

**HABITAT USE BY RODENTS IN A SANDY HABITAT
AROUND SAM, WESTERN RAJASTHAN.**

**DISSERTATION SUBMITTED TO SAURASHTRA UNIVERSITY, RAJKOT, IN
PARTIAL FULFILMENT OF THE MASTER'S DEGREE IN WILDLIFE SCIENCE,
JUNE 1999**

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CERTIFICATE

This is to certify that Shomen Mukherjee of the Wildlife Institute of India has carried out an original piece of work titled "*Habitat use by rodents in a sandy habitat around Sam, Western Rajasthan*" in partial fulfillment of the M.Sc. (Wildlife Science) degree of Saurashtra University. These investigations were carried under my supervision at the Wildlife Institute of India from November 1998 to June 1999. I also certify that this work has not been submitted for any other degree of any university.

Date: 22nd June 1999

Place: Dehradun

Dr. S.P. Goyal

Scientist – SF

Faculty of Wildlife Biology

To,

Vivek and Ashok who started it all.....

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ACKNOWLEDGEMENTS

First and foremost I would like to thank my camel 'Raju' for carrying me on his back and introducing me to the true charms of the desert. My fieldwork would have been tough without his help and co-operation.

I thank the Rajasthan Forest Department, especially Mr. R.G. Soni, CCF, Mr. R.K. Singh, ACF, Mr. J.S. Bhatti, RFO and the other staff of Forest Department at Desert National Park office at Jaisalmer. I thank Shri. Hajara Ram, Shri Bhura Ram , Shri Chain Singh and his family for making me feel at home during my stay. A special thanks to Manohar, my field assistant, who was always there to help me.

I thank Director, Wildlife Institute of India for providing me facilities. I also thank all the faculty members at WII with whom I could interact freely during this course, especially Dr. Y.V. Jhala, Mr. Q. Qureshi, Dr.G.S. Rawat, Dr. Ravi Chellam and Dr. A.J. T. Johnsingh. Special thanks to Dr. Goyal, who kept on inspiring me during my work. Dr. H.C. Bohra, Dr. Idris, Dr. Tripathi and Dr. B.D.Rana at Central Arid Zone Research Institute, Jodhpur, for supporting me throughout my study. Thank Ashok Shankala at C.A.Z.R.I., Jodhpur, for helping me photograph the captive rodents. Also would like to thank Dr. Mertia of C.A.Z.R.I., Chandan, for identifying the plants in my study area. I also thank Prof. Ishwar Prakash for his comments, suggestions and references on the Thar desert, without which interpretation of my results would have been very difficult. His voluminous knowledge and contributions to the study of Thar desert made my life much simpler.

The researchers at WII for their support over the last two years. Special thanks to Rajah Jaipal, for his help during my analysis and also for his moral support. I also thank Dinesh Pundir (for digitising my maps) and the other staff members of the Computer Center. I thank the 'cheerful staff' of WII library for their constant support.

Thanks to Vivek, Ashok, Anuprita, Anita, Sanaya, Leela, Campboss, Aunty Laila, D.J., Neema and Kaustubh for always boosting my morale. Thanks to Samraat, Avanti, Manu, Sayantan, Tanu, Anand, Krish. and Cheryl for their company especially Samraat and Avanti, who helped me pull through the tough times.

Last but not the least, I would like to thank my parents, sister and Pisto for their constant support and encouragement.

SUMMARY

Earlier studies on rodents in the Thar have recorded only the broad habitat types in which the different species occur. Except Rogovin *et al.* (1994), no other study has looked into microhabitat use by rodents. The present study aims to look at habitat use by three species of gerbils in a sandy habitat.

The macro and microhabitat use by three species of rodents viz. *Gerbillus gleadowi*, *G. nanus* and *Meriones hurrianae*, in a sandy habitat, receiving rainfall of around 100-200 mm, was studied in Thar desert. Three distinct sandy habitats (Stabilised dunes, Barren dune and Interdune), within 4 sq. km. area around Sam, Jaisalmer, was selected for the study. Due to zero captures after 500 trap nights, the use of Sherman traps was discontinued. Instead, circular track plots made out of chalk powder were used for looking at microhabitat use within each of the habitats. Track identification, up to species level, was first standardised from live specimens in captivity and then used in field. A total of sixteen variables representing habitat complexity (vertical), heterogeneity (horizontal) and phenology were enumerated around each plots.

G. gleadowi was found to be the most abundant species, occupying all the three habitats. *G. nanus* was found to inhabit the Stabilised and Interdunal areas, while *M. hurrianae* was present only in the Interdune. Factor analysis using principle component extraction was used to determine the microhabitat characteristics. *G. gleadowi* was the sole occupant of Barren dune, where it did not show preference for any particular microhabitat. During winter, in Stabilised and Interdune, *G. gleadowi* was found using areas with relatively less compact soil, lower mean vegetation height and fewer number of hummocks compared to *G. nanus*. In summer, the species still continued using areas

with relatively lower soil compactness, mean vegetation height and fewer hummocks compared to *G. nanus*, but showed higher use of areas with more ground cover (vegetation) compared to winter. *G. nanus* was found using areas with relatively more compact soil, higher mean vegetation height and greater number of hummocks. Overall, *G. gleadowi* was found to use the maximum range of microhabitats compared to the other two species.

The summer niche space of *G. gleadowi* was found to be greater than its winter niche. During summer it was found using areas with more ground cover, higher percentage mature leaves, young leaves and fruits. *M. hurrianae* was found to have a strict association with *Capparis decidua* tree, under which it burrows. The species is probably facing microhabitat loss due to collection of *C. decidua* poles by villagers.

1. INTRODUCTION

1.1 General introduction and literature survey

Various definitions for the term community exist in literature. MacArthur (1971) has defined community as 'any set of organisms currently living near each other and about which it is interesting to talk', while according to Magurran (1988) community is a group of interacting organisms.

The studies on community are carried out at two levels. They are the patterns (Dueser and Shugart 1978, Kincaid *et al.* 1983, Chandrashekar -Rao and Sunquist 1996) and processes (Brown and Lieberman 1973, Brown 1989). Studies on patterns deal with the structure and organization of communities, the trends of species diversity within and between habitats, and distribution along an environmental gradient (topography, etc). Processes deal with the underlying causes because of which the above pattern results. A hypothesis on process is always more difficult to frame and test (Wiens 1989), hence the knowledge of pattern is important for designing any study on process.

The habitat acts as a templet producing a community with a certain set of properties. During this process it may itself get slightly modified (Southwood 1987). Productivity and structure of a habitat has been known to determine its species composition (Brown 1973, Brown and Lieberman 1973, Abramsky 1988). A species may use this space (habitat) either along a horizontal or vertical axis (Rosenzweig *et al.* 1975). The term heterogeneity has been used by some authors to indicate the horizontal variation or patchiness in a habitat and complexity to describe the vertical strata within a habitat. Some have also used these terms interchangeably (August 1983). The increasing species

richness across the complexity gradient, possibly because of increasing resources (August 1983).

The number of species that a habitat can support depends on abundance, predictability and the distribution of the resources within it (Brown 1973). These resources are not uniformly distributed within a habitat. They may either be randomly distributed or clumped within a habitat. Resources are either used as encountered by the species or it may be selected. A species is said to be showing resource selection if it does not utilise the resources, in the proportion in which it discovers them (Rosenzweig *et al.* 1975). In extremely productive habitat, species would have a more specialized diet because of greater abundance of food species, hence show resource selection (MacArthur 1972).

The desert being a simple ecosystem has attracted many community ecologists (Kotler and Brown 1988). Studies on desert rodents have been on for several decades and these have contributed considerably in strengthening and refining the theories and approaches to community ecology (Kotler and Brown 1988). Community studies on rodents have concentrated on the theories of limiting similarity (M'Closkey 1978), niche breadth, coexistence (Brown 1989), optimal foraging (Brown and Liberman 1973) and these in turn have stimulated studies on patch use and habitat selection (Dueser and Shugart 1978, Brown 1989, Abramsky *et al.* 1991). Biogeographic studies have looked at the distribution of different species with respect to body size and patterns of species co-occurrences (Kotler and Brown 1988).

Previous studies on resource utilization by rodents have shown that microhabitat plays an important role in structuring rodent communities (Rosenzweig and Winakur

1969; Brown 1973; Dueser and Shugart 1978). This microhabitat may be present along the horizontal or vertical axis of the habitat. The predation risk acts as an axis along which habitat selection has been found to occur and hence plays an important role in structuring desert rodent communities (Brown 1973, Ziv *et al.* 1995).

Most studies have involved trapping by either Snap traps or Sherman traps. These methods either remove the rodents from the area or restrict their free movement. Compared to traps, tracking has been found to be an effective method in studying the home range and habitat use of these small mammals (Sheppe 1965, Maybee 1998).

Over the years many studies have been conducted on rodents in the Thar desert. These studies have concentrated on their food habits (McCann 1927, Prasad 1954, Parrack 1966, Fitzwater 1967, Prakash 1969), reproduction (Khajuria 1965), burrow patterns (Prakash 1981), physiology and control (Prakash 1964, Prakash 1969 ; Prakash *et al.*,1969, Prakash and Jain 1970, Prakash *et al.* 1965). Except for a few studies (Prakash and Rana 1973, Rogovin *et al.* 1994, Prakash *et al.* 1995) most of these studies have looked at the biology of each species in isolation. Barring a few species like *Meriones hurrianae* (Prakash 1981) detailed information on food habits of most of the other species are not available. Most of these studies have been conducted to cater to the needs of farmers in the desert region hence have been considered as pests. As Jain *et al.* (1996) puts it " Due to their sheer numbers and omnipresence in almost all habitats, they have assumed a pest status."

