HOME RANGE, RANGING PATTERNS AND ABUNDANCE ESTIMATION OF GOLDEN JACKALS IN THE *BHAL* REGION OF GUJARAT

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CERTIFICATE

This is to certify that Ms. Ambika Aiyadurai of the Wildlife Institute of India has carried out original research titled " Homerange, Ranging Patterns, and Abundance Estimation of Golden Jackals in the *Bhal* Region of Gujarat. " for the partial fulfillment of the Master of Science (Wildlife Science) degree from Saurashtra University, Rajkot, India. These investigations were carried out under my supervision from November 2000 to June 2001. I also certify that this research has not been submitted for any other degree to any University.

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SUMMARY

I studied Golden Jackals (*Canis aureus)* in the *Bhal* area of Gujarat using radio-telemetry. Six jackals were trapped in Velavadar National Park during November and December 2000 using rubber-padded leg-hold traps. The average home range size of jackals was estimated to be 14. 30 ± 4.06 sq. km. The core areas of jackal home ranges were highly correlated with vegetation cover. Habitats preferred for core areas were *Prosopis juliflora* and grasslands. Jackals ranged an average distance of 6.8 ± 0.91 km in a night. Most movements were out of the park to surrounding villages, which were rich in food resources for jackals. I evaluated two techniques to estimate jackal abundance namely the track plot method and simulated howling responses method in six areas differing in jackal abundances in the *Bhal* and Kutch regions. The latter technique gave a better resolution of abundance categories within the study sites.

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1. INTRODUCTION

1.1 General Introduction

Family Canidae consists of approximately 35 species that are categorized into 15 genera. They occur throughout the world from Arctic to tropical forests (Sheldon, 1992). Monogamy, parental investment, large litter size, long period of infant dependency (Kleiman and Eisenberg, 1973) and a cooperative breeding system (Van Lawick-Goodall and van Lawick-Goodall, 1986) are the principle aspects of a canid social system. Jackals are medium-sized unspecialized and opportunistic canids and are very flexible both in their feeding habits and habitat requirements.

Jackals as a group amongst canids are even more adaptable. There are three species of jackals, Silver-backed jackal (black-backed) *Canis mesomelas,* Golden jackal (*Canis aureus*) and Side-Striped jackal (*Canis adustus*). Distribution of side-striped and black-backed jackals are limited to Africa where as the golden jackal range occuring in northern Africa presumably extends across the Arabian Sea through India (Fox, 1975) and in Sri Lanka, extending east to Myanmmar, Thailand and Vietnam (Jhala and Moehlman, in press).

Golden jackals occur in varied habitats and are found in humid forest country, in dry plains, desert and also found in the Himalayas. A greater number live around human settlements with abundant food resources and cover (Prater, 1980). They seem to have a flexible social system. The basic unit is the mated pair and its offspring (Sheldon, 1992) and sometimes with helper from the previous litter (Moehlman, 1979). Golden

jackals also form large groups on garbage grounds (Macdonald, 1979) and on carrion (pers. obs.).

In most ecosystems, jackals are predators feeding on small prey; hares, rodents and ground dwelling birds. Due to an omnivorous diet and ability to adapt to human habitation, jackals are an extremely successful canid. The ecological role of Golden Jackals as carnivores and scavengers makes them an important component in shaping community structure. Golden Jackal is a Schedule II species under the Wildlife (Protection) Act 1972 (Anonymous, 1992) and not being an endangered or threatened species, not much importance has been given to their ecology. Even though there is information available on the golden jackals in Africa, very little is known about jackals in India or Asia.

The *Bhal* ecosystem is a semi-arid flat srcubland/grassland of Gujarat where jackals are found in large numbers. They are observed to hunt fawns of blackbuck and believed to be a limiting factor for blackbuck in the *Bhal* (Jhala *et al.*, in review). Unfortunately, the role of jackals in any given ecosystem is not well documented. One of the important components in the ecology of a species is the study of home range and its ranging patterns. To understand the relationship of jackal with its surroundings, and other species in the Bhal ecosystem, telemetry studies were undertaken. Some of the main objectives were to study the habitat use, ranging patterns, and develop indirect estimation techniques for jackals.

1.2 Literature review

The Jackals in Africa has been studied intensively as compared to the jackals in Asia

Van Lawick-Goodall and van Lawick-Goodall (1971), Kruuk (1972), * Moehlman (1983), Ferguson (1988)). The black-backed Jackal (Rowe-Rowe, 1982). Van Lawick-Goodall and van Lawick-Goodall (1971) have made some very interesting observations on various aspects of social behaviour for e.g. on social dominance-subordination relationships, communal howling, courtship and hunting. Kruuk (1972) observed social relationships between spotted hyenas and both golden and black-backed jackals. McShane and Grettenberg (1984) have reported the diet items of golden jackals. Information on resource partitioning among sympatric species of jackals in the Rift Valley of Kenya by Fuller *et al.*, (1989). The social system of golden jackals was studied by MacDonald (1979) in Isreal. Golani and Keller (1975) have studied the behaviour of Golden Jackals on the sand dunes of Israeli coastal plains. Most of their observations were on pair-formation, courtship feeding and compared its behavior of other pairs and individuals in the same population.

Food habits of jackals in Kanha National Park shows 80% of dietery to be rodents with reptiles and fruits as important components (Schaller, 1967). Jackals feeding on crops such as corn, sugarcane and melon has been reported (Poche *et al.*, 1987). Zizyphus (*Zizyphus jujuba*), date palm (*Phoenix sylvestris*) and jamun (*Syzygium cumini*) have been also reported in their scats (Sankar, K 1988). Scavenging or predation of ungulates by jackals is relatively unimportant in Kanha meadows (Schaller, 1967). Schaller also noted the occasional occurrence of langur remains in their scats. Newton (1985) gives a detail account of langur and jackal association and reports incidence of jackals attacking langurs. His work suggests jackals as important predators on terrestrial langurs, particularly immature ones. Macdonald's study in Isreal (1979) illustrates that jackal populations obtained 92% of their food from one

feeding site of only 10-sqm area. Territory limits were delineated by feaces arranged in piles and middens as genuine territorial boundary. The jackals were identified individually by white marking on their throat and chest and by the extent of white fur on their lower limbs. Jackals in some places subsist mainly on garbage and carrion near towns and villages (Poche *et al.,* 1987). Jackals hunt down adult Thompson's gazelle (Lawick and van Lawick-Goodall, 1971). Packs may kill sheep and goats (McShane and Grettenberg, 1984). Instances of cooperative hunting of langurs by jackals (*Presbytis pileata*) has been described by Stanford (1989). Soni *et al.,* (1995) talks about jackal dens in human altered places and their destruction being very critical to the reproduction of jackals.

Vocalizations are common in jackal (Van Lawick-Goodall and van Lawick-Goodall, 1971). Howling is more frequent between December to April a time when pair-bonds are being established and breeding occurs, suggesting a role in territory delineation and defense and during denning period, however howling decreases because of the vulnerable young (Jaeger *et al.,* 1996). No other study on jackal howling is available but studies on other canids include Harrington and Mech, (1979) and Tooze *et al.,* (1990) on wolves. Vocalizations of coyotes have been studied by Lehner (1978). Population of coyotes in Montana have been estimated through coyotes howl responses to siren survey (Pyrah, 1984).

The earliest home range work was employed in the early 1940s (Burt 1943, Mohr, 1947 and has been defined in various ways for the past 4-5 decades. A home range consists of a more or less restricted area within which an animal moves when performing its normal activities (Harris *et al.* 1990). Jewell (1966) explains home

range as an area with a certain productivity that meets the energy requirements of the individual or group that occupies it. Sometimes part of the home range is of particular importance because it contains the most favoured resting places and refuges. This is designated as "core area". Usually, home ranges of individuals could overlap but mostly core areas are exclusive for individuals or family units (Ewer, 1968).

One of the earliest simplest and most widely used model for home-range calculation is minimum convex polygon (MCP). The results from MCP are easy to interpret and are comparable with other studies. It is more robust than other techniques when the number of fixes is low, it has a few disadvantages. Its range boundary encompasses all the fixes including occasional fixes well beyond the main area of activity and gives no indication of the intensity of range use. To exclude the outliers, home range is calculated at 95% MCP method was calculated (White and Garrot, 1990). Harmonic Mean method gives an idea of the configuration of the home range, largely avoiding areas not visited by the animal (Dixon and Chapman, 1980) and provides a technique for the accurate calculation of centers of activity.

There is information available on home range of African jackals (Black-backed and side-striped jackals) but a very few studies are specific on golden jackals. Home ranges of jackals in Bangladesh report 1.1 and 0.6 sq km for males and females respectively with a tracking period of 3 months (Poche *et al.*, 1987). In Serengeti, home range of 10.24 – 23 sq. km for golden jackals was estimated (Van Lawick-Goodall and van Lawick-Goodall, 1971). In Ngorongoro crater, home range of golden jackals was 5.1 sq. km (Van Lawick-Goodall and van Lawick-Goodall, 1971). Golden jackals in Rift Valley show that range size of a pair to be atleast 2.4 sq. km. but range

of two juvenile females were 5.6 and 21.7 sq. km (Fuller *et al.*,1989). Radio-collaring was attempted on one golden jackal in Kanha National Park but no information is available on their home ranges (Kotwal *et al.*, 1991).

Studies on other jackals are available. The movements of Black-backed jackals has been studied in the African montane region and their estimated home-range size was 18.2 sq km (Rowe-Rowe, 1982). He reports that pair-living jackals did not overlap their home ranges with other mated pair. Immature jackals occupied home ranges within the mated pair home ranges. The Black-backed jackals were also studied in Kalahari Gemshok National Park where they are reported to have 5.3 sq km and in Transvall, the home range size is 181.7 sq km with 95% MCP (Ferguson *et al.*, 1983). He also reported the age-related difference and adults occupied smaller home range than the sub-adults. Work by Hiscocks and Perrin (1988) in Namib desert shows their home range to be 24.9 sq km.

Habitat Use

Habitat use is a critical aspect in the ecology of a wildlife species. Habitat provides food and cover important for the survival of the population. Habitat selection is an important feature of behaviour and population dynamics (Rosenzweig, 1981). Habitat selection may take place at several spatial scales (Johnson, 1980). Home range of an animal is itself a selection and the animal allocate their time with respect to the habitat types available within its home range. If they are using a particular habitat, then the use may or not be in proportion. They might use a particular habitat patch more than others. It could be because of the territoriality of the animals. All available habitats may not be suitable to animals.

Golden jackals studied in Rift Valley were reported to use grassland more often than closed woodland and open *Euphorbia* Woodland habitat (Fuller *et al., 1989).* Dense scrubs and thickets close to agricultural fields and villages were observed to be preferred habitats of the jackal in western Rajasthan (Sharma, 1998).

Sometimes part of the home range is of particular importance because it contains the most favoured resting places and refuges. This is designated as "core areas" (Ewer, 1968). Usually it is the home ranges that overlap and not core areas.

A lot of literature is available on use and availability of different habitats and there are several ways in which habitat use is analysed (Neu *et al.,* 1974), Johnson (1980), Marcum-Loftsgaarden (1980). A Chi-Square test (Neu *et al.,* 1974) is the common approach to test the null hypothesis that habits are being used in proportion to their availability. The test is based on the goodness of fit of utilized habitat to available habitat types.

1.3 Objectives

(a) To estimate the seasonal home ranges and the ranging patterns of the Golden Jackals (*Canis aureus*) in and around Velavadar National Park.

(b) To estimate the habitat use and preference of different habitats by jackals in and around Velavadar National Park.

