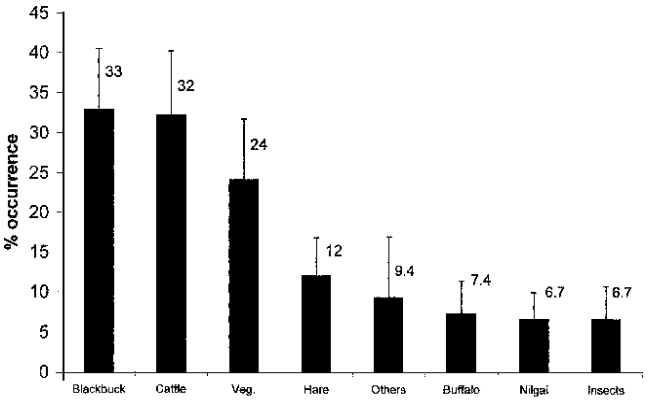


Fig. 2: Food habits of Golden Jackals in the *bhal* region of Gujarat. The number shown above each bar are percentage occurrence (with bootstrap standard errors) of food items obtained from scat analysis

ranging paths of Jackals had higher nutritional index values when compared to randomly generated paths (t=2.588, df=12 p=0.021) (Fig. 3).

## DISCUSSION

### Home ranges

The home ranges of Golden Jackals in Velavadar National Park were much larger than those reported for Jackals in Bangladesh 0.6-1.1 sq. km by Poche *et al.* (1987) and 0.5 sq. km by Jaeger *et al.* (2001) and in Ngorongoro crater (5.1 sq. km) (Poche *et al.* 1987; Van Lawick-Goodall and Van Lawick-Goodall 1971) but similar to those reported in Serengeti (10.34-23 sq. km) (Van Lawick-Goodall and Van Lawick-Goodall 1971). The study in Bangladesh was carried out near agricultural areas and radio-telemetry was used on only two individuals, a male and a female, for about two months and one of the transmitters ceased functioning within one and half months of collaring (Poche e*t al.* 1987). Jaeger *et al.* (2001) monitored Jackals only during daylight hours. This short monitoring period only during daylight hours combined with an agricultural landscape rich with food resources in the form of garbage in Bangladesh and a resource rich habitat in Ngorongoro are likely responsible for the small home ranges. In the Serengeti, Jackals resided in the short grass plains similar to the landscape of the *bhal*, with a more homogenous habitat and seasonally low resource availability. The low diversity of food sources in the *bhal* was likely compensated by the resources available from the villages in the form of garbage and domestic livestock carcasses.

Even though the radio-collared Golden Jackals belonged to different family groups, their home ranges overlapped. The high degree of home-range overlap in the silver-backed Jackals in Namib Desert coast was related to the presence of large localized food resources such as seals and nesting cormorants (Hiscocks and Perrin 1988). Over 10 Jackals have been reported to congregate on a lion kill in Africa (Schaller 1972). During the course of the current study, we observed 16 Jackals feeding on a single bullock carcass. Five to six Jackals were commonly observed on Blackbuck and cattle carcasses. Such aggregations have been observed in Israel where food was provisioned (MacDonald 1979). It is likely that in a clumped food resource area it would be difficult for individuals to defend their territory against intruders, thus resulting in a breakdown of territorial behaviour. Even though the average home range overlap in the *bhal* Jackals was 14-16%, the core areas of each Jackal were almost exclusive. It seems likely that the different family groups defended smaller core areas in their home range for resources like cover and denning habitat.

**Table 3**: Nocturnal ranging distance (km) by Golden Jackals in the *bhal* region of Gujarat

| Jackals | No. of nights | Average ± SE | Range |
|---|---|---|---|
| F1 | 1 | 7.8 | - |
| F2 | 2 | 7.34 ± 2.8 | 4.5 - 10.18 |
| M1 | 3 | 6.96 ± 2.5 | 3.4 - 11.8 |
| M2 | 2 | 1.3 ± 0.9 | 0.4 - 2.2 |
| M3 | 3 | 7.55 ± 2.2 | 4.8 - 12.06 |
| M4 | 2 | 6.73 ± 0.6 | 6.1 - 7.36 |
| Overall | | 6.28 ± 1.5 | 0.4 - 12.06 |

**Table 2**: Mean and standard errors of indices of Golden Jackal prey (numbers per ha, except for hare) in different habitats of the *bhal* region of Gujarat

| | Grassland | *Prosopis* Scrubland | Saline and Mud Flats | Crop Fields | Village Periphery |
|---|---|---|---|---|---|
| Hare (pellet index) | 4.5 ± 1.3 | 12 ± 3 | 0.53 ± 0.26 | 0 | 0 |
| Locust | 20 ± 20 | 2.6 ± 1.20 | 0 | 0 | 0 |
| Blackbuck | 0.58 ± 0.20 | 0.15 ± 0.33 | 0.01 ± 0.16 | 0.001 | 0 |
| Cattle Carcass | 0 | 0 | 0 | 0 | 2.13 ± 1 |