The rodent species association changes across the Thar desert with the rainfall and soil regime [Table 1.1 (Prakash 1996)]. The present study aims to examine macro and microhabitat parameters important for three species of gerbils in three habitats. Food and

Table 1.1: Rodent communities across the Thar Desert

Rainfall	Major Soil formation	Rodent Community
Very Arid (100 mm rainfall)	Sand Dunes with interdunal planes.	<i>Gerbillus gleadowi</i>
Arid (100 –250 mm rainfall)	Sandy plains with dunes	<i>Gerbillus gleadowi</i> , <i>Meriones hurrianae</i> , <i>Gerbillus nanus</i> .
Arid (250- 400 mm rainfall)	Sandy Plains, sand dunes and rainfed crop fields	<i>Meriones hurrianae</i> , <i>Tatera indica</i> , <i>Gerbillus nanus</i>
Semi- arid (more than 400 mm rainfall)	Sandy plains with hilly out crops and irrigated agriculture	<i>Tatera indica</i> , <i>Millardia meltada</i> , <i>Golunda ellioti</i> , <i>Bandicota bengalensis</i> , <i>Cremnomys cutchicus</i> , <i>Mus phillipsi</i>

1.2 Study Animals

Various communities of rodents have been described from the Thar desert. One finds an increase in the number of species, within each community, with the increase in rainfall. In the extreme arid tract of the Thar desert only a single species is known to occur while in the semiarid region one finds an association of six species (Prakash 1996). Three species of rodent viz. *Gerbillus gleadowi*, *Gerbillus nanus* and *Meriones hurrianae* are known to co-occur in the 100-200 mm rainfall zone (Prakash 1996). All the species belong to Subfamily Gerbillinae (Family Cricetidae). The members of this subfamily are adapted to semi arid conditions and are found in the semi desert regions of the Old world (Roberts 1977).

- The Indian Hairy Footed Gerbil *Gerbillus gleadowi* Murray 1886: This species is endemic to the Thar desert. It is distributed from E. Pakistan till N.W. India (Corbett and Hill 1992). This gerbil is the most dominant species of rodent in the very arid tracts of the Thar desert (Prakash and Gupta 1976). Its hairy soles allows it lead a successful psamophilus life (Roberts 1977). This species is known to be associated with shifting sand dunes and are not found in the rocky areas (Roberts 1977, Goyal and Ghosh 1992). They are not very social and their burrows are widely distributed in an area. Their burrow entrance is either at the base of a plant (Roberts 1977) or on the slope of sand dunes. They are nocturnal and omnivorous in habit, insects forming a major part of their diet especially during the summer (Roberts 1977). The animal has an exceptional renal concentrating ability, which helps it to live in xeric habitats.
- The Baluchistan gerbil *Gerbillus nanus* Blanford 1875: This is a polytypic species with many well defined geographical races. It is distributed from N. Africa through Israel, S. Afganistan, Pakistan till N.W. India (Corbett and Hill 1992). It prefers areas

with firm substratum and are known to avoid sandy areas in Sind and Baluchistan (Roberts 1977). They are less social compared to *Tatera indica* and *Meriones* species but their burrows are found close together. They are nocturnal in habit, feeding mostly on seeds during winter and also insects during summer (Roberts 1977). The animal has been found to be active throughout the year.

- The Indian Desert Gerbil *Meriones hurrinae* Jerdon 1867: It is distributed from S.E. Afganistan across Indus Plains (Pakistan) upto N.W. India (Corbett and Hill 1992). The species is known to occur in the alluvial plains and edges of agricultural fields. The species avoids extensive sand dune habitats and are not found in rocky areas (Roberts 1977). Being gregarious in habit, their burrows are found in close proximity. Their burrows have numerous entrances often giving a honey comb like picture. Though several individuals may be using the same burrow entrances, they probably occupy separate underground chambers (Roberts 1977). They are diurnal in winter months and become crepuscular during summer. Leaf, stems and grass roots form an important part of their diet (Robert 1977,1981, Prakash and Idris 1992). At times they are also known to store seeds and vegetation in their burrows.

1.3 Objectives

The present study is aimed to:

- Describe the macro and microhabitats of the three species.
 - ⇒ To examine the niche overlap between the two nocturnal species.
 - ⇒ To examine the niche overlap between diurnal and nocturnal species.
- To examine the seasonal differences in niche width.

2. STUDY AREA

2.1 Location

Sam is situated at around 45km S. W. of Jaisalmer city within the Thar Desert in Rajasthan. It lies in the northern part of the 3162 square km Desert National Park in Jaisalmer district. The study area was situated around 5 km east of Sam village (Figure 2.1). The Thar desert is the eastern most limit of the large desert tract which stretches from Africa to Asia. The Aravalli hills, which are among the oldest surviving ranges of the world, marks the eastern boundry of the desert while the western limit is set by the fertile plains of the Indus. The Great Rann of Kutch forms a sharp boundry in the South while its northern limits are formed by the riparian sub Himalayan planes (Dhir *et al.* 1991).

According to Wadia (1976), the Thar desert is of recent origin and originated due to long period of extreme aridity and because of the "sand drifting " activity of the South West monsoon. The dust is picked up from the Rann of Kutch and transported inland. Since the rainfall is very low these dust particles are not transported back to the sea.

2.2 Climate and Geology

Jaisalmer district with an annual average rainfall of 200 mm or less comes under the extreme arid climate (Chatterji and Kar 1992). May and June are the hottest month with a mean maximum temperature of 41⁰ C while mean minimum of 10⁰ C is experienced during the winter months. Strong winds start from March having an average speed of more than 10 km/hr and continue till September (Chatterji and Kar 1992). The winds reach their peak in the month of June.

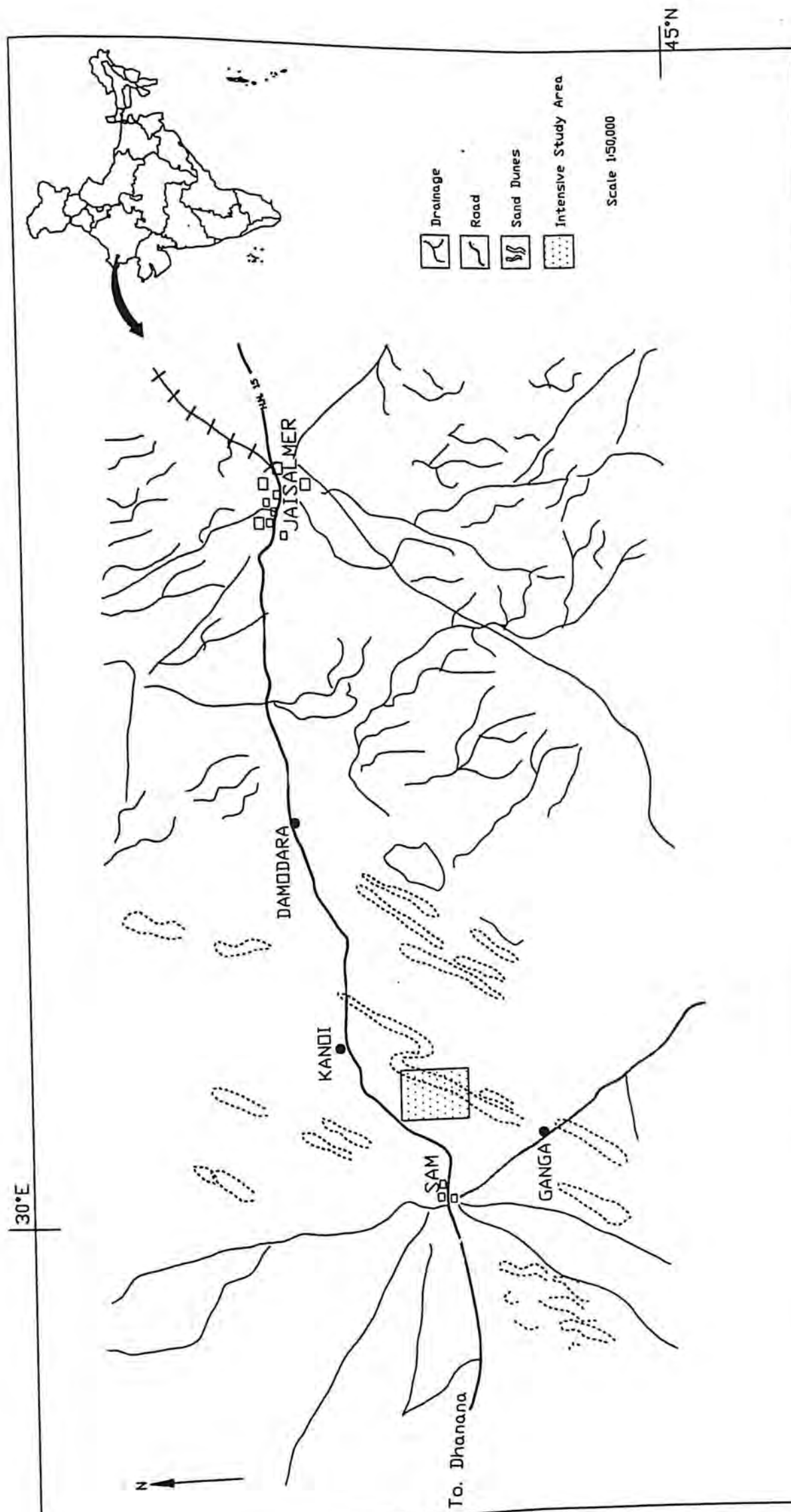


Fig.2.1 Study Area indicating terrain features

The area is arid in nature and has two distinct terrain features, the sandy form and the barren- rocky or gravelly form (Chatterji and Kar 1992). Because of the above climatic and terrain features there are very few streams (ephimeral in nature) which are chiefly confined to the rocky areas (Chatterji and Kar 1992). The rocky or gravelly pediments, the sand dunes and the interdunal plains form the major habitat types in the area.