(c) To develop an index for estimating jackal abundance.

2. STUDY AREA

The present study was carried out in two regions of Gujarat, the *Bhal* region in Bhavnagar district and in Abdasa region of Kutch district. The intensive study area was Velavadar National Park (VNP) in the *Bhal* region.

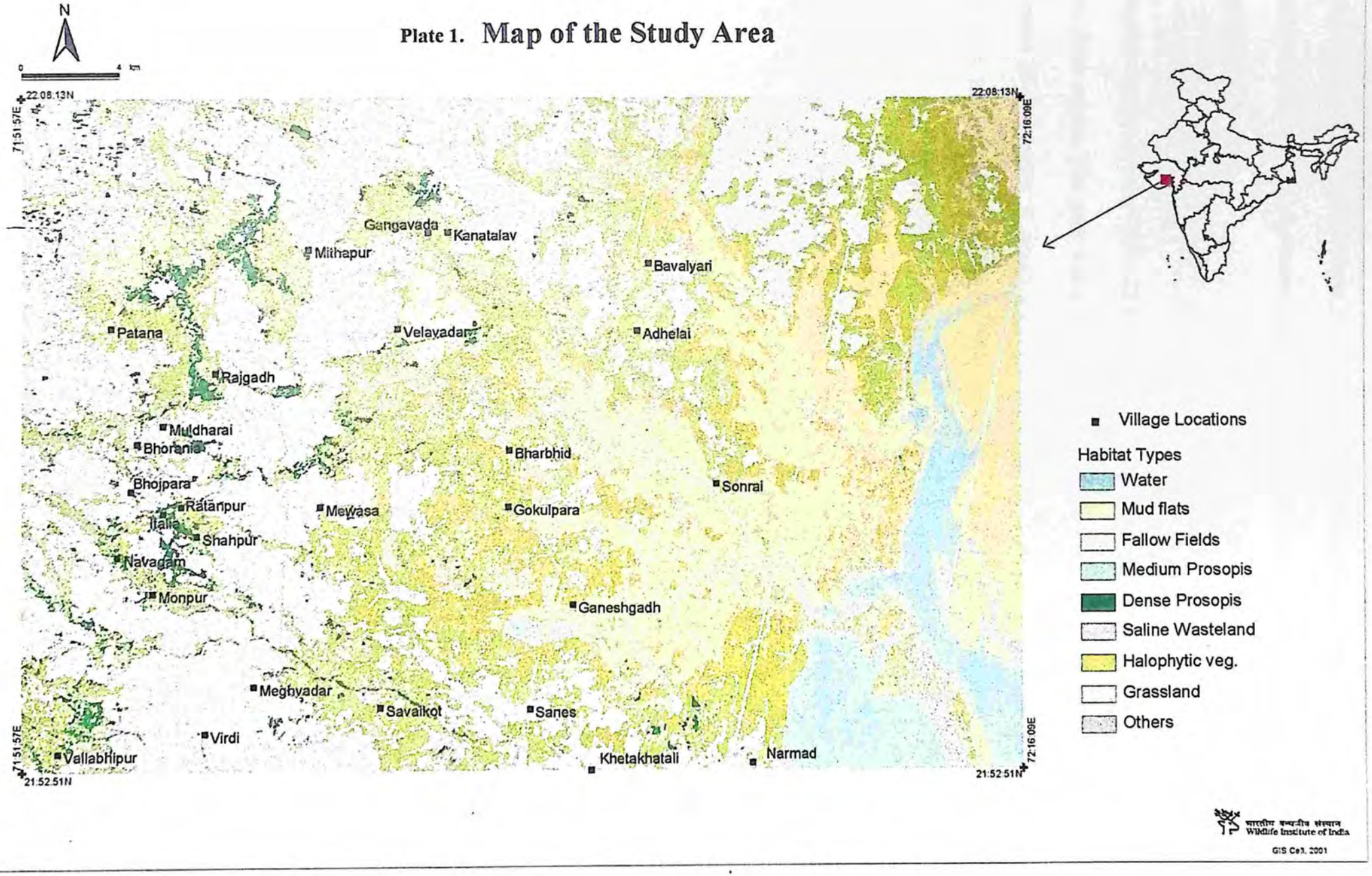
2.1 *Bhal*

The *Bhal* covers an area of about 2590 km^2 of Saurashtra in the state of Gujarat. The *Bhal* (literally meaning the forehead) is flat alluvial plain made up by silt deposits from rivers flowing into the Gulf of Cambay and the Arabian Sea (Plate 1). It consists of a mosaic of croplands, saline wastelands, grasslands, and marshes (Dharmakumarsinhji 1978). The *Bhal* region is bordered on the south by the Kalubhar river, on the northern side it extends to Dholka and Dhandhuka towns and the town of Limbdi marks its limits on the northwest border (Dharmakumarsinhji 1978). It extends from the eastern cost of 'Gulf of Cambay' on the western side, the National highway connecting Dhandhuka-Vallabhipur and Bhavnagar marks its boundary.

The *Bhal* region is known for its large concentration of blackbuck (*Antelope cervicapra rajputane*). Other important wild herbivores of the *Bhal* region include nilgai (*Boselaphus tragocamelus*), wild pigs (*Sus scrofa*) and hares. Where as among important carnivores the indian wolf (C*anis lupus*), indian jackal (*Canis aureus*), indian fox (*Vulpes bengalensis*), and jungle cat *(Felis chaus*).

The *Bhal* area was an open and nearly tree-less habitat but now is dominated by *Prosopis juliflora* (mesquite). It is an exotic species and a native of southwestern America. *P. juliflora* was introduced in India in 1876-77 (*Muthana & Arora 1983).

Plate 1. Map of the Study Area



Mesquite was planted in VNP about 70 years ago to provide fuel-wood. Mesquite has since spread rapidly and converted much of the grasslands into savanna and thorn-forested habitat.

Velavadar National Park (VNP) (22° 04 58 N, 72° 00 46'E) is the only protected area in the Bhal region. The park was a part of the private grazing grounds of the late Maharaja of Bhavnagar. It covers an area of 3408 ha of semi-arid grasslands and scrublands. It is just above the sea level and is 18 km from the Gulf of Cambay. Three seasons can be distinguished in VNP. Almost all the precipitation occurs in the monsoon, which begins at the end of June and continues until mid-september. October is a transition period with sporadic showers. Average rainfall for 1978 to 1990 was 518 mm. The temperature ranged between 1°C to 38°C in winter, which extends from November to February. During summer (March to June) the day temperatures normally range between 37°C to 48°C. hot winds called "*loo*" sweep the hard-baked earth; dust storms and dust devils are common.

VNP forms the intensive study area where all jackals were trapped. Areas for telemetric studies were not only limited to the park but area till Muldharai, Bharbheed, Mewasa and Nawagaam villages. Sanes and Adhelai areas in the *Bhal* region was used to develop the index of jackal abundance.

2.2 Kutch

The study area in Kutch was located near the village of Tera in Abdasa taluka. The vegetation is classified as Northern tropical Thorn Forest (6B/C1) and is sub-classified as desert thorn forest by Champion & Seth (1968). According to the

Biogeographic classification, the study area is a desert (3A) (Rodgers and Panwar, 1988). The area is undulating and interspersed with low hillocks dominated by *Acacia senegal, Acacia nilotica, Prosopis cineraria, Prosopis juliflora, Salvadora persica, Salvadora oleoides,* and *Euphorbia nudiflora.*

The major carnivore species found in Kutch region are indian wolf (*Canis lupus*), striped hyaena (*Hyaena hyaena*), golden jackal (*Canis aureus*), jungle cat (*Felis chaus),* Caracal (*Felis caracal*), Desert Cat (*Felis libyca*), indian fox (*Vulpes bengalensis*) (D K Sharma, per. comm.). Other mammals found in the region are the indian gazelle (*Gazella gazella*), Nilgai (*Boselaphus tragocamelus*), wild pigs (*Sus scrofa*) and hares.

Three specific areas were chosen for sampling jackal abundance namely Paat, Daun and Hyena ridge. Daun area is grassland dominated by *Cymbopogon* spp, *Chrysopogon* spp. and *Dicanthium* spp. Hyeana ridge *has Salvadora persica* interspersed with *Acacia nilotica & Prosopis juliflora.* Paat area is dominated by *Acacia senegal* and *Acacia nilotica* interspersed with crop fields.

People in kutch have a large number of live stock which results in the heavy grazing and the carnivores in the region subsist mainly on livestock (Jhala, 1999).

3. METHODS

3.1 Home Range

As the study was carried out from November 2000 to end of April 2000, the home range estimated is for this period only and should be considered as jackal's seasonal home range. The radio-fixes with accuracy levels more than 400m were dropped from the home range analysis and the difference was highly non-significant (t-test, p=0.363, df=5, t=1) (SPSS, 1999) in the size of home range when these fixes were included. So, all fixes were used in home range size estimation.

To determine the core zones within jackal's home range, Harmonic Mean isopleths values ranging from 20 to 100 % were plotted against home range size (Dixon and Chapman 1980). The point at which the gradient of the slope changes is identified as the core area. When the inflexion point lies between two values, the lower one is used to define the core area.

Trapping and Collaring

The jackals were trapped using rubber padded victor softcatch leg-hold traps (Linhart and Dasch, 1992) within Velavadar National Park. The traps were set in areas where the movement of jackals was more likely to occur. Indirect evidences of presence of jackals such as trails, tracks, scats and scratch marks were searched. Places like the junctions of two or more trails were appropriate to set traps. Pieces of meat and fishes were used as bait to lure the jackals. Traps were set by late afternoon and were baited in the evening and were checked every 3-4 hours after baiting. Six jackals were trapped over one hundred and twenty three trap nights. Ketamine (8-10 mg/kg) and Xylazine (0.2 to 0.3 mg/kg) were used to tranquilize the animals (Kreeger, 1996).

Four males (two adults and two sub-adults) and two females (one old and one juvenile) were collared with HPLM Wildlife Material Inc. activity collars. Approximate age was determined from tooth eruption, tooth wear, teat size and genitalia (Table 1).

Jackals were equipped with wildlife materials activity radio-collars. The collars were <2% of the body weight of the jackals.

Table – 1 : Details of the jackals collared in Velavadar National Park during November – December 2000.

S.No	Name	Sex	Age-class	Date collared	Wt (kg)	Tracked till
1	Punchkati	F	Old	13 Nov 2000	7.75	7 Apr 2001
2	Captain	M	Adult	14 Nov 2000	9.5	16 Apr 2001
3	Rob	M	Juvenile	20 Dec 2000	7.50	16 Apr 2001
4	Priyanka	F	Juvenile	19 Dec 2000	7.35	17 Apr 2001
5	Don	M	Juvenile	16 Nov 2000	9.15	15 Apr 2001
6	Alibaba	M	Adult	28 Dec 2000	8.75	16 Apr 2001

Collared jackals were monitored using telonics radio-receiver and a three-element hand held Yagi antenna. Radio fixes at various times of the day and night were obtained by homing in and circling the jackals from a distance of 30-500 m. The animals were located 2-3 times a day with a minimum of six hours interval between locations. The day was divided into four 6-hour periods and locations were obtained for each period. Jackals were followed continuously from sunset to sunrise on a minimum of two nights and a maximum of three nights to determine foraging and related ranging patterns. During continuos monitoring approximate location of jackals was obtained by circling the animal (30-150 m accuracy) GPS fixes were taken at every 20-30 minute interval.