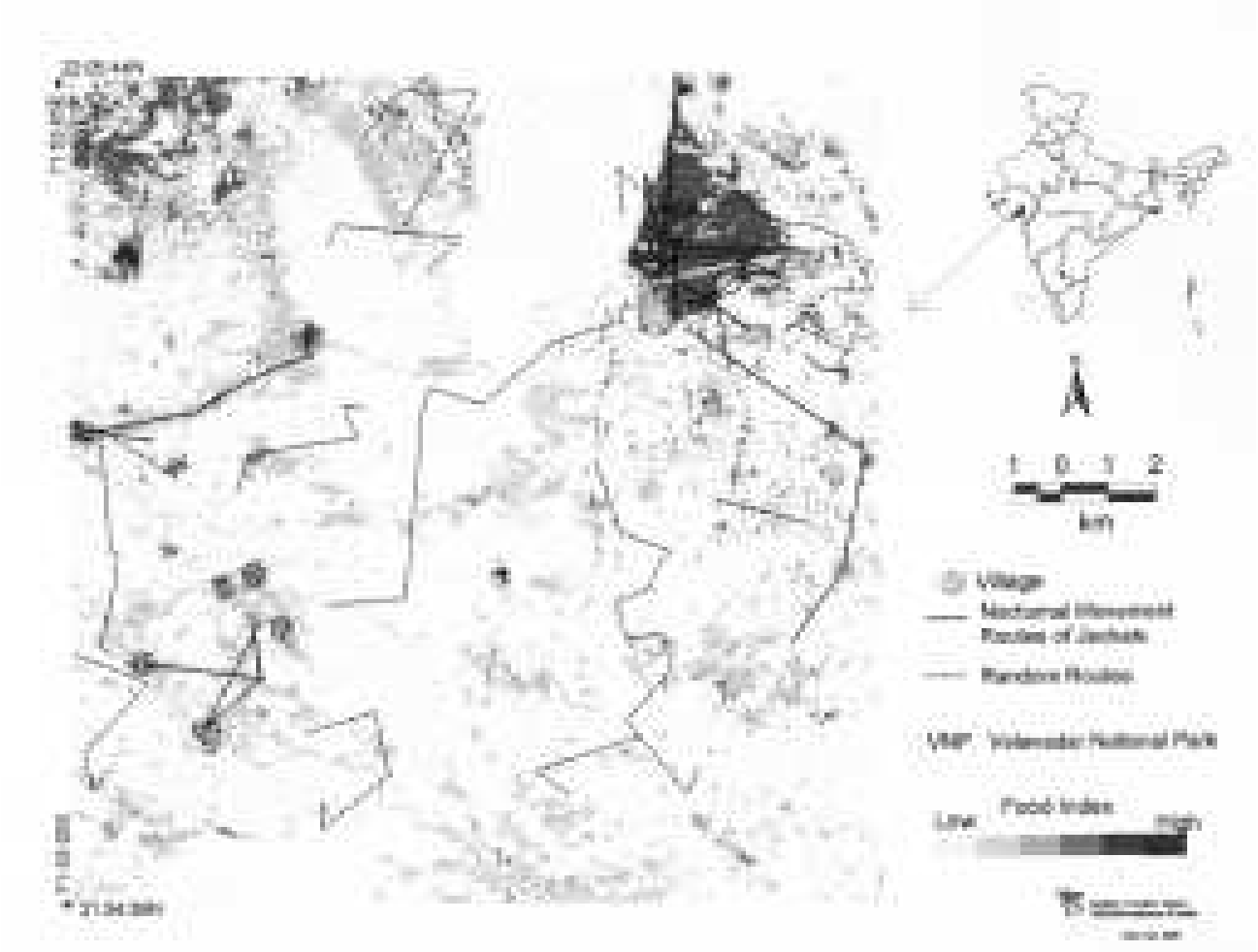


Fig. 3: Nocturnal travel paths of jackals and random paths of equal lengths plotted on composite food index map of the *bhal* study area. The map inset shows the general location of the study site within India

**Habitat use**

*Prosopis* scrubland, villages and grasslands were the most preferred habitats compared to other habitats. Though the Jackals ranged outside the Park at night for foraging, they used the Park during daytime as a refuge with high cover availability and less human disturbance. Jackals were mostly active at night and twilight hours. Daytime activity was primarily to and from the core area cover to a waterhole. *P. juliflora* thickets were important habitat and served as cover for Jackals during the day in the study area. NDVI values indicate that core areas have more vegetation compared to the rest of their home ranges.

**Ranging patterns**

Continuous night observations indicate that Jackals heavily use garbage sites and livestock carcass and the frequent visits to village outskirts were related to food availability. There were more than 5 villages around the Park within a radius of 8 km. All villages in the *bhal* have one or more garbage dumping sites and at least one site where the dead cattle were dumped. However, this food resource is not available only for Jackals but is shared with village dogs, Wild Boars and Indian Wolves. Dogs dominate livestock carcasses during the day while Indian Wolves, Wild Boar and Golden Jackals fed on them, primarily after dark. Jackals were the lowermost in order of dominance for feeding on these carcasses. In spite of the low rank in the feeding hierarchy, Jackals spent a lot of time in the village outskirts. This suggests that the sheer magnitude of food available from cattle carcasses and garbage made it profitable for Jackals to invest time in procuring food from villages. The food index map clearly highlights the importance of food resource patches since Jackals were observed to track rich food patches during their nocturnal forays.

Blackbuck form an important component of the Jackals' diet. Jackals primarily scavenged on carcasses of Blackbuck killed by Indian Wolf and predated on Blackbuck calves (Jhala 1991). Since the study period was a drought year, Blackbuck

calving peak was not as pronounced and may explain the high frequency of visits to villages by Jackals residing within the Park (high Blackbuck density area). Population of carnivores like Indian Wolves and Hyenas living outside the protected areas are highly dependent on human generated food resources (Jhala 2002, 2003). This study highlights the importance of human generated food resources for carnivores in rural India. Even though the Jackals resided in a protected area, they were dependent on village dump piles to obtain a significant portion of their food.

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