In the Rocky or gravelly area, limestone and sand stone are the major constituents (Chatterji and Kar 1992). Sand dunes in the area has been classified as hair-pin parabolics by Wasson *et al.*(1983**) (in Dhir *et al.* 1991) while Kar (1987**) (in Dhir, *et al.* 1991) has classified them under complex longitudinals, transitionals and parabolics. The sand moving from SW to NE direction, along with the SW monsoon, mostly consists of Quartz grains along with grains of felspar and hornblend (Blatter and Hallberg 1921). Large stretches of interdunal areas, consisting of aeolian sand, are found within the dunal areas and their shape depends on the orientation of the dunes (Chatterji and Kar 1992).

2.3 Vegetation

The grasses and shrubs mostly dominate the terrain with very few trees (Chatterji and Kar 1992). The desert vegetation can be divided into two distinct groups, ephemerals and perennials. Ephemerals (herbs) turn up after the first rains and they cover the entire desert floor. They complete their life cycle before summer and hence the terrain again looks barren (Bhandari 1990). The following broad vegetation or habitat types are found:

Rocky / Gravelly Pediments: These are flat terrain, often with varnished fragments of aeolian sand. The vegetation on this dominated by species like *Acacia senegal*, *Zizyphus*

nummularia, *Capparis decidua*, *Aristida*, *Dactyloctenium sidicum* and *Eleusine compressa* (Shankarnarayan *et al.* 1992).

Sand Dunes: Seven different types of sand dunes have been recorded from the area. Out of these the megabarchanoids, the smaller barchans and other sandy streaks are the mobile ones. The others are relatively stable and vegetated. They consist of calcareous aeolian sand. *Leptadenia pyrotechnica*, *Calligonum polygonoides*, *Calligonum procera*, *Aerva pseudotomentosa*, *Lasiurus indicus*, *Panicum turgidum* and *Eleusine compressa* (Shankarnarayan *et al.* 1992)

Interdunal area: They are mostly flat sandy areas. Their shape is determined by the direction of the sand dunes. The vegetation on it is dominated by species like *Prosopis cineraria*, *Capparis decidua*, *Calligonum polygonoides*, *Zizypus nummularia*, *Lasiurus indicus*, *Haloxylon salicornicum* and *Aerva pseudotomentosa* (Shankarnarayan *et al.* 1992).

2.4 : Intensive Study Area:

The study was conducted within an area of 4 km², east of Sam village (Figure 2.2).

Three broad habitat types were selected for the study.

- **Stabilized Dune:** The mobile sand dunes are colonized by perennial species like *Crotolaria burhia*, *Cyperus arenarius*, *Aerva persica* and pioneer ephemerals like *Indigofera cordifolia*. These pioneers stabilize these mobile dunes. *Panicum turgidum*, *Lasiurus indicus*, *Haloxylon salicornium*, *Aerva pseudotomentosa* are the dominant species in this habitat (Figure 2.3). *Dipterygium glaucum* and *Crotolaria burhia* are also found but in less numbers.
- **Barren or Unstabilised dune:** These have least number of plants on them because of their mobile nature. The dominant plant in this habitat is *Dipterygium glaucum*. Most of the vegetation in this habitat type is found in the depressions, where the soil is compact, thereby allowing the plants to establish. *Aristida mutabilis*, *Aerva pseudotomentosa*, *Calotropis procera* are the other plants found in it (Figure 2.4).
- **Interdune:** These are areas between two mobile or stabilized dunes. *Lasiurus indicus*, the most nutritive and quick growing grass (Bhandari 1990), is the most dominant plant found in this habitat. Due to this reason it is the most intensely grazed area among all other habitats. This also happens to be the only habitat in which *Capparis decidua*, in the tree form, was found (apart from the agricultural fields). *Leptidinia pyrotechnica*, *Haloxylon salicornicum*, *Aerva pseudotomentosa* are the other perennials found (Figure 2.5).

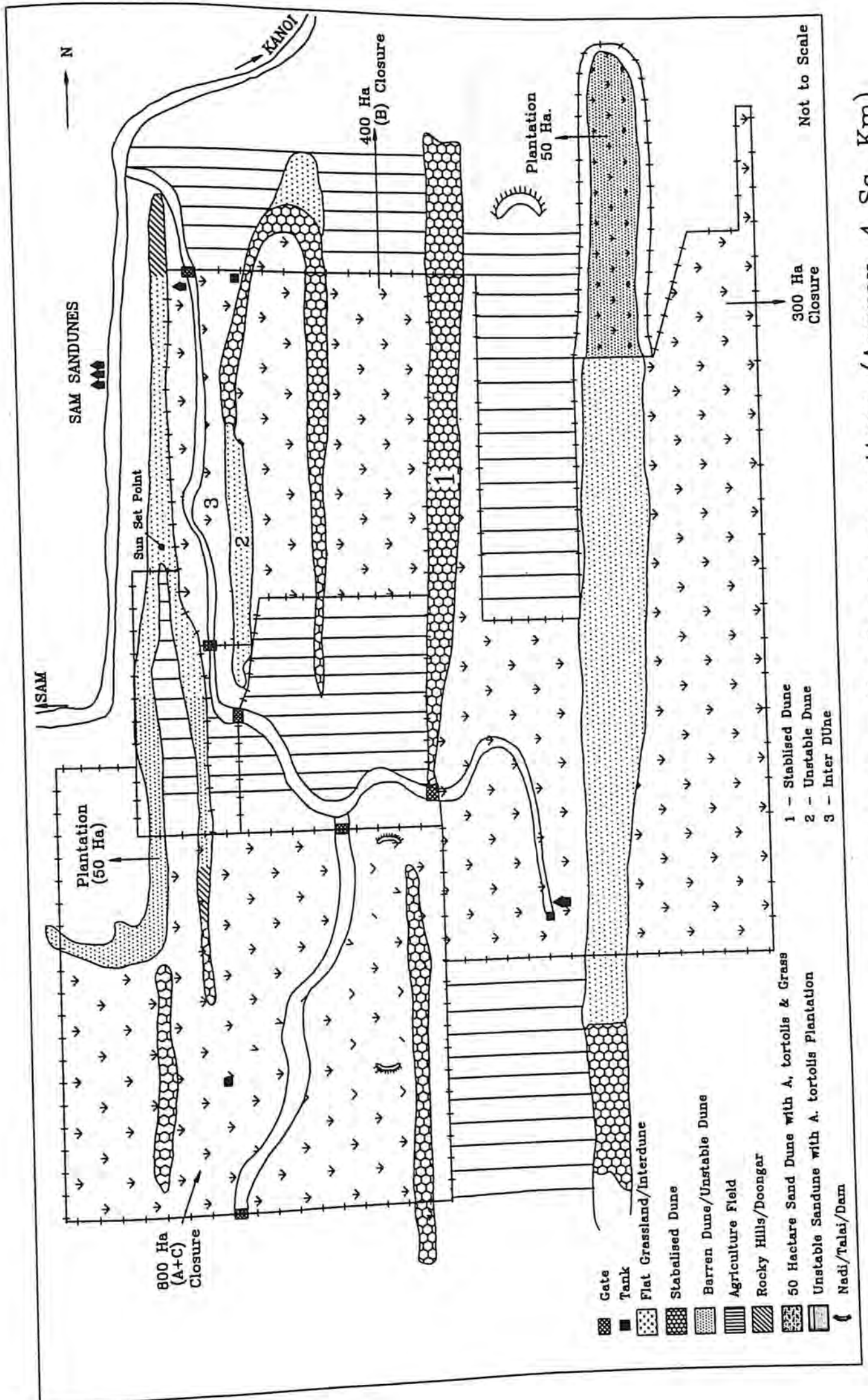


Fig. 2.2: Intensive Study Area indicating the land use pattern (Approx. 4 Sq. Km)

- Gate
- Tank
- Flat Grassland/Interdune
- Stabilised Dune
- Barren Dune/Unstable Dune
- Agriculture Field
- Rocky Hills/Doonger
- 50 Hectare Sand Dune with *A. tortolis* & Grass
- Unstable Sanddune with *A. tortolis* Plantation
- Nedi/Talai/Dam