Habitat, time, group size, activity and an estimation of fix accuracy (approximate distance from animal when circling) were recorded for every location. The coordinates of the locations were recorded using a global positioning system unit (Magellan Trail Master). These location data were converted to Universal Transverse Mercator coordinates and used in estimating the home range size (White and Garrot, 1990) with a computer programme CALHOME (Kie *et al.*, 1994).

The jackals studied will be referred with their names as shown in Table 1 through the entire text.

3.2 Habitat Use and Availability

To estimate the habitat use and availability, Indian Remote Sensing Satellite imagery (IRS- ID/LISS III) with four bands (blue, green, infrared and near infrared) was used.

The imagery of January 2001 was acquired, path and row is 092 and 056. The size of the pixel was 23.5 m.

This study is focussed at the second order of selection and the habitats preferred by the jackals within its core zones is the prime concern.

Available habitat types and their area for each jackal's home range was obtained by plotting their 95% MCP on the image. The random use of the habitats by the jackals were obtained by plotting 100 random points within the 95% MCP polygons USING Arcview software (1996). The actual habitat use by the jackals were determined by plotting the radio-fixes.

Chi Square tests (Zar, 1984) were used to test whether jackals are making any choice in habitats. All jackals showed a preference in the use of different habitat types (χ^2 test $p<0.01$, df varied from 30 to 35). To determine which habitats were preferred Compositional Analysis was used (Aebischer *et al.*, 1993). The proportional habitat use by individual animals is a bias for analysis. So, compositional analysis was used to remove the non-dependence of habitat proportions.

Habitat use and Availability using regression

The habitat use and availability can also be shown using regression (Lagory, 1985). Random points of the same number as radio locations were plotted with the 100 % Minimum Convex Polygon (MCP) of each jackal. Frequency of a point falling in a habitat type was recorded.

The percent habitat coverage by random points was regressed against the percentage area of that habitat within the home range of a jackal (LaGory, *et. al.*, 1985). A 95% Confidence Interval (CI) was generated on the regressed line. Since random points should sample habitat types in proportion to their availability the regression was expected to have a slope of 45^0. The variability responsible for the 95 % CI coverage was essentially a function of the number of random points. Since these were considered to capture the error variability of radiolocations in case they were non-selective of habitat type. Habitat choice was determined by plotting percentage area of a habitat in the core zone of jackals' home range (75% HM) on the same graph. Habitat types above the 45^0 line were preferred, while those below the line were considered avoided.

(Normalized Difference Vegetation Index) NDVI map for the *Bhal* area was generated and 100% Minimum Convex Polygon (MCP) and Harmonic Mean (HM) core areas were plotted on this layer. NDVI is an index of vegetation cover of an area. This index demonstrate the usefulness in estimating vegetation cover (Jensen, 1986) and its values are obtained by the following equation:

$$NDVI = \frac{\text{Infrared band} - \text{red band}}{\text{Infrared band} + \text{red band}}$$

The 95% MCP and 75% HM polygons were superimposed on the image layer. A comparison of average values of NDVI in the MCP and HM core areas was done to determine if jackals preferred areas with more vegetation.

3.3 Ranging Pattern

To understand the ranging pattern of jackals, the food items were quantified and a combined index was developed. The index and continuos tracking data were used to see if jackals visited resource rich areas.

To get an index of prey abundance in different habitats of Velavadar and in entire *Bhal* different methods were used.

Sampling was done in four different habitats, namely grassland, saline, *Prosopis* and crop fields. Only the major prey species (Blackbuck, hare, locust and cattle carcass) were quantified for abundance. Different sampling methods were used for different prey species.

Belt transects were laid for counting hare pellets (Sutherland, 1996). Rectangular plots of 20 x 1m were laid systematically in each of these habitats. In each habitat, 20-25 plots were laid and the number of hare droppings were counted.

Hundred metre transects were walked with a 1-m stick that was waved on either side to flush locusts. Ten transects were walked in each habitat categories. The herd size of the blackbuck was counted in different habitat categories. Each habitat category was sampled thrice. Information on the domestic livestock carcass deposition rate near villages was obtained from villagers. The number of dead cattle, skulls and other skeletal remains of cattle lying outside the villages were also counted. Eleven villages surrounding the VNP were sampled at regular intervals.

Jackal Food Index

The data obtained from quantifying different prey availability was combined to obtain a standard index of jackal food resource richness for different habitats of *Bhal*. Each prey item was given a weightage by converting the index of prey items into a value for each habitat type based on two assumptions (1) proportion of prey item in jackal's diet (2) converting the prey index to density (hectare), for e.g., 100 hare pellets ≡ 1 hare. The density of prey is multiplied by the proportion of hares in jackal's diet

(assumed to be 10% in this case). Similarly, the food index was calculated for other prey items.

The deposition rate of livestock (mostly cattle) carcasses was computed from 11 villages. Index is calculated for a buffer zone of 1 km around the village where carcass and garbage are more likely to be available to jackals. A carcass was considered available to jackals for 5 days after deposition.

The value for each combined index was transformed into separate image layers on the habitat map using Arc/Info software (1995). Thus, each habitat types falls in a gradient of resource richness scale from low to high.

The radio-fixes taken during the continuos night tracking of jackals were plotted on the food resource map to obtain the nocturnal movements of jackals.

3.4 Jackal Abundance Estimation

The jackal abundance was estimated using two methods (a) responses to simulated howling and (b) scent / track plot method, baited with an attractive scent (Sutherland, 1996).

Based on prior knowledge six different areas were identified in the *Bhal* and Kutch areas that likely varied in jackal abundance. Each category area was differentiated from each other by their distinct habitats namely grasslands, saline areas, coastal mud flats, scrub dominated by *Acacia* sp. and undulating hillocks with *Salvadora* sp. It was not possible to have areas with absolute known jackal densities. The six study areas each of about 10 x 10 km, were classified into abundance classes on a relative scale, a priori (Table. 2). The rating shown in the table was subjectively allocated based on food resources and habitat for jackals.

Table – 2 : Study areas sampled for estimating jackal abundance using track plot method and simulated howling responses

Place	Location	Major vegetation types	Preallocated jackal abundance
Bhal	VNP	Grassland	Very high (National Park)
Bhal	Sanes	*P. juliflora*, scrubland with halophytic vegetation	Low
Bhal	Adhelai	Halophytic vegetation	Very low
Kutch	Daun	Grassland & scrubland	Medium
Kutch	Paat	Thorn scrub	Medium
Kutch	Hyaena Ridge	*Prosopis*, *Euphorbia* and *Salvadora Scrubland*	High

3.4.1 Scent Plot Method

Ten 1-m radius scent plots were laid in each of the abundance categories. The plots were placed atleast 1-km distance apart in a systematic design. At habitat level, plots were laid all across to cover the whole area, and at a specific site level, plots were laid in places were jackals were likely to investigate, e.g., trails, junctions and next to prominent landscape features. The ground was cleared off vegetation and other materials such as pebbles and litter. The area was flattened and smoothened. A thin layer of fine sand was then sieved over the plot to get a clear impression of the animals' foot. The plots were baited with a liquid mixture prepared from rotten meat, fish and fermented eggs to lure jackals to the plots. Bicycle wheel spokes were used as scent posts. A cotton string of 2-3 cm length and 0.5 cm thickness was tied at the tip of the spoke and dipped in lure. The spokes were planted at the centre of the plots so that the baited lure was about 8 inches from the ground.

All the plots were baited before sunset and were checked 1-2 hour after sunrise. Number of tracks and trails identified to species were recorded. The spokes were removed once the plots were checked. The plots were baited again after a break of a minimum of one day. This was to avoid habituating the jackals to the smell of the bait if the plots were laid everyday. Each plot was sampled a minimum of three times.

3.4.2 Simulated Howling Response Method

A simulated howl of a single jackal lasting 19 seconds was recorded and broadcasted in each of the abundance categories. A set of two 40 watt megaphones attached to an amplifier of 250 watt was used to broadcast howls. The megaphones were placed on the ground facing opposite directions.

Howls in each abundance category were broadcasted from five different places. All abundance categories were systematically sampled. Howling stations were atleast at two km apart. The distance between the two stations was based on the maximum distance from which human ear could hear jackal howling is ca. 400m (Jaeger *et al.*, 1996). Two howls were broadcasted after a gap of 5 minutes between broadcasts. To give a 360-degree coverage, the loud speakers were kept at N-S direction in the first broadcast and then in E-W direction for the second broadcast to give a 360-degree coverage. The number of responses, their direction, estimated number of individuals responding, approximate distance, phase of moon and intensity of wind were recorded at each station. All howling sessions were carried out after sunset and till 21:00hrs when jackals were known to respond most (Y.V. Jhala, pers. comm).

If the howls were heard before the beginning of the broadcast, the broadcasting site was either changed or the broadcasts were carried out after 10 min. Because, if the jackals had already howled, it was very unlikely that they would respond to the broadcast howl immediately. While counting the number of response howls, it was difficult to count the individual howls when several individuals responded. All chorus howl (>2 individuals) were assumed to have a minimum of two individuals.

4. RESULTS

4.1 Home Range

Estimates for individual home ranges reached asymptote at different values. Four jackals were observed to stabilize over the sampling duration. Don (Juv. ♂) and Punchkati's (old ♀) home range did not reach asymptote. Average number of sample size required for estimating home range of jackals is 60 – 70 (Fig 1).

Average of all inflexion points in the HM isopleth graphs was at 75.83. So, 75% HM isopleth value was chosen to estimate the core zone (Fig 2).

Mean home range size (95 % MCP) of jackals (n= 6) was observed to be 14.30 ±4.06sq km (Table 3) (Plate 2). Females had larger home range (24.45±5.34 sq. km) compared to males (9.23±0.8 sq. km) (t-test, df=5, p=0.017) (Table 4). The old female Punchkati had home range of 29.8 sq. km while the home range of the younger female Priyanka was only 19.11 sq. km. Juvenile jackals had almost similar home ranges (14.21±5.38 sq. km) as the adults (14.4 ±9.95 sq. km) (t-test, df=5, p=0.94,) (Fig 3).

Trends in home range size obtained by the harmonic mean method were similar to MCP. Females had larger core areas (7.63 ± 3.87sq km) than the males (2.1 ± 0.8 sq. km) (t-test, df=5, p=0.05) (Fig 4).

Fig. 1 : Cumulative home range size 100% Minimum Convex polygon (MCP) plotted against sequential number of radiolocations to determine sample size for home range estimation.