- 1 - Stabilised Dune
- 2 - Unstable Dune
- 3 - Inter Dune

Not to Scale

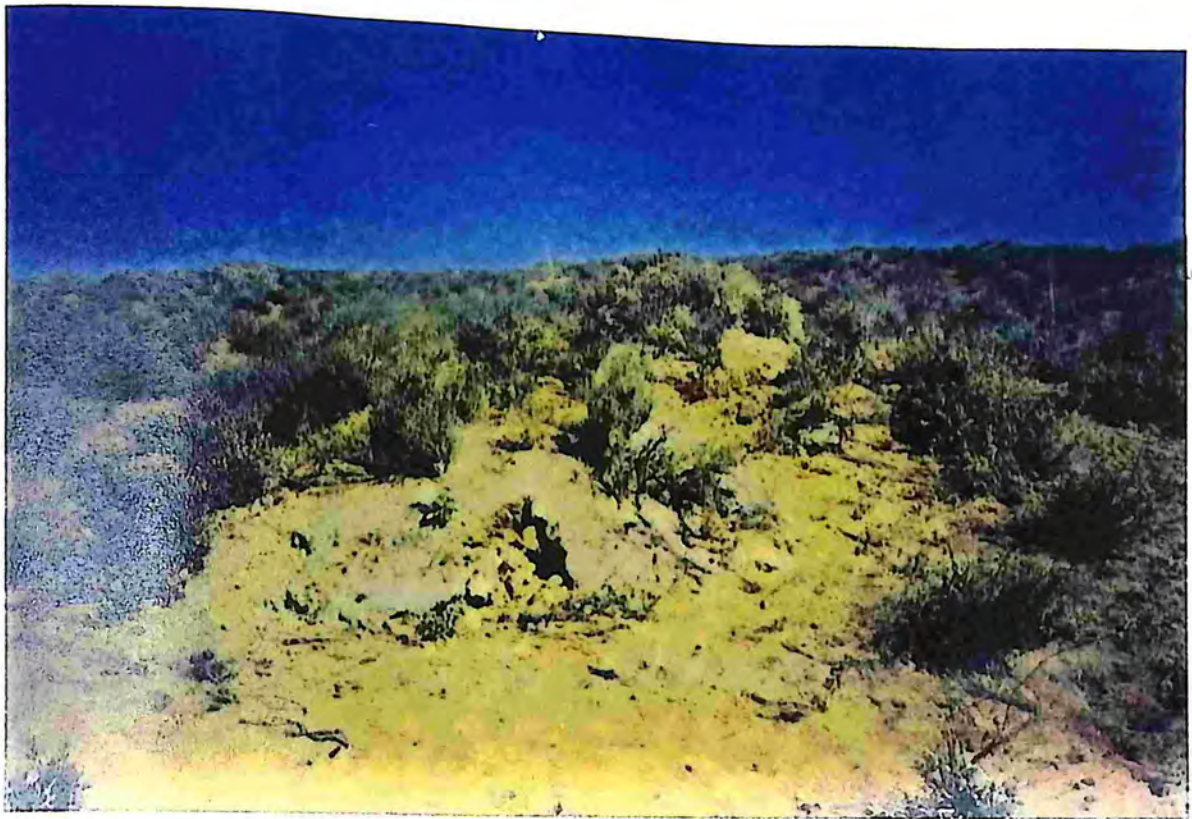


Figure 2.3 : Stabilised Sand Dune.



Figure 2.4: Barren Sand Dune



Figure 2.5: Interdune



3. METHODS

One of the objectives of this study was to look at macro and microhabitat use by the three rodents.

3.1 Sampling Rodent habitat use

Three different methods were used to study the microhabitat use by the three species of gerbils.

- Live trapping
- Track plots
- Direct sighting and other indirect evidences.

3.1.1 Live Trapping

Medium sized Sherman traps were used to look at the microhabitat use by the three species of gerbils. Traps were laid at 20m interval, across the outermost contour of Stabilised dune and Interdune, in straight lines in following a particular compass direction. The trap lines covered roughly 30-40 % of the area in each habitat.

3.1.2 Track Plots

Tracking has been one of the most effective methods for looking at the presence, movement, home range and habitat use by small mammals (Sheppe 1965, Maybee 1998). It has been used successfully used in wildlife as well as pest control studies (Sheppe 1965, Ratz 1997, Spaulding & Jackson 1984). Compared to traps, tracking does not restrict the animal's movement, allows one to cover a larger area and is also less time and labour intensive (Sheppe 1965, Van Apeldoorn *et al.* 1993, Maybee 1998). Since it does not involve handling of rodents, it reduces exposure to transmissible diseases (Drennan *et*

al. 1998). Various methods like aluminium tracking plots, weather – resistant tracking stations, sand, dirt and lime track beds have been used (Sheppe 1965, Drennan *et al.* 1998, Spaulding and Jackson 1984).

For the present study lime track beds were used. This technique allows easy movement of animals, is less expensive and easy to lay (compared to track stations). Unlike track stations, track beds can be used only in favorable weather conditions and the data obtained has to be recorded at the site itself.

Reference tracks for the two sympatric species of nocturnal gerbils (*G. gleadowi* and *G. nanus*) were recorded in captivity as it was difficult to identify the species from burrow pattern or any other indirect evidences. Tracks were standardised from captive specimens at Central Arid Zone Research Institute, Jodhpur.

3.1.3 Direct Sightings and Indirect Evidences

The Desert gerbil (*Meriones hurrianae*) being a diurnal species could be easily sighted. The burrow of *M. hurrianae* is more extensive and complicated compared to the other gerbils (Prakash 1981). Their network of burrows which are interlaced among themselves are very easy to identify. When alarmed, the animal makes a 'Thumping' noise inside its burrow, which acts as an alarm for other members of its colony (Roberts 1977, Prakash and Idris 1992). The presence of long nails makes the animal an efficient digger and hence the presence of fresh sand outside its burrow entrance is a good indication of an active burrow site. Combination of the above clues was used to identify the areas used by this diurnal gerbil. Four to six parallel plot (track plot) lines, having a fixed bearing were laid across the outermost contour of each habitat, from a randomly selected point within a particular habitat. These track lines were spaced at 20m interval. Circular track plots of

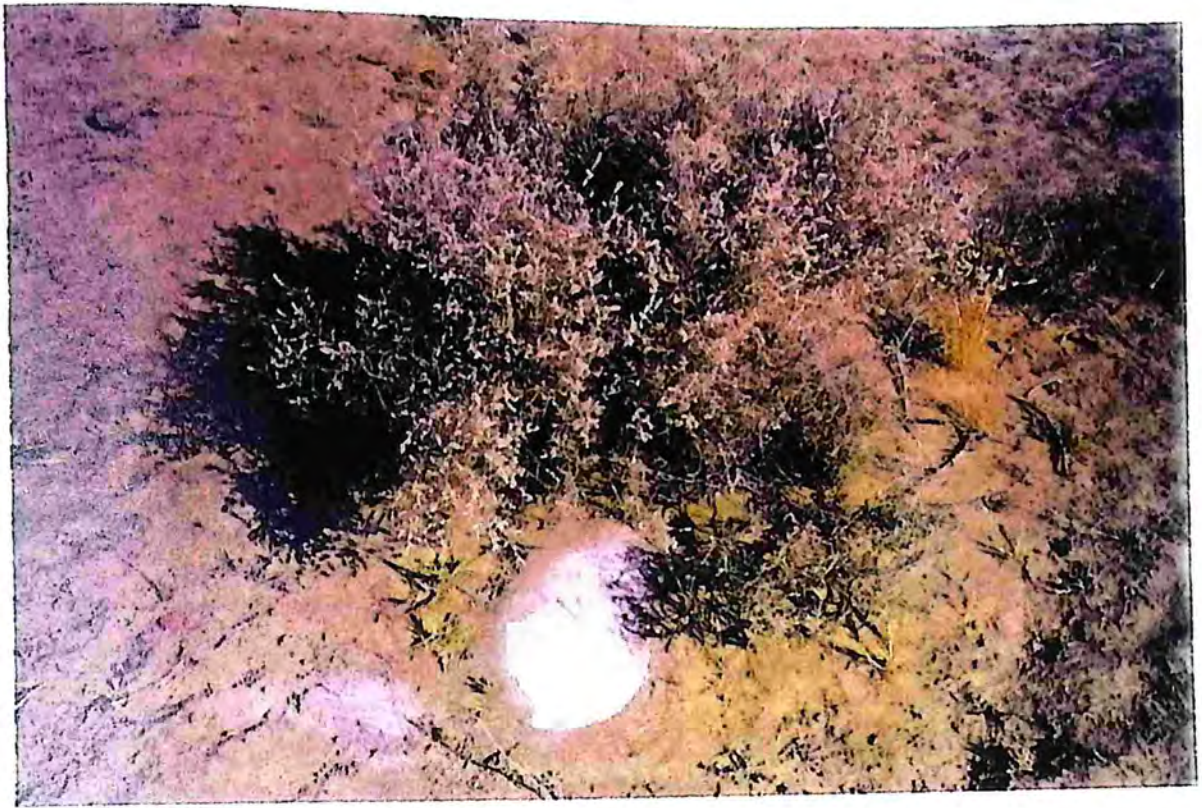


Figure 3.1: Track Plot

lime, having a diameter of 25 cm., were laid at 20m interval on these lines.

Following procedure was used to make the track plots:-

1. Lime was sieved on to the soil
2. A metal plate was used to smoothen it. This made the plot more compact which in turn left a better quality track.
3. Finally a small stick (roughly 1.5 - 2 inches long) was placed perpendicularly at the center of the plot with some peanut butter at its tip (Figure 3.1).

The track plots were laid an hour before sunset and was checked the following day during early morning hours. Each plot was used only for a single night. On an average around 20 track plots could be laid in an hours time. During winter (December '98 to January '99) 60, 41 and 55 track plots were laid in Stabilised dune, Barren Dune and Interdune respectively, while during summer (March – April 1999) 65 track plots were laid in each of the three habitats (Table 3.0).

3.2 Sampling Vegetation

Several habitat variables have been found to influence the distribution of a species within and between habitats (Rosenzweig and Winakur 1969, Dueser and Shugart 1978). For the present study, microhabitat variables were selected based on the following criteria (Dueser and Shugart 1978):-

- The variable should describe the structure of the environment which is either known or suspected to have an influence on the distribution or abundance of a species.
- It should be quickly and precisely measurable. It should not involve any destructive sampling.