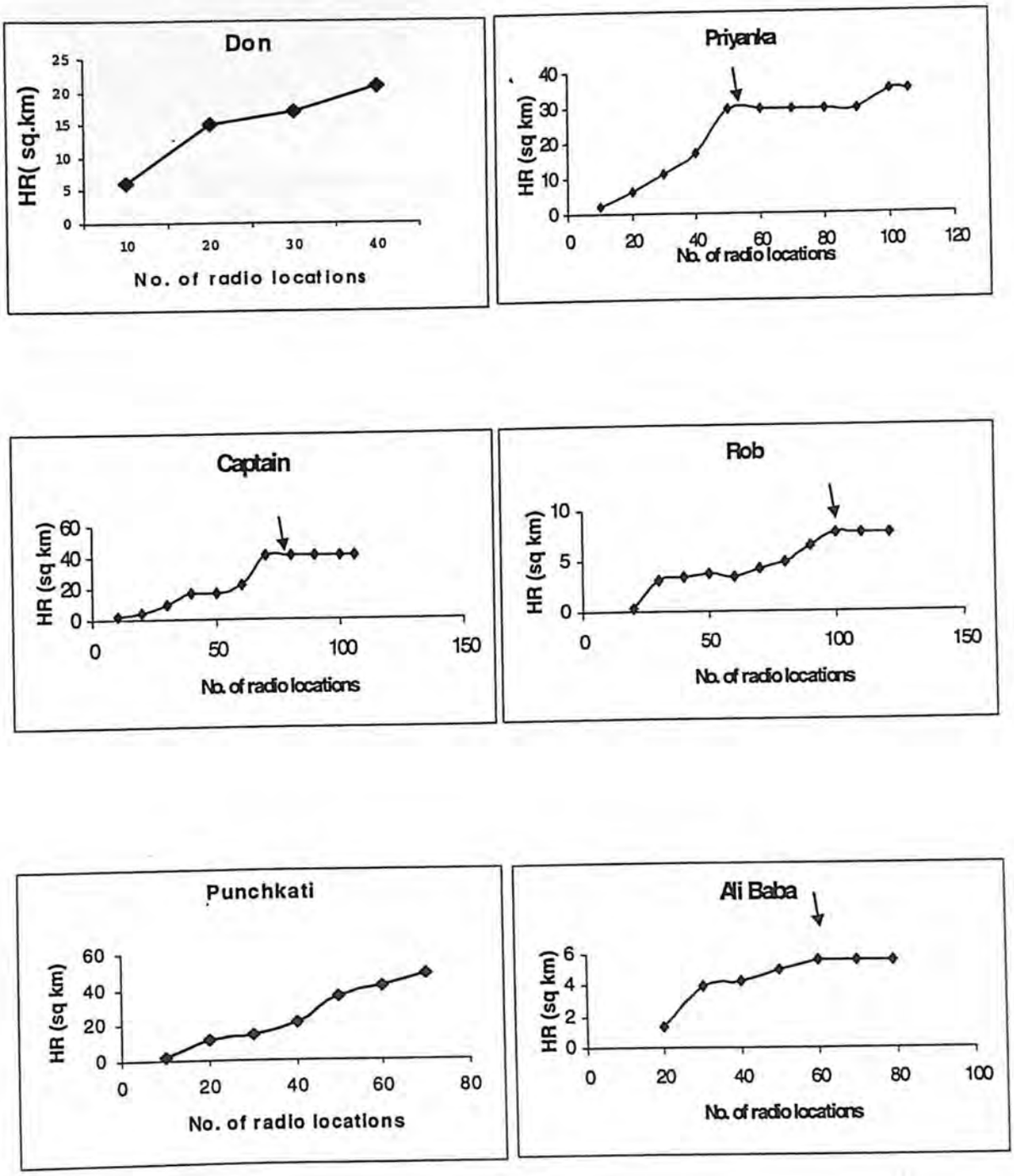


Fig. 2 : Harmonic Mean (HM) isopleths were plotted against home range size to determine the core areas.

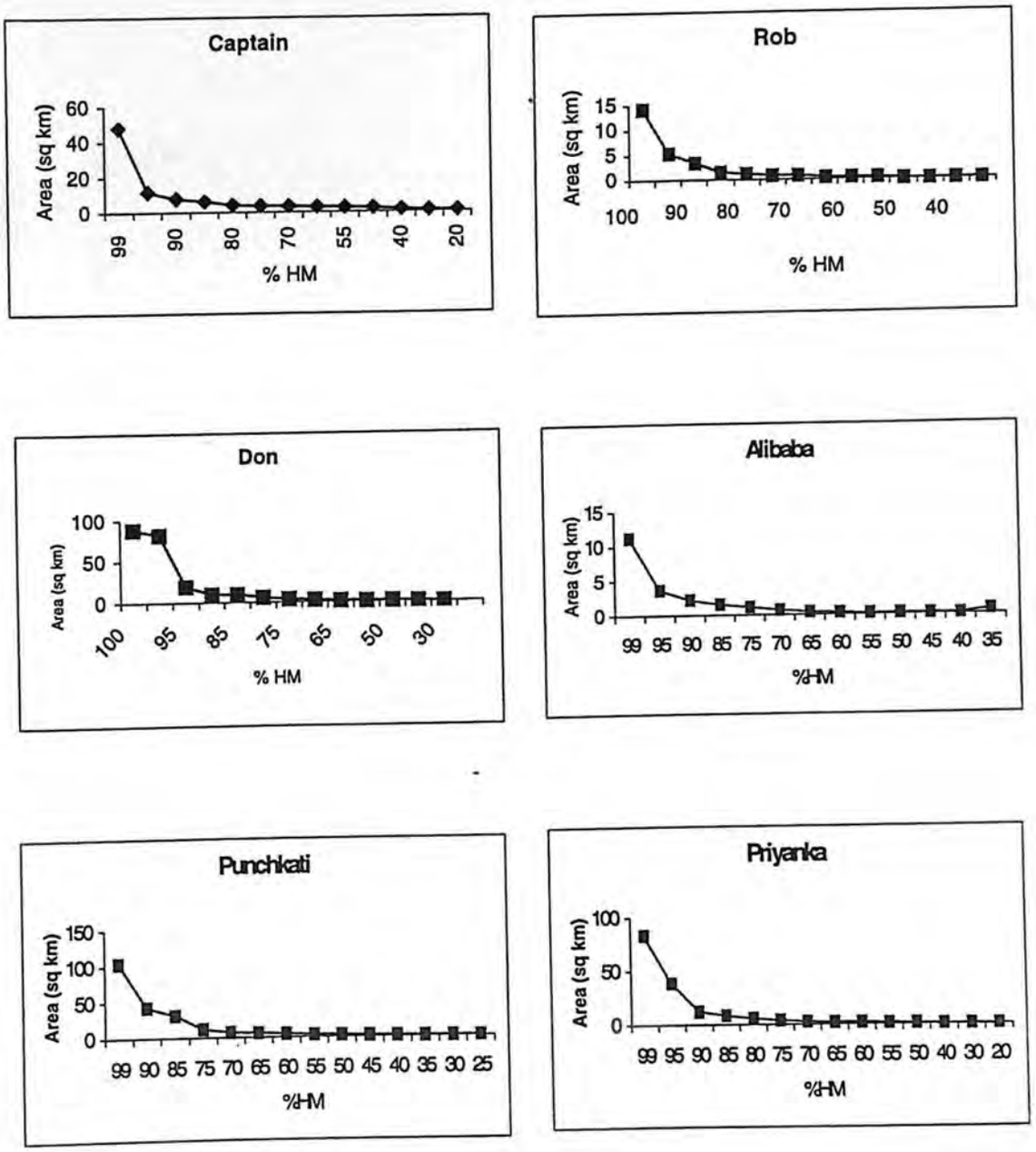


Table – 3 : Home range of jackals in the *Bhal* region of Gujarat as estimated by 100%, 95% MCP, 95% AK and 75% HM.

Jackal	Sex	Age group	100% MCP (sq km)	95% MCP (sq km)	95% AK (sq km)	75%HM (sq km)	N
Punchkati	Female	Adult	48.13	29.80	16.79	11.51	79
Priyanka	Female	Juvenile	34.92	19.11	32.68	3.76	104
Captain	Male	Adult	41.54	10.40	77.22	3.58	109
Rob	Male	Juvenile	7.77	5.60	5.33	0.70	121
Don	Male	Juvenile	20.78	17.93	39.34	3.6	41
Alibaba	Male	Adult	5.60	3.0	7.24	0.67	79

MCP - Minimum Convex Polygon
AK - Adaptive Kernel (Worton, 1989)
HM - Harmonic Mean
N - No. of radio locations

Plate 2. Habitat types and Home ranges 100% Minimum Convex Polygon (MCP) of Jackals in the *Bhal* region of Gujarat

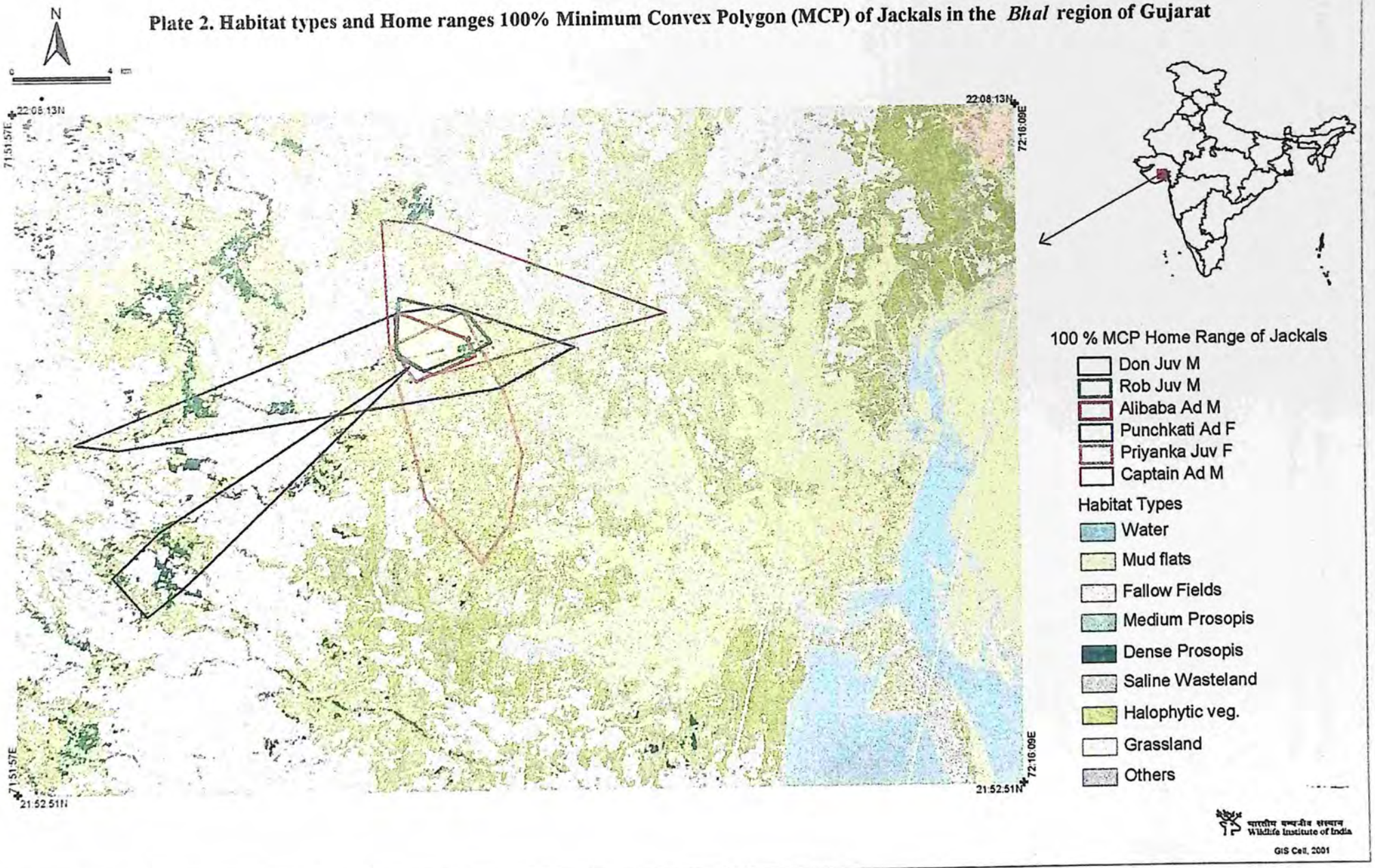


Table – 4 : Bootstrap Confidence Interval and Standard Errors of 95% Minimum Convex Polygon home range of jackals in the *Bhal* area of Gujarat.