- The intra seasonal variation of the variable should be small compared to the inter season variation.
- The variable should describe the microhabitat around used sites so that minor differences between sites, which look similar, can be detected.

To study the microhabitat use, the following microhabitat variables, representing habitat complexity, heterogeneity and phenology, were recorded around each sampling point.

- Soil compactness
- Ground cover
- Mean grass and shrub height
- Grass and Shrub density
- Phenology (Vegetative and Reproductive)
- Number of "Mounds"
- Number of "Hummocks"
- Distance from the nearest Mound/Hummock
- Distance from the nearest *Capparis decidua*/*Calotropis procera*

Soil Compactness – Lang Penetrometer (Blue Generation model of Forestry Suppliers) was used to measure soil compactness. The probe of the instrument is inserted into the soil and the resistance to this penetration is expressed in pounds. The instrument reads between 1-20 units. The instrument can measure compaction from 0 to 969.44 psi (Forestry Suppliers 1999). Four such readings were taken randomly within 1m radius around each track plot. Higher the reading the more compact the soil. The average of the four readings was taken as a representative for a plot.

Ground Cover – Point count (Muller-Dombois 1974) was used to record the ground cover around each track plot. The presence/absence of three parameters viz. sand, vegetation and dung was recorded at 10 points (spaced at 10 cm. interval) in both east and west direction, within 1m radius around each track plot. These readings were later converted to percentages.

Mean Grass and Shrub Height – Mean height for each species of grass and shrub were measured within 5m radius around each track plot. Each tussock of grass was treated as a single individual. The mean vegetation height for each such 5m radius plot was calculated by averaging the means of all the plants within it.

Grass and Shrub Density - The total number of grass tussocks and shrubs within 5m radius around each track plot gave a measure of shrub and grass density.

Phenology – The phenological stage of a plant can be divided into two broad categories, namely the vegetative phase and reproductive phase.

1. Vegetative phase: - The entire vegetative phase of a shrub / herb can be divided further into three stages.

- No leaves.
- Young Leaves.
- Mature leaves.

Together the above stages constitute 100%. A visual estimate (in percentage) of the three stages was recorded for each individual plant.

2. Reproductive phase: - The reproductive phase of a shrub/ herb can be divided into three broad categories.

- Buds.

- Flowers.
- Fruits.

Together these stages constitute 100%. A visual estimate of each stage was recorded for each individual plant.

Phenology for Ephemerals and herbs: The above phenological stages were recorded for all individuals within two .25x.25m plots located within 1m radius around each track plot, in east and west direction.

Phenology for grasses: The above phenological stages were recorded for all individuals touching the two five meter lines (North – South) from the center of each track plot.

Number of “Mounds” – Over the years, sand gets accumulated at the base of the grass tussocks. Due to this the new shoots grow on a raised platform. These structures are called “mounds.” The mounds are roughly 10 to 15 cm in height and have a diameter of 25-50cm. All such structures within 5 m radii around the plots were recorded.

Number of “Hummocks” – The hummocks are structures formed by the accumulation of sand at the base of shrubs. They are roughly 50 cm. in height 150-200 cm. in diameter hence cover a wider area compared to mounds. They are mostly found at the base of shrubs like *Haloxylon salicornium*, *Aerva pseudotomentosa* and *Leptidinia pyrotechnica*. The hummocks are much more stable structures compared to the mounds. Most field rodents are associated with hummocks (Prakash and Rana 1973) hence it was selected as one of the variables for this study. Their number within 5m radius around each plot was recorded.

Distance from the nearest Mound/ Hummock: The distance of each track plot was placed in the following categories: On mound/hummock, < 0.5 m, 0.5 – 1 m, 1 – 3 m, 3 – 10 m, > 10m.

Distance from the nearest *Capparis decidua*/*Calotropis procera*: The distance of each track plot from the nearest *C. decidua*/*C. procera* was placed under the following categories: < 1m, 1 – 5m, 5 – 10m, > 10m.

The above variables were recorded first around the plots in which tracks were found and from the remaining un-utilised plots every third plot was sampled. The effort of such habitat sampling plots per habitat has been given in Table 3.0

3.3 Statistical Method

Factor Analysis (FA) with principle component extraction was used to reduce the dimensions of the data set. The factors extracted were subjected to Kaiser's Varimax rotation to simplify the structure. Correlation-Partial correlation matrix was constructed from the original data matrix using Pearson's Product-Moment correlation coefficient. This correlation matrix was then subjected to eigen analysis to derive the factors. Factors with eigen values more than unity were chosen. This method reduces the number of variables into fewer numbers but the data still contains the same amount of information (Jongman *et al.* 1995).

Litvak and Hansell's (1990) method was used to draw the niche space for the two species of nocturnal rodents. All the sample plots are plotted on a graph, with Factor 1 on its x - axis and Factor 2 on its y-axis. The co-ordinates of the outermost plots for a particular species are then joined to form a rectangle. This rectangle (also known as n-dimensional rectangular parallelepiped) forms the niche space for that particular species.

Table 3: Sampling Effort per habitat

Season	Habitat	Total number of Habitat Sampling plots	Total number of track plots
Winter	Stabilised Dune	37	60
	Barren Dune	40	41
	Interdune	29	55
Summer	Stabilised Dune	65	65
	Barren Dune	66	66
	Interdune	34	65

4. RESULTS

4.1 Live trapping

During the initial part of the study, medium sized Sherman traps were used for trapping the rodents and finding out the microhabitats used by them. There were no success after having put an effort of 500 trap night within a span of five days in Stabilised dune and Interdune. Hence they were not used further in this study. The results of Sherman trapping in two habitats have been summarised in Table 4.1.

4.2 Track plots

The Sherman trap failed in trapping any rodents hence track plots made of lime were used for the study. On an average 59 track plots were laid in each habitat per season (Figure 4.1 and 4.2). For both winter and summer, maximum track success was in the Barren dune and minimum in the Interdunal areas (Table 4.2).

4.3 Indirect evidences and burrow count for *M. hurrianae*

The desert gerbil was found to be strictly associated with *Capparis decidua* tree and was found to occur only in the Interdunal area. Very low sightings/indirect evidences was found for this species (Table 4.3). According to Prakash (1975), their population builds up during winter and continues till spring, again their numbers reduce in summer.

Table 4.1: Success of Sherman traps in the two habitats.

Month	Habitat	Number of Trap Nights / habitat	Success
December '98	Stabilised Dune	200	Nil
January '99	Interdune	300	Nil

Table 4.2 : Track plots success in the three habitats.

SEASON	HABITAT	TOTAL NUMBER OF TRACK PLOTS	% SUCCESS <i>Gerbillus</i> <i>gleadowi</i> (n)	% SUCCESS <i>Gerbillus</i> <i>nanus</i> (n)	TOTAL % SUCCESS
Winter	Stabilised Dune	60	25 (15)	16.67 (10)	41.67
	Barren Dune	41	97.56 (40)	-	97.56
	Inter Dune	55	32.72 (18)	3.64 (2)	36.34
Summer	Stabilised Dune	65	44.62 (29)	18.46 (12)	63.08
	Barren Dune	66	98.48 (65)	-	98.48
	Inter Dune	65	26.15 (17)	4.62 (3)	30.77

% Success = (No. of Track plots with tracks/Total No. of Track plots)*100

n = Actual number of samples

Table 4.3: Number of *M. hurrianae* sighted/ burrows in the Interdunal area during winter and summer.

Season	Number of sightings/ burrows observed
Winter	9
Summer	7

4.4 Species composition

In all, three species of rodents have been reported from this region (Prakash 1996). From the track plot data, the following composition of rodents was found in the different habitats. *G. gleadowi* was found to occur in all the three habitats, *G. nanus* in two and *M. hurrianae* was found only in one of the habitat (Table 4.4).

4.5 Habitat use

Factor Analysis (FA) with principle component extraction was used to reduce the dimensions of the various habitat variables. The variance in the habitat attributes have been given in Appendix 1. This was calculated separately for the two season viz. winter and summer. The data of the two habitats (Stabilised dune and Interdune) in which *G. gleadowi* and *G. nanus* co-occur were pooled together for each season and analysed.

4.5.1 Winter

The two factors accounted for 74% of the variation in the data set (Table 4.5.1). The first factor comprised of vegetation cover, soil compactness in one direction and bare soil in the other, together explaining Ground layer characteristics. The second factor consisted of average vegetation height and number of hummocks, together explaining habitat complexity (Table 4.5.2). A total of five factors were extracted out of which only the first two were chosen because they had eigen values more than unity. *G. gleadowi* was found to be a more generalist species having a wide niche dimension compared to *G. nanus* (Figure 4.3). *G. gleadowi* was found to use areas with lower mean vegetation height, less number of hummocks and less compact soil. On the other hand *G. nanus* used areas having higher mean vegetation height, greater number of hummocks and relatively more compact soil. *G. gleadowi* used a much wider range of all the variables (%vegetation, % bare soil, soil compactness, mean vegetation height and number of hummocks) compared

Table 4.4: Rodent Species composition in the different habitats.

SPECIES	STABILISED DUNE	BARREN DUNE	INTER DUNE
<i>Gerbillus gleadowi</i>	Present	Present	Present
<i>Gerbillus nanus</i>	Present	Absent	Present
<i>Meriones hurrianae</i>	Absent	Absent	Present

Table 4.5.1: Eigen values and variance explained by each factor during winter for *G. gleadowi* and *G. nanus*

Factor	Eigen Values	Variance	
		% of Variance	Cumulative %
1	2.21	44.274	44.274
2	1.49	29.731	74.005

Table 4. 5.2: Rotated Component Matrix for habitat use by *G. gleadowi* and *G. nanus* during winter data.

Variables	Factor	
	1	2
% Vegetation	0.961	
Soil compactness	0.550	-0.268
% Bare Soil	-0.959	
Mean Vegetation Height	-0.203	0.871
Number of Hummocks	0.166	0.799

to *G. nanus*.

4.5.2: Summer:

For summer 72% of the variance was explained by the first two factors (Table 4.5.3). A total of 5 factors were extracted out of which only the first two were selected as they had eigen values greater than unity. Factor 1 consisted of % bare soil in one direction and % vegetation in the other, together these variables constitute ground cover (Table 4.5.4). The second factor consists of mean vegetation height, number of hummocks in one direction and soil compactness in the other (Figure 4.4). They together contribute to habitat complexity. *G. gleadowi* continued to have a wider niche compared to *G. nanus*. *G. gleadowi* still used areas with relatively lower soil compactness, greater ground cover, lower mean vegetation height and less number of hummocks. *G. nanus* still used areas with higher soil compactness, mean vegetation height and greater number of hummocks. By looking at Figure 4.3 and 4.4, there appears to be greater overlap of niche between the two species during summer compared to winter.

**Figure 4.3 : MULTI-DIMENSIONAL NICHE RELATIONSHIP
BETWEEN *G. gleadowi* AND *G. nanus* IN WINTER**

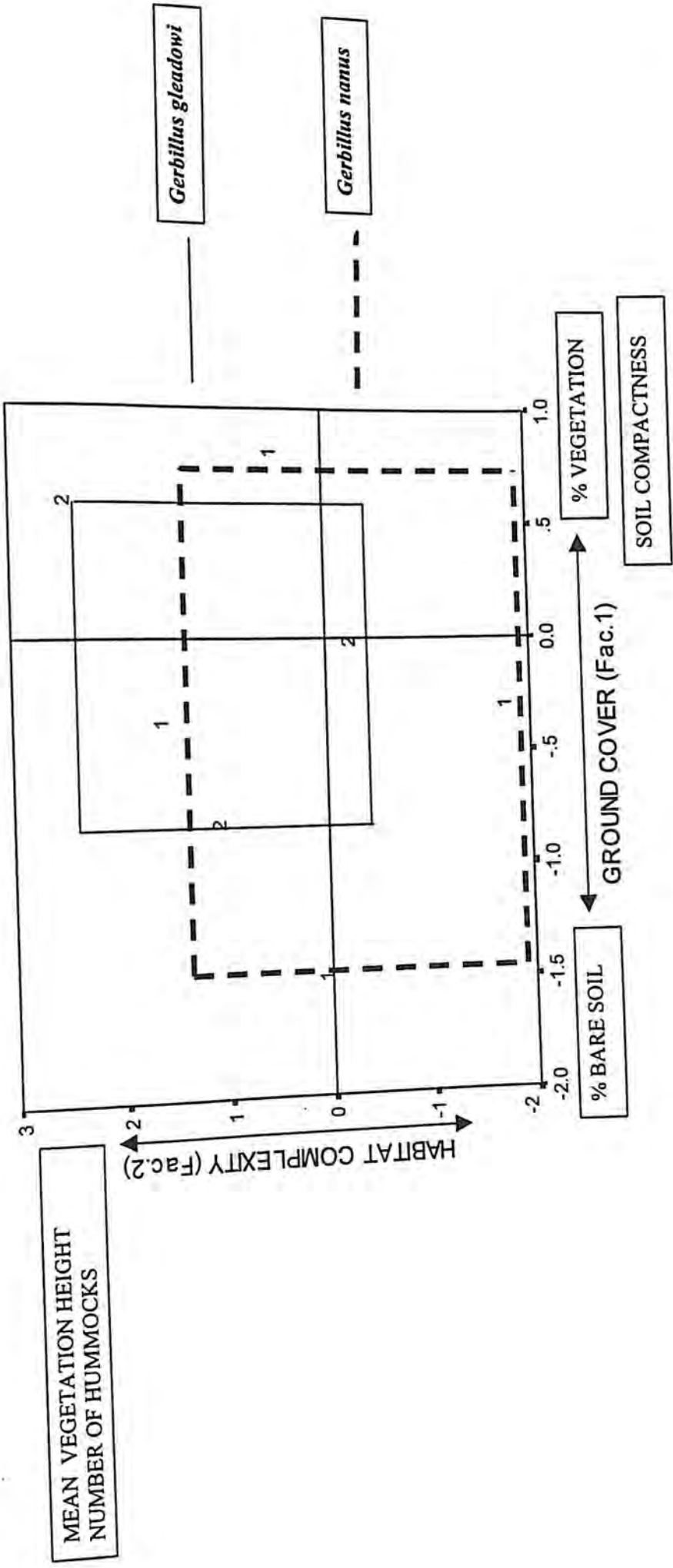


Table 4.5.3: Eigen scores and variance explained for *G. gleadowi* and *G. nanus* by each Factor in summer.

Factors	Eigen Values	Variance	
		% of Variance	Cumulative %
1	2.022	40.439	40.439
2	1.566	31.328	71.767

Table 4. 5.4: Rotated Component Matrix for habitat use by *G. gleadowi* and *G. nanus* during summer data.

Variables	Factors	
	1	2
% Vegetation	0.996	
% Bare Soil	-0.996	
Mean Vegetation Height	0.128	0.870
Number of Hummocks		0.716
Soil compactness	0.147	-0.545

Table 4.6.1: Eigen values and total variance explained by each factor for *G. gleadowi*

Factors	Eigen Values	Variance	
		% of Variance	Cumulative %
1	2.312	46.235	46.235
2	1.743	34.852	81.087

4.6 Increase in Niche dimension of *Gerbillus gleadowi*

There was an increase in niche dimension of *G. gleadowi* in the stabilised dune during summer (Figure 4.5). The winter niche was found nested within its summer niche. Out of a total of four factors only the first two factors had eigen value greater than unity. These two factors together explained 81% of the variance of the data set (Table 4.6.1). The first factor consisted of plant and soil characteristics with % vegetation and % mature leaves in one direction and % bare soil in the other. The second factor consists of the phenological stages with % fruit and % young leaves forming the major variables (Table 4.6.2). Compared to winter, the species used areas having higher percentage of fruits, young leaves and mature leaves during summer. It also used areas having higher ground cover. Phenology played a much important role during the summer months.

Figure 4.4.: MULTI-DIMENSIONAL NICHE RELATIONSHIP BETWEEN *G. gleadowi* AND *G. nanus* IN SUMMER.