Jackal	Age group	Sex	95% MCP (sq km)	SE	LCL	UCL	No.of Radio locations
Punchkati	Adult	Female	29.80	1.56	24.8	37.5	79
Priyanka	Juvenile	Female	19.11	0.94	14.4	22.4	104
Captain	Adult	Male	10.40	3.03	9.76	31.9	109
Rob	Juvenile	Male	5.60	0.27	3.75	6.38	121
Don	Juvenile	Male	17.93	1.72	2.72	16.7	41
Alibaba	Adult	Male	3.0	0.33	2.09	4.98	79

SE - Standard Error
LCL - Lower Confidence Interval
UCL - Upper Confidence Interval
MCP - Minimum Convex Polygon

Fig. 3 : **Comparison between 95% Minimum Convex Polygon Home Range and core areas (75% HM) of adult and juvenile jackals in the *Bhal* area of Gujarat**

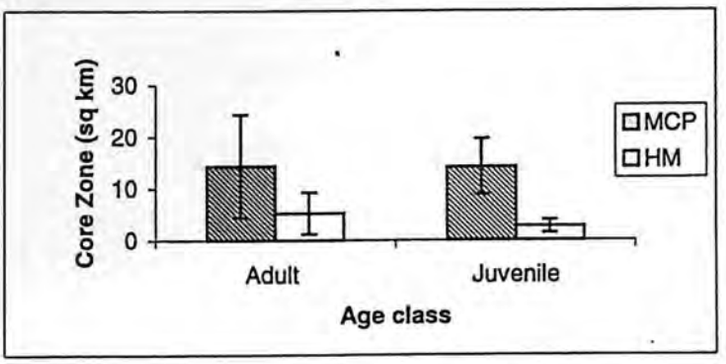
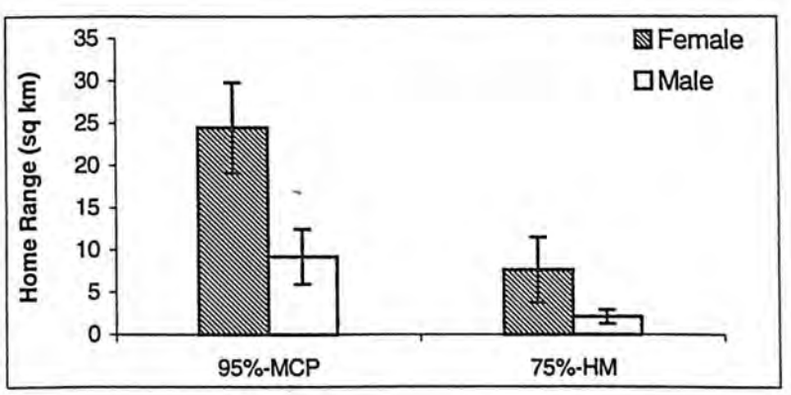


Fig. 4 : **Comparison between 95% Minimum Convex Polygon Home Range and core areas of male and female jackals in the *Bhal* area of Gujarat**



4.2 Habitat Use and Availability

Individual animals have different habitat preference but in general, grassland, medium and dense *Prosopis* are most preferred had maximum χ^2 values. Captain (adult ♂), Priyanka (juv. ♀) and Punchkati (old ♀) seem to prefer grassland to other habitats. Don (Juv. ♂), Rob (Juv. ♂) and Alibaba (adult ♂) show a high preference for dense *Prosopis*. Overall saline land with vegetation and saline wasteland fall in the middle of order of preference (Table 5).

ANOVA on the difference matrix obtained from Compositional Analysis rejected the Null Hypothesis of no habitat choice. Multiple range tests (Duncans) on the same data set shows the habitat categories in importance of their preference by jackals (Table 6). Jackals in the *Bhal* use eight different classes namely grassland, medium *Prosopis*, dense *Prosopis*, saline wasteland, halophytic scrub, fallow fields, mud flat, others (road edges, canal etc.)

Regression graphs (Fig.5) show a similar trend as the results obtained from compositional analysis. Among all, Captain (adult ♂), Priyanka (juv. ♀) and Punchkati (old ♀) intensively prefer grassland areas whereas Alibaba (adult ♂), Rob (juv. ♂) and Don (juv. ♂) show more preference for dense prosopis, while mud flats were least preferred by jackals. Habitats like medium prosopis, fallow fields and halophytic vegetation are used in proportion to availability, which means they are neither avoided nor preferred.

The NDVI values of core zone of jackals are significantly different from the NDVI values of MCP (t-test, df=11, $p<0.001$) (Plate. 3).

Table – 5 : Order of preference of habitats by jackals obtained using Compositional analysis in a scale of 1 to 8. (1=least preferred, 8=most preferred)

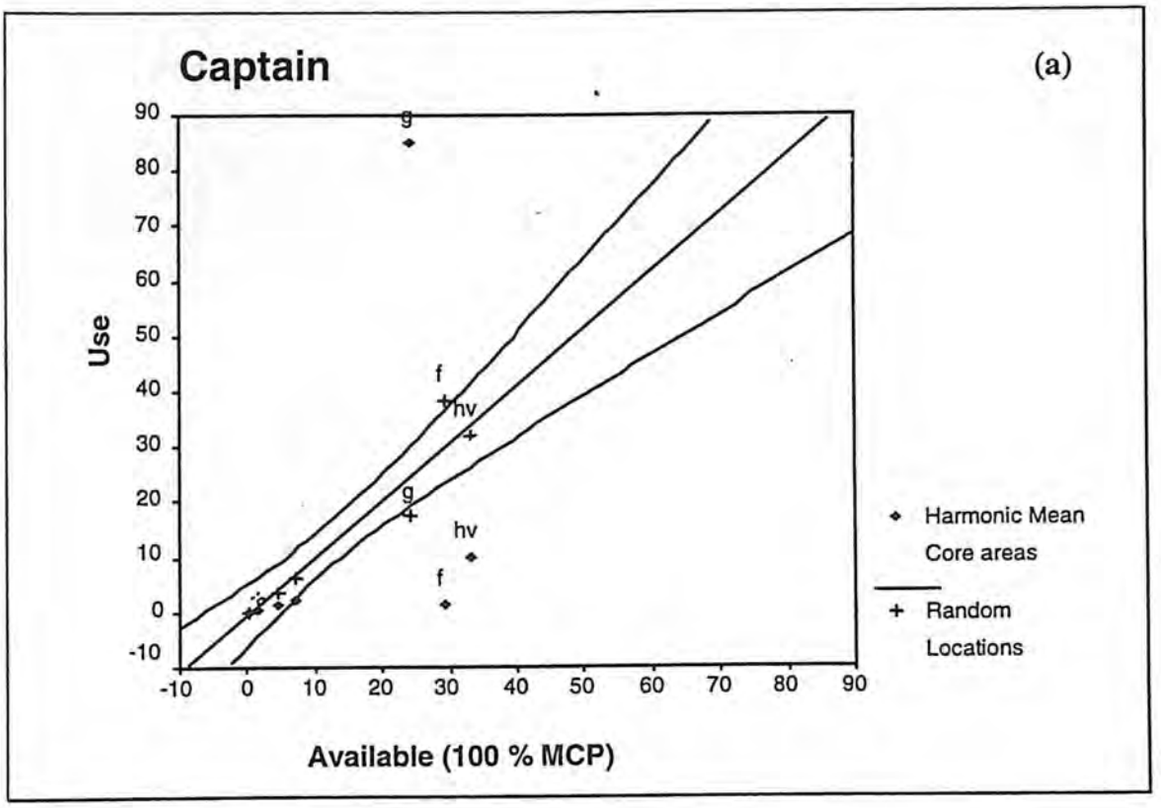
	G	MP	HV	SW	DP	F	O	M
Captain	8	7	6	5	4	3	2	1
Priyanka	8	4	6	7	3	1	2	5
Rob	4	6	5	3	8	7	1	2
Don	4	6	5	-	7	2	3	1
Alibaba	5	6	3	4	7	1	-	2
Punchkati	8	7	6	4	5	3	1	2

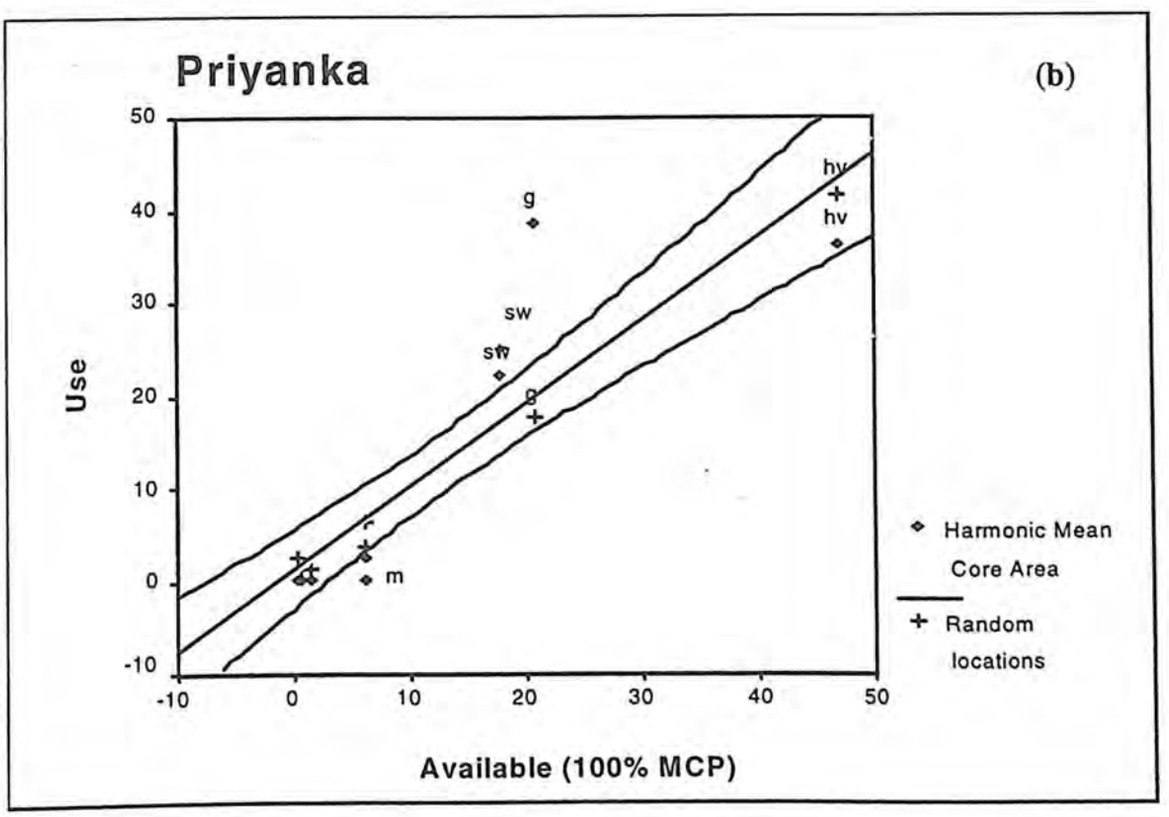
Table – 6 : Multiple range tests (Duncans) with the habitat categories in importance of their preference by jackals.