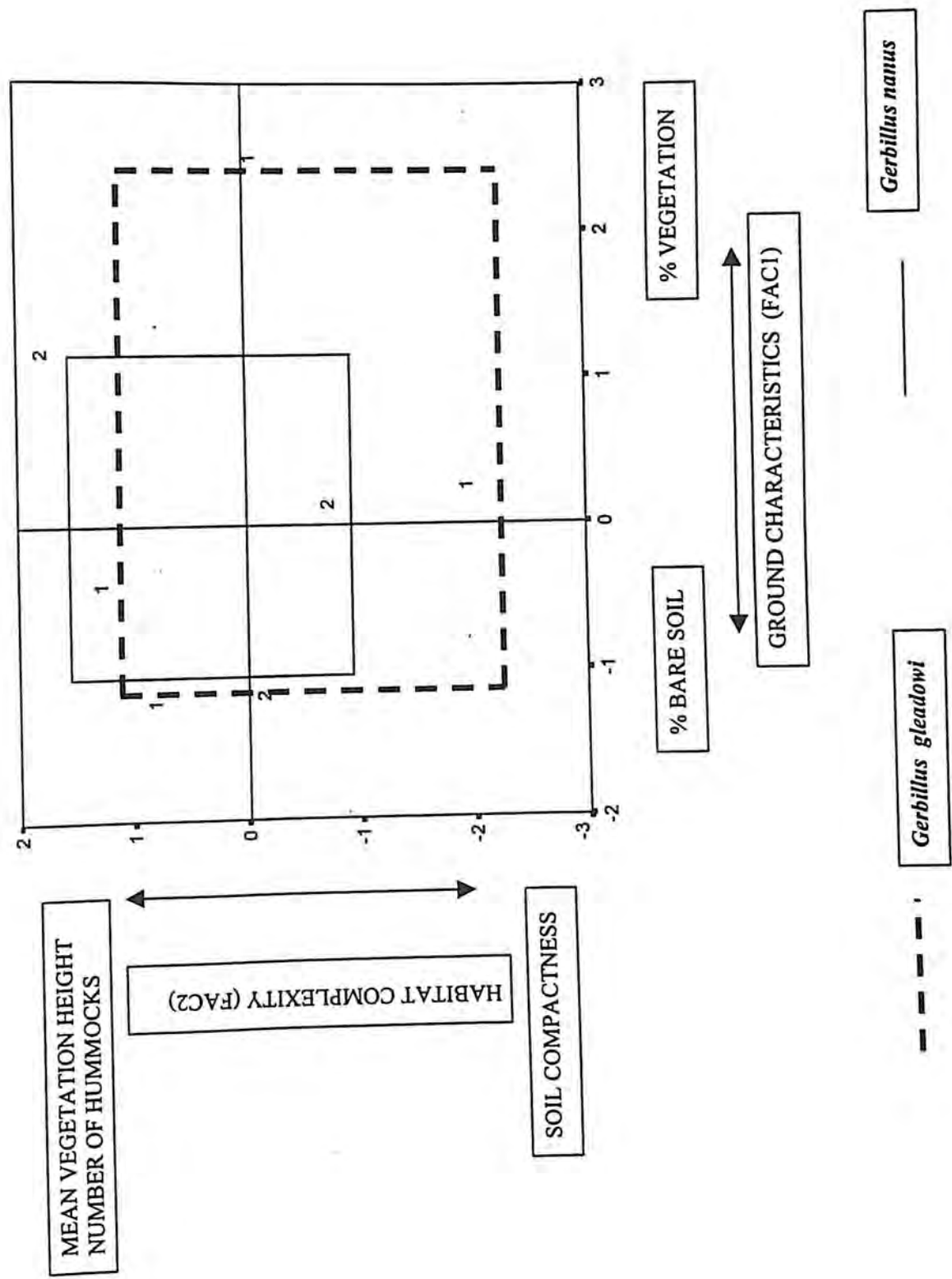


Figure 4.5 : NICHE DIMENSIONS OF *G. glaberrimi* IN STABILISED DUNE

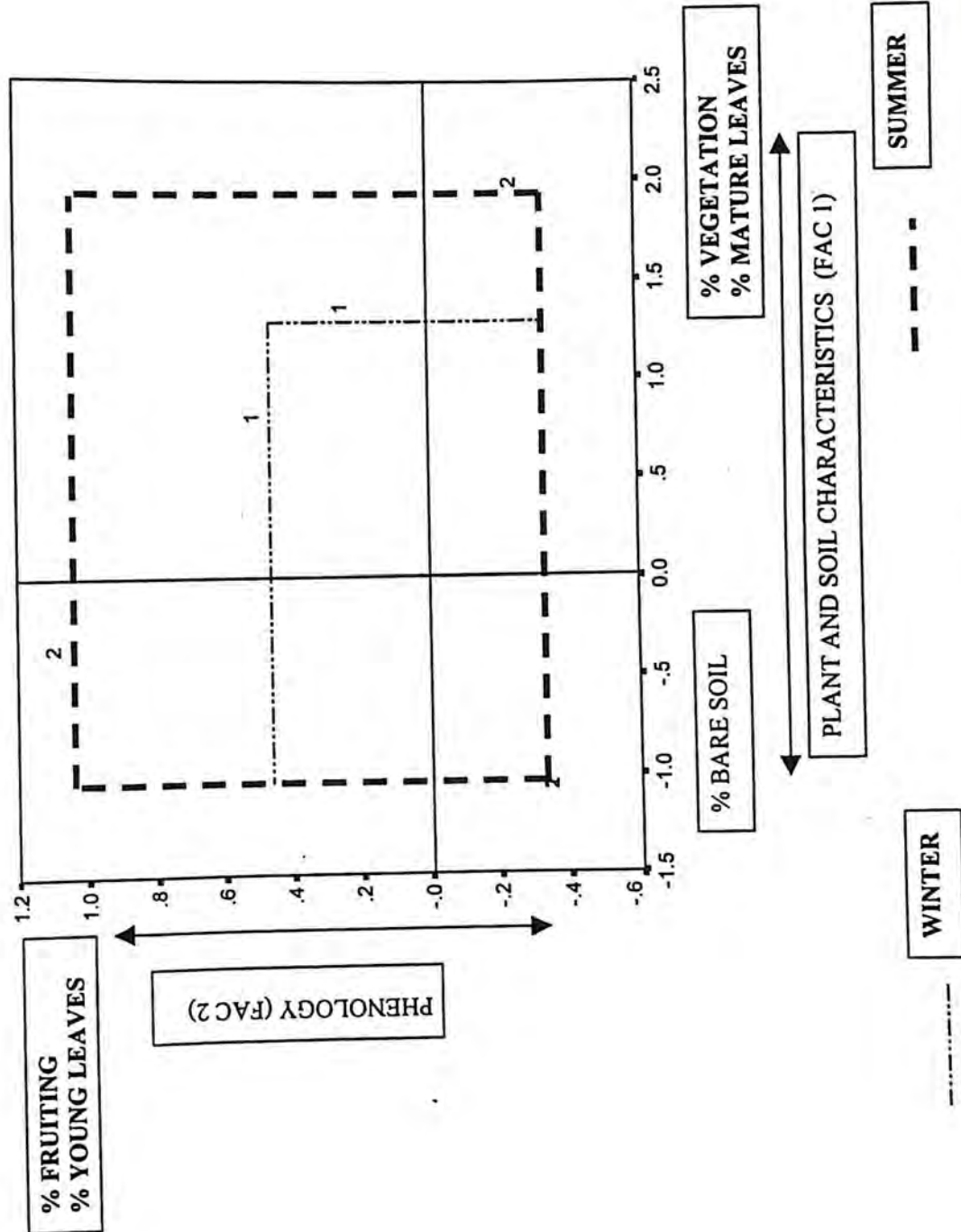


Table 4.6.2: Rotated Component Matrix for *G. gleadowi*.

Variables	Factors	
	1	2
% Vegetation	<i>0.969</i>	
% Mature leaves	<i>0.509</i>	
% Bare Soil	<i>-0.969</i>	
% Fruit		<i>0.975</i>
% Young leaves		<i>0.970</i>

5. DISCUSSION

5.1 Niche dimensions of *Gerbillus gleadowi* and *Gerbillus nanus*

It has been observed that the structure and productivity of a habitat determines its species composition (Brown 1973, Abramsky 1988). Food being an important resource has a very important role in structuring communities (Brown 1973). In the desert, seeds of annuals have been found to play an important role in the reproduction of desert rodents (Beatley 1969, Rosenzweig *et al.* 1975).

The species composition across the Thar desert follows a particular pattern with respect to rainfall and soil patterns (Prakash 1971, 1996). In the extreme arid tract of the desert (precipitation <100 mm) the association is of *G. gleadowi* (82.1%) and *M. hurrianae* (17.9%) (Prakash and Gupta 1976). *G. gleadowi* has the ability to produce very concentrated urine because of its efficient kidneys (Roberts 1977). This efficient renal system allows the species to conserve a lot of water and hence contribute to the animals success in extreme desert terrain.

If a species uses a habitat or a microhabitat in a manner other than the proportion in which it is available, then it is said to be showing some kind of habitat selection, while on the other hand, if a species does not utilize resources in the proportion it encounters these it is said to be a resource allocator (Rosenzweig *et al.* 1975).

During this study *G. gleadowi* was found in all the three habitats (Table 4.2). It was found to be the sole occupant of the Barren / Shifting dune which is possibly because of its ability to withstand extreme conditions. Here they mostly occur in the depressions and along some slopes, where the soil is compact. The presence of compact soil and

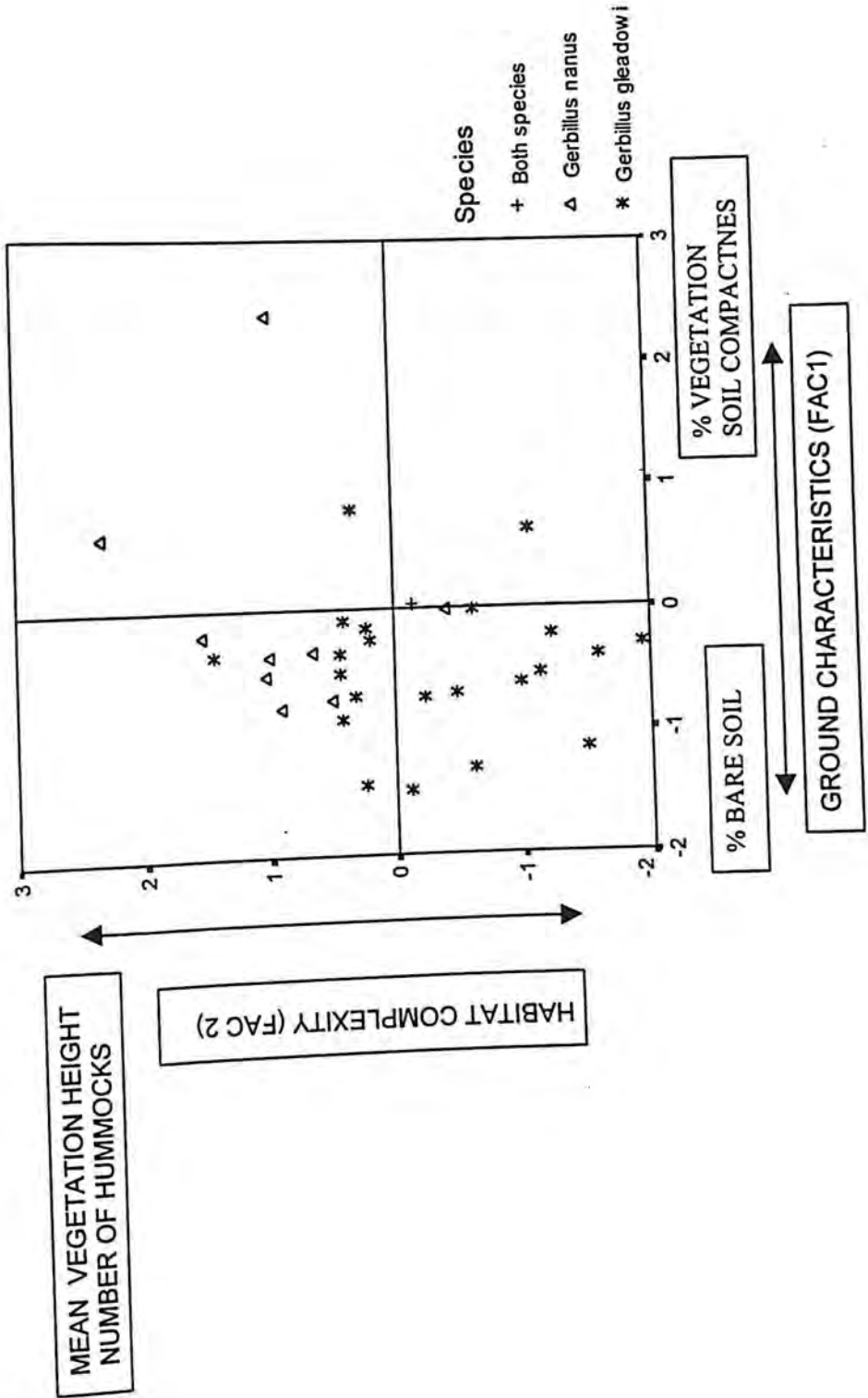
vegetation make these places suitable for burrows (Prakash and Rana 1973). The track plot data shows that the relative abundance of this species is highest in this habitat (Table 4.2). This may not be true, as it could be an artefact of the habitat itself. Since the habitat is devoid of vegetation it is safe to assume that very few individuals may be occupying the habitat. These may be having larger home ranges compared to the individuals in the Stabilised or Interdunal areas. Within this habitat, tracks were recorded on plots which were more than 70 meters from the nearest clump of vegetation. This could be because a single individual might be covering more than one track plot while foraging. In order to have a more reliable estimate of the relative abundance of this species in the Barren dune, one can increase the distance between two track plots to around 75 meters. This will reduce the chance of getting the same individual on successive/ neighbouring track plots. *G. gleadowi* has the ability to live in simple, shallow burrows and it also has the ability to find its way out even when the burrows are buried under the sand (Prakash 1975). Hence at time it becomes difficult to locate their burrows in the Barren dunes.