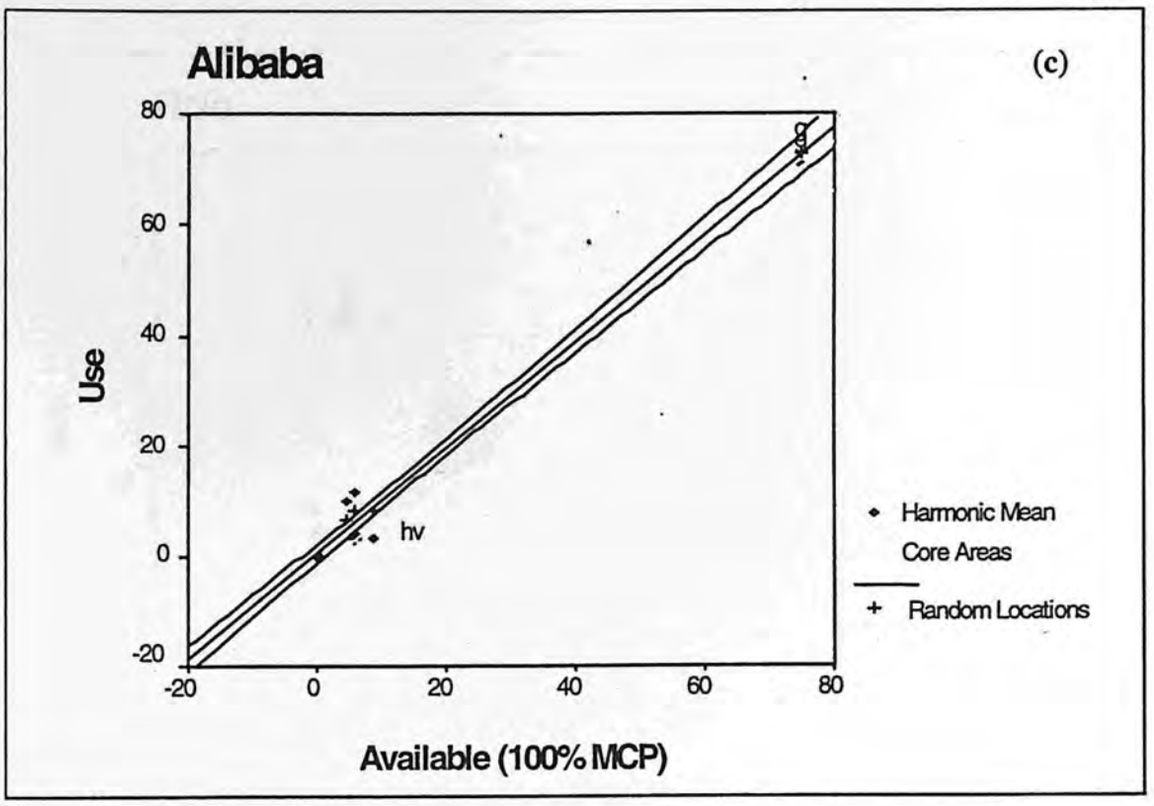
Habitats	1	2	3
Captain	G	MP, HV, SW, DP, F	O, M
Priyanka	G	MP, HV, SW, DP,	F, O, M
Rob	G	MP, HV, DP,	F,O,M
Don	DP	G, MP	HV, F, SV, O, M
Alibaba	MP	G, SV, HV, O, M	F
Punchkati	G	MP, SV, HV, DP,	F, O, M

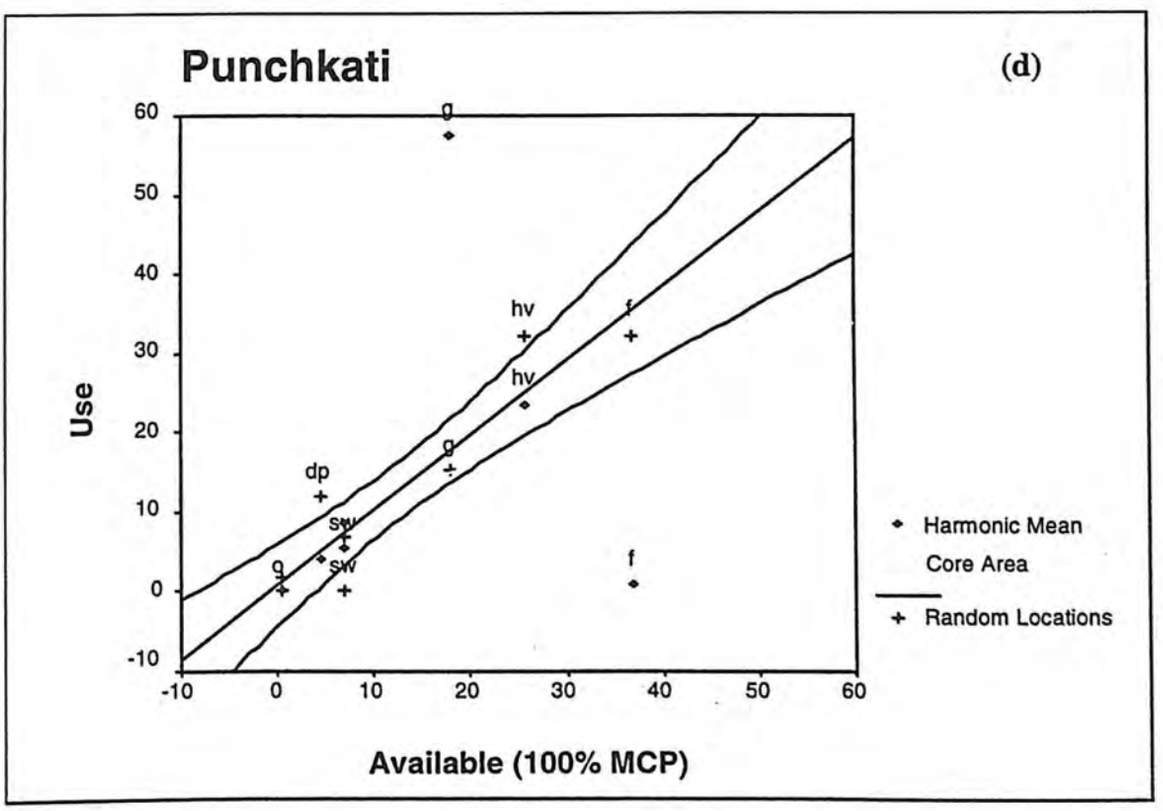
G=Grassland, MP=Medium Prosopis, DP=Dense Prosopis, HV= Halophytic Vegetation, SW=Saline Wasteland, F=Fallow fields, M=Mud flats, O=others

Fig. 5 : Habitat preference of jackals: Random use of habitat is regressed against availability and a 95% Confidence Interval (CI) generated. Actual use of habitat (as a proportion of the habitat in the 75% Harmonic Mean (HM) is superimposed. Habitats above the regressed line are preferred while those below are avoided.






Alibaba
(c)
Use
Available (100% MCP)
80
60
40
20
0
-20
-20
0
20
40
60
80
hv
Harmonic Mean
Core Areas
Random Locations


Punchkati
(d)
Use
Available (100% MCP)
60
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50
60
g
hv
hv
f
dp
sw
sw
g
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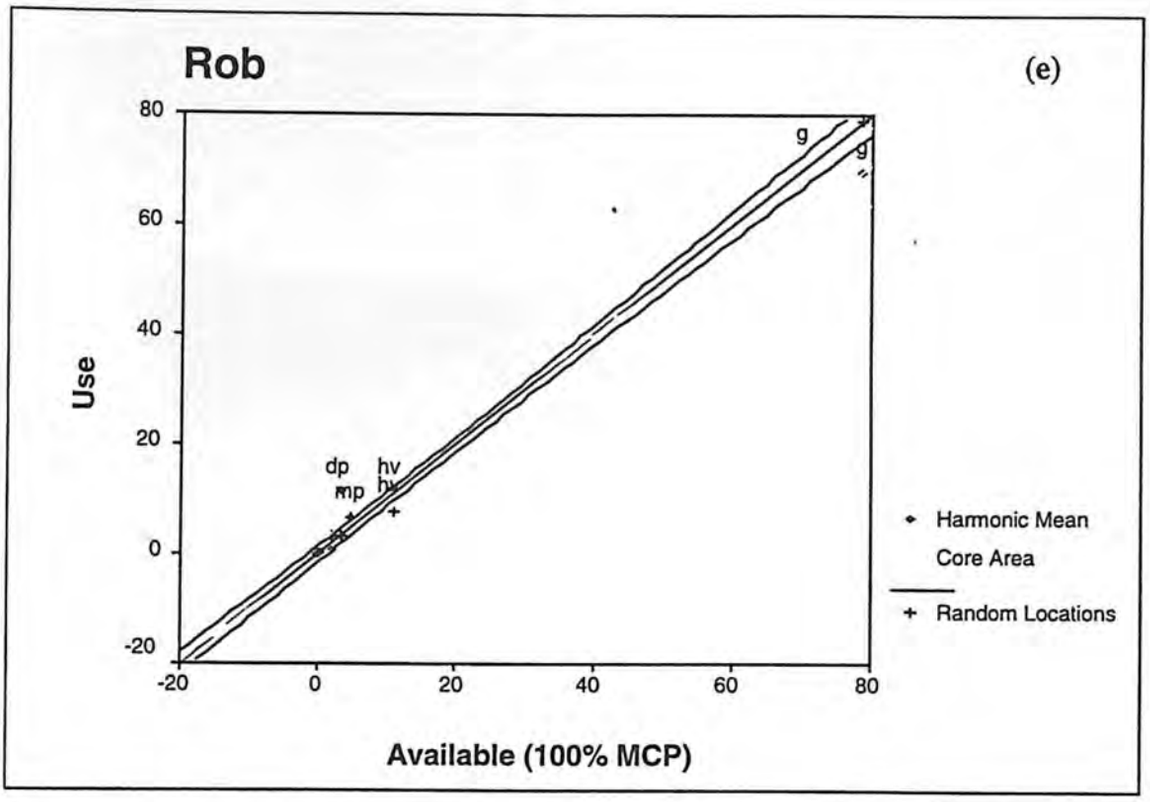
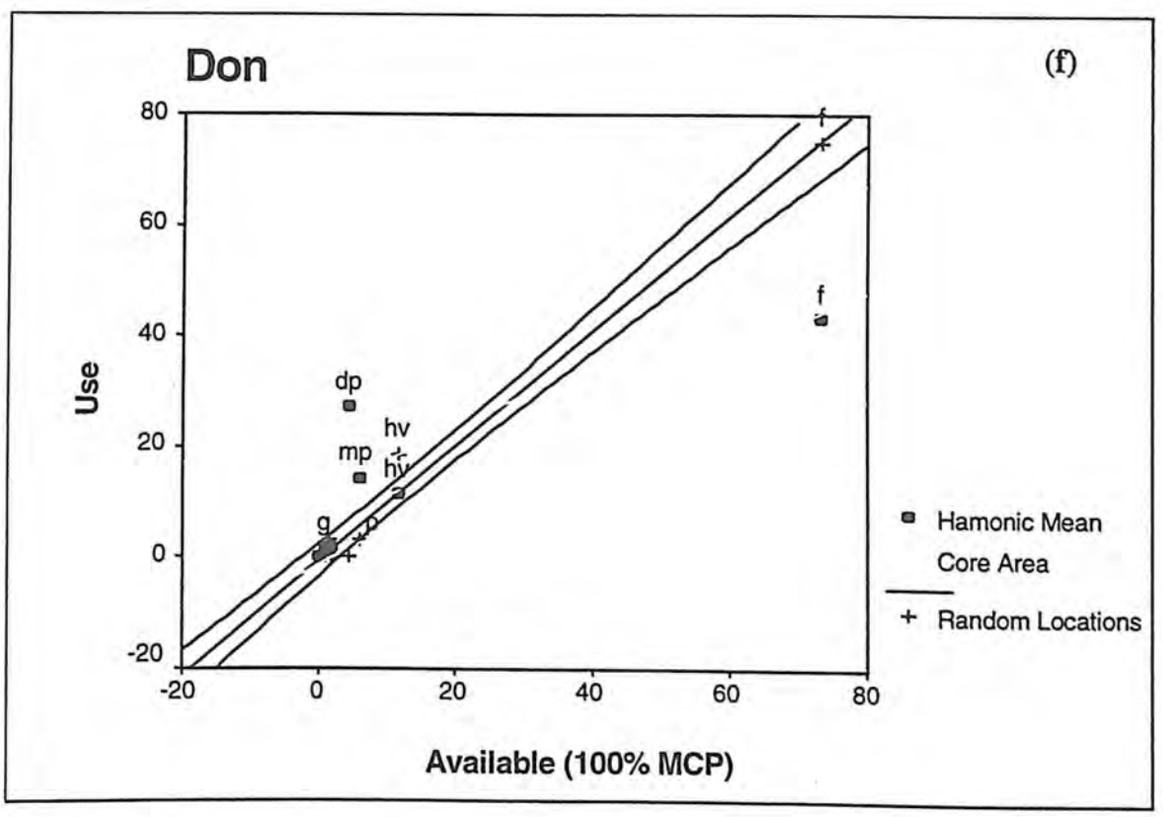
Harmonic Mean
Core Area
Random Locations





g = grassland; dp = dense prosopis; mp = medium prosopis; sw = saline wasteland; hv = halophytic vegetation; f = fallow fields; m = mud flats; o = others

Plate 3. 95% Minimum Convex Polygon (MCP) and 75% Harmonic Mean (HM) home ranges of Jackals plotted on Normalized Difference Vegetation Index (NDVI) map of the *Bhal* region of Gujarat

4.3 Ranging Patterns

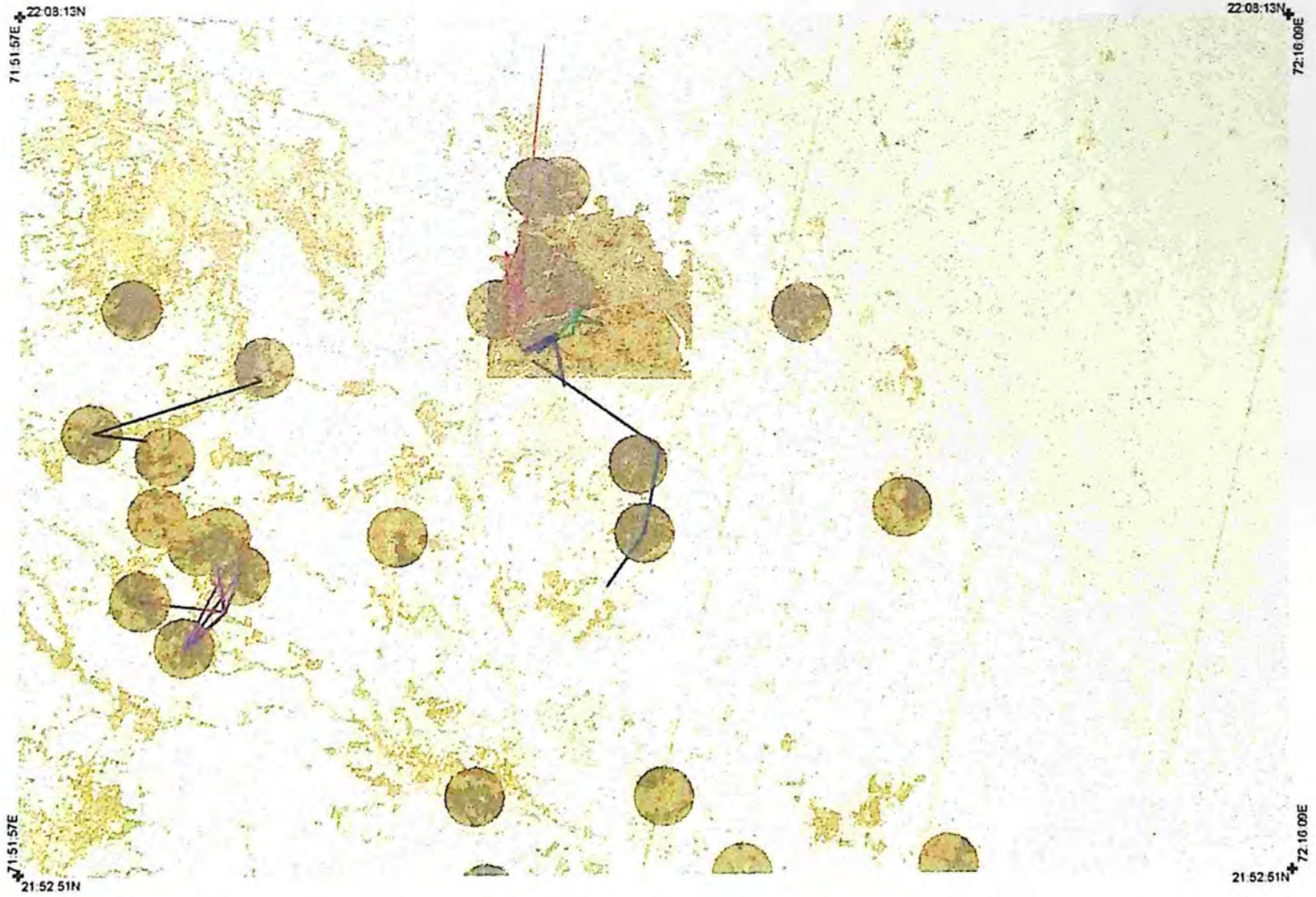
Velavadar National Park and the villages show high degree of resource richness compared to other habitats. Average distance moved by jackals is 6.22 ±1.05 km per night. Average distance moved per hour is 0.685±0.14 km.

Out of 14 continuous tracking nights, during 10 nights, jackals were observed to visit villages where the food resources are high (Table-7) (Plate. 4).

Table – 7 : Details of Continuous Tracking of Jackals during nocturnal foraging forays in *Bhal* region of Gujarat.

Sl. No.	Jackal	Date	Time tracked	Dist (km) moved	Hours	Villages visited	Distance moved/hour
1	Alibaba	5-Feb-01	21:00 - 5:00	7.36	8	Velavadar	0.92
2	Alibaba	13-Feb-01	18:15 - 6:40	6.1	10	Velavadar	0.61
3	Priyanka	31-Jan-01	21:15 - 2:00	10.18	5	Bharbheed, Gokulpara	2.036
4	Priyanka	5-Apr-01	20:45 - 7:45	4.5	10	within park	0.45
5	Punchkati	2-Feb-01	18:02 - 5:30	7.8	11	Rajgarh, Muldharai	0.709091
6	Don	26-Mar-01	19:20 - 7:00	4.8	12	Shahpur, Monpur	0.4
7	Don	29-Mar-01	19:08 - 7:00	12.06	12	Nawagaam, Shahpur, Monpur	1.005
8	Don	4-Apr-01	19:18 - 7:00	5.8	12	Shahpur, Monpur	0.483333
9	Rob	30 Mar 01	19:15 - 7:00	2.2	12	within park	0.183333
10	Rob	10 mar 01	21:00 – 6:40	0.4	12	within park	0.033333
11	Captain	7-Apr-01	00:04 - 7:00	5.7	7	VNP	0.814286
12	Captain	10-Apr-01	20:30 - 8:15	11.8	12	VNP, Kanatalav	0.983333
13	Captain	11-Apr-01	18:33 - 8:00	3.4	12	VNP, Velavadar	0.283333
	Average			**6.2**	**10.38**		**0.685**

Plate 4. Nocturnal ranging patterns of Jackals plotted on food index map of the *Bhal* region of Gujarat. Food index is a composite of blackbuck, locust, domestic livestock carcasses and garbage at village dumps (details in text)



Don
Priyanka
Captain
Alibaba
Puchkati

Jackal Food Index

0 - 20
20 - 40
40 - 60
60 - 80
80 - 100

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

GIS Cell, 2001

4.4 Jackal Abundance Estimation

94 broadcast nights and 259 responses were recorded during the study. Adhelai and Sanes show low jackal abundance where as VNP has a relatively higher abundance compared to others (Fig 6 & 7). Howling responses give better result than track plot. The areas got categorized into three subsets (Table 8) in howling responses but in track plot data show Sanes and Adhelai in one group and rest in the other (Table 9).

The mean trail/plot and mean howl/station show a high positive correlation and gives a R^2 value of 0.712 (p=0.072) (Fig 8). The values of both the methods for VNP, Sanes, Adhelai and Paat are highly correlated and are close to the regression line where as hyena and Daun showed variation.

During this study, the phases of moon and the wind level has no effect on the responses (ANOVA, p=0.962, F=0. 039) and (p= 0.819, F=0.309) respectively.

Fig. 6: Mean howl responses and their standard error recorded per station in the six areas of varying jackal abundances.

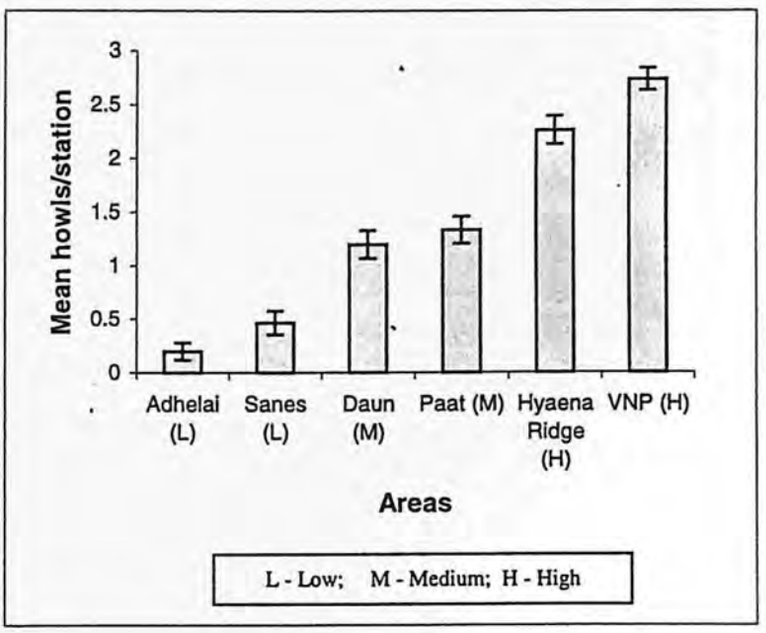


Fig. 7: Mean trails and their standard errors recorded per plot in the six areas of varying jackal abundances

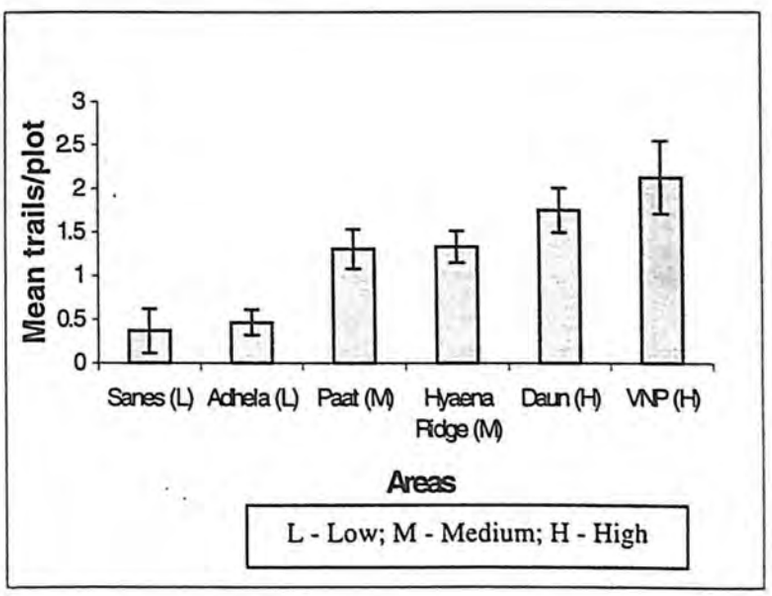


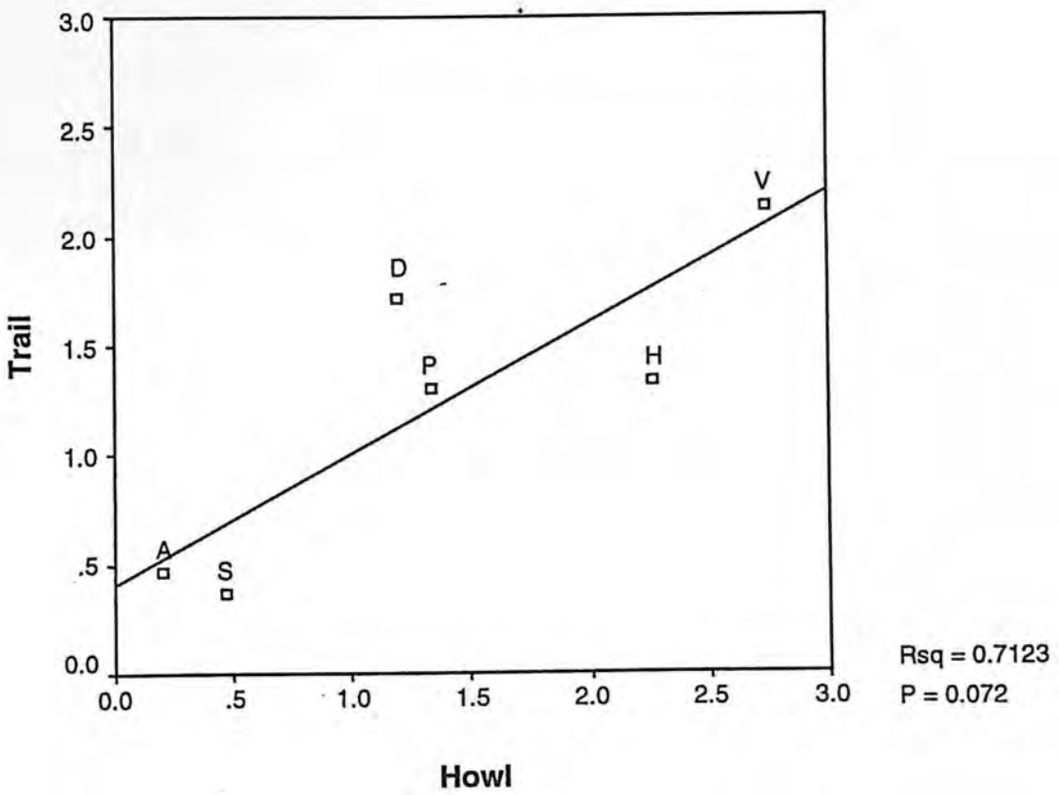
Table – 8 : Categories obtained from Multiple range tests (Duncans, α=0.05) for Howling responses method in the six areas of varying jackal abundances

Areas	N	Subset 1	Subset 2	Subset 3
Adhelai	19	.2632		
Sanes	15	0.6000		
Daun	15	1.000	1.000	
Paat	15	1.667	1.667	
Hyaena Ridge	15		2.2000	2.2000
VNP	15			3.2000
Sig.		.051	.085	.129

Table - 9: Categories obtained from Multiple range tests (Duncans, α=0.05) for track plot method in the six areas of varying jackal abundances.

Areas	N	Subset 1	Subset 2
Sanes	10	.3666	
Adhelai	10	.4332	
Paat	10		1.3166
Hyaena Ridge	10		1.334
Daun	10		1.75
VNP	10		2.100
Sig.		.872	.085

Fig. 8 : Correlation between the mean jackal track trail/plot and mean howl responses/station in the six areas of varying jackal abundances



A - Adhelai, S – Sanes, P – Paat, D – Daun, H – Hyaena Ridge, V – Velavadar National Park.

5. DISCUSSION

5.1 Home Range

The home range sizes of jackals in *Bhal* region of Gujarat are much larger than reported for jackals in Bangladesh (0.6-1.1 sq km) (Poche *et al*., 1987) and similar to the home ranges 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 study was conducted on two individuals, a male and a female, for about two months (Poche *et al.*, 1987). In Serengeti, jackals resided in the short grass plains. Jackals in Ngorongoro crater showed small home ranges (5.1 sq. km) (Van Lawick-Goodall and van Lawick-Goodall, 1971). The home ranges obtained from this study are seasonal and are not exactly compatible with the home range studies conducted in Africa.

As no other study other than the work by Poche *et al.*, (1987) is available, several speculations are made during this discussion.

In populations that experience strong seasonal and/or yearly fluctuations, territory size might be determined by the minimal food resource conditions (Moehlman, 1989). As the food habits by scat analysis was not determined, any thing concrete cannot be said about the food items jackals in winter. But, observations made on them indicate that they depend heavily on the garbage and carcass availability.

The jackals in this study ranged out of the park to the nearby villages. Jackals that ranged for greater distances show a larger home range. Both the females, Punchkati (old) and Priyanka (juvenile) were observed to range more than males. Out of six jackals that were collared in the park, Don (juv. ♂) moved out of the park within two days of collaring. After six weeks, he was located in a *Prosopis* thicket at 12-13 km

from his capture site. Between other two juveniles, rob (♂) restricted himself within the park but Priyanka (♀) visited villages. Both the adult males (Alibaba and Captain) were resident of the park but their visitations to the Velavadar village were not uncommon. Nevertheless, Captain (adult ♂) ranged till Kanatalav close to the park during early summer.

In general, jackals studied in the park frequently visited the Velavadar village adjacent to the park to feed on carrion and garbage. There are more than 5 villages around the park within a radius of 8 km. Jackals were observed to congregate in large numbers whenever there is a carcass in the outskirts of the Velavadar village.

The home ranges of jackals overlapped substantially. The high degree of home-range overlap in the black-backed jackals in Namib desert coast is related to the presence of large localized food resources such as seals and cormorants (Hiscocks and Perrin, 1988). The "territorial" boundaries in the *Bhal* jackals were flexible especially when surplus food is available in form of carrion in the park or in the villages. More than 12 jackals were observed feeding on carcass both within and outside the park. Temporal and spatial availability of food can affect the spacing system of canids in general (Moehlman, 1989). Clumped resources and homogenous habitat also breaks down the territoriality behaviour of jackals and such aggregations have been observed in Israel where the food is provisioned (Macdonald, 1979). Due to flexible nature of the territorial boundaries, there are overlaps in home ranges.

Relationship between home range and density of jackals is important. Home range may not be affected directly by the changes in the availability of food but it may affect the pup survival and cause short term changes in the availability of food

(Bertram, 1973). Based on previous work in VNP, the annual jackal density fluctuates between 0.76 to 1.16 sq. km. being highest between August to February and lowest between March to July (Jhala, *et al.*, 2000).

Differences in food availability would result in a jackal requiring a larger or smaller home range to satisfy its requirements, and consequently density would be affected in a long term (Rowe - Rowe, 1982).

Skin disease like mange is common in jackals that occurred at high densities (Jhala and Moehlman, in press). The occurrence of disease in jackals could also affect the home range size. In the Namibia study, one of the black-backed jackals occupied the smallest area of 500-sq. m over a 24-h period. The probable reason is of heavy infestation of sarcoptic mange (Hiscocks and Perrin, 1988). In this study, Alibaba (adult ♂) had mange and a small home range. It is contradictory that Punchkati (old ♀) with severe mange did not occupy a small area rather had a large home range (29.80 sq. km). On the other hand, Alibaba (adult ♂) occupied small home range and had mange (3.0 sq. km.). Towards the beginning of summer, other two jackals, Don (juv. ♂) and Captain (adult ♂) developed mange. Captain started using *Prosopis* thicket and ranged alone out of the park towards villages when he did not have mange. Don (juvenile ♂) also had developed mange but was seen with a jackal and every sighting of his was with atleast three other jackals. It was not possible to state any conclusion about the role of disease in the home range or the ranging pattern of jackals.

Grassland and *P. juliflora* were the most preferred habitats compared to other habitats. Though the jackals ranged outside the park at night on foraging forreys and used the

park during daytime. Jackals were observed moving around during early mornings and late evening. During the hot hours of the day, they are seen either moving towards the water hole or resting in shade. Jackals also used grassland for resting even after the temperature rose in winter.

They seem to occupy *P. juliflora* thicket close to villages where people venture in the thicket to collect *Prosopis* gum and Don (juvenile ♂) was observed several times resting within 50-60 m distance from the coal maker's *basti* during day time. There are several small *bastis* like this in entire the *Bhal* where people settle down for a short period during the late winter and early summer to make coal. This involves cutting down *P. juliflora* and burning them. But jackals continued to occupy the area inspite of disturbances, which do not seem to bother them.

P. juliflora is very important habitat type for jackals. NDVI values show that the core areas have more vegetation compared to the rest of their home range. High values of NDVI indicate more vegetation cover; in this case, *P. juliflora* show high NDVI values. Core areas had more *P. juliflora* compared to MCP and core zones are used more for resting than for food resources. Jackals use *P. juliflora s* thickets as visual cover and protection from sun.

Seasonal shift in the use of habitat was by Captain (adult ♂). During the early summer, he moved outside the park and occupied a dense *P. juliflora* thicket in between Gokulpara and Kanatalav villages whereas in winter, all his locations were found to be in grassland.

The habitats like the mud flats and fallow fields are used as pathways to reach villages or other *P. juliflora* thicket during their nocturnal foraging movements.

5.2 Abundance Estimation

Both simulated howling response method and track plot method give a reliable index of jackal abundance of an area. All areas except hyaena ridge and daun show variation due to the differences obtained in both the methods. Hyaena ridge was categorized as a high density area when simulated howl sampling was done where as in track plot method, hyeana ridge was classified along with Paat and Daun. To get the actual density of jackals, simulated howling response method in combination with other technique would give better results. Earlier study carried out in the *Bhal* estimated the jackals density using simulated howling responses survey in combination with the telemetry data. The jackal population in VNP was reported between 7 – 8 packs which was further confirmed by the simulated howls (Jhala *et al.*, in review).

The simulated howling method can be only done during the jackal's pair-mating period and sampling period at the night is critical. In this study, the sampling period was immediately after sunset.

Pyrah's (1984) study on population estimation of coyotes reports that the best estimate of coyote abundance were derived by combining siren-response and den-area surveys. Both methods gives information about the abundance level and gives an index of the jackal population, it is difficult to estimate the jackal density using these methods only unless further experiments are done. More detailed studies are required to develop this technique of simulated howling responses.

6. CONCLUSIONS

Major conclusions that could be drawn from this study are:

(1) The seasonal home range of jackals in the *Bhal* was estimated to be 14.30 ± 4.06 sq km.

(2) Grassland and *Prosopis juliflora* were more preferred and mud flats and fallow fields were least preferred by jackals. In short, core areas of jackals were highly correlated with vegetation cover.

(3) Jackals ranged out of the park to visit villages, which were rich food resource patches. They ranged an average of 6-7 km distance per night.

(4) Techniques to develop jackal abundance index using track plot method and stimulated howling responses show that both the methods can be used to get an index of jackal abundance. However, howling responses gave better resolution of abundance classes.

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