G. nanus, which is found exclusively in sandy habitats, was found to coexist with *G. gleadowi* in the Interdune and Stabilised dune (Table 4.4). It was represented by higher numbers in Stabilised dune. Though *G. gleadowi* was the most abundant species its numbers were least in the Stabilised dune (Table 4.2). Earlier studies have looked into resource partitioning and overlap by pair wise approach (Schoener 1970) but the community perspective using factor analysis, as used by Litvak and Hanssel (1990), brings forth a very interesting picture. When one pools together the information from Factor analysis results, for the habitats in which the two species co-occur, one finds a very interesting pattern. In both seasons *G. gleadowi* was found having a much wider

niche dimension, compared to that of *G. nanus* (Figure 4.3 and Figure 4.4). During winter (Figure 5.1), *G. nanus* was found to use areas with higher vegetation height and greater number of hummocks compared to those used by *G. gleadowi*. The Hairy Footed Gerbil was found using a wider range of each variable which had contributed to the formation of its niche. It used areas with lower ground cover (% bare soil), lower vegetation height and fewer number of hummocks, compared to the *G. nanus*. During summer the food resource gets reduced hence both the species started using areas with more ground cover (Figure 5.2). *G. nanus* continued using areas with more number of hummocks and higher vegetation height. Since with increase in vegetation the soil compactness increases, one finds *G. nanus* using areas having more compact soil. The naked sole of *G. nanus* probably restricts the animal from using areas having loose sand, hence restricting its movement to compact areas. The hairy soles allows *G. gleadowi* (hence called Hairy Footed Gerbil) to live and burrow in sandy habitats (Roberts 1977). It also possibly helps the animal to distribute its body weight (Nowell and Jackson 1996), hence the species can cover much wider areas on sand.

One thing is clear that during both the seasons there is a substantial amount of overlap between the two species. The overlaps are probably more during summer as the annuals dry and wither away. More overlap should indicate less competition. If the two species had been competing heavily, they would have had separate, non overlapping niches. Before considering competition, one needs to actually quantify the resources. The resources may be allocated to the coexisting species according to intrinsic (size and shape) or extrinsic (distribution in space and time) properties (Brown and Liberman 1973).

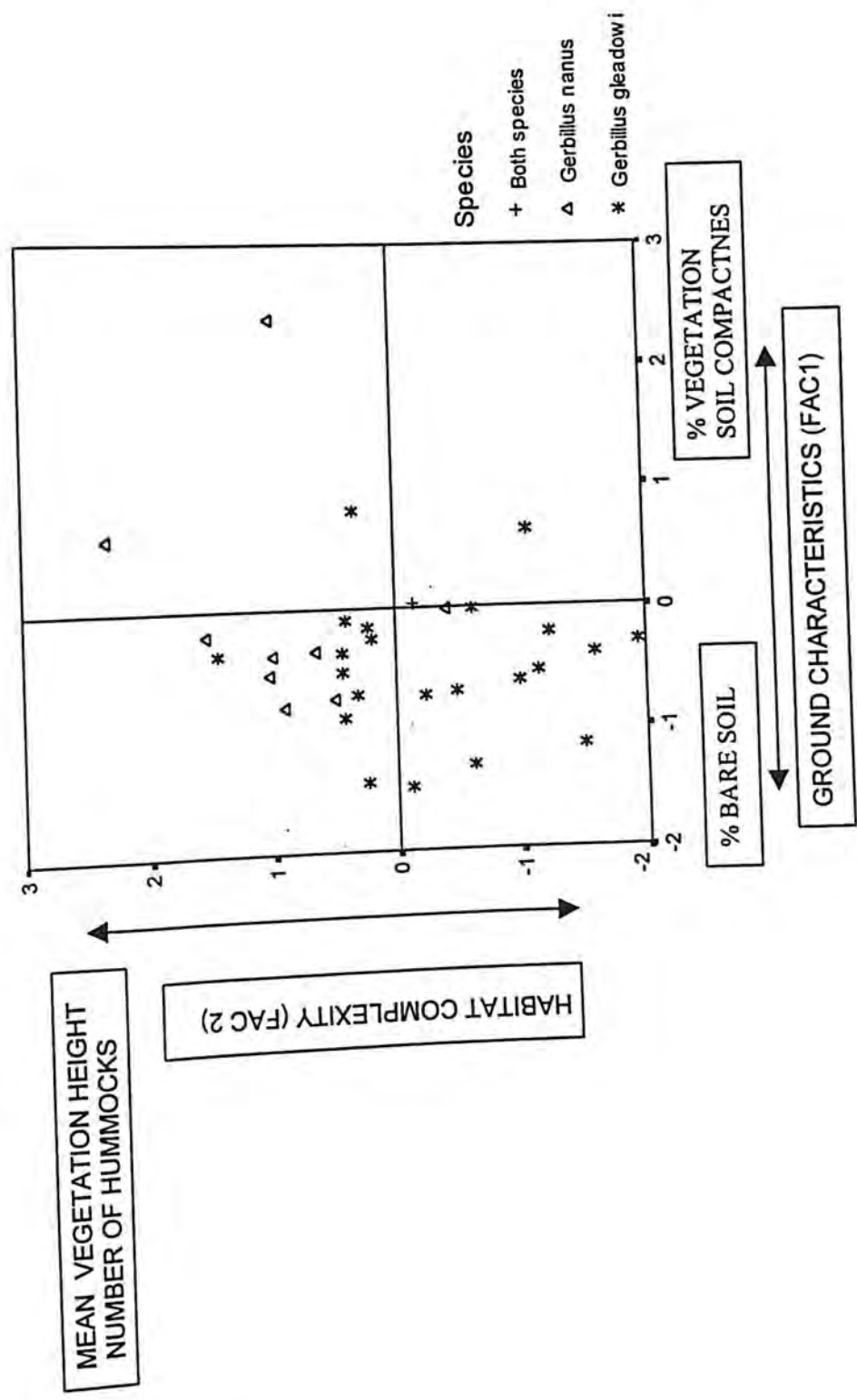
Figure 5.1: ORDINATION OF MICROHABITAT USE BY *G. gleadowi* AND *G. nanus* IN STABILISED DUNE AND INTERDUNE DURING WINTER.



In order to check whether competition occurs or not, one first need to find out if at all the two species subdivide their resources. The food and space are two most important resources required any animal. Detailed studies on food habit and ranging patterns during different seasons will give us an insight about the important food items and sites to be sampled. Though for this present study I had considered hummocks and *Capparis decidua* to be the important for rodent burrow, other studies have shown that *G. gleadowi* also prefers to burrow under bushes like *Calotropis procera*, *Zizypus numularia*, and *Aerva psedotomentosa* (Prakash 1977). In such situations it becomes difficult to select and quantify all these variables, hence one may need to select different plants at different sites depending on the places where the burrows are found. One good method could be to try out track plot in front of burrows and to see whether a species prefers any particular species of bush for its burrow site.

The low relative abundance of *G. nanus* in the Interdune could be because of lower number of hummocks and possibly heavy grazing pressure. Grazing makes the top soil loose and hence may be hindering the movement of this naked soled rodent. As seen earlier, *G. nanus* seems to use areas with relatively more compact soil. These could be the possible reason for its low abundance in the Interdune.

Figure 5.2: ORDINATION OF MICROHABITAT USE BY *G. gladowi* AND *G. nanus* IN STABILISED DUNE AND INTERDUNE DURING WINTER.



5.2 Habitat loss of *M. hurrianae*

Very few individuals and burrows of *Meriones hurrianae* were sighted in the Interdune. During this study I found the Desert Gerbil and its burrows to be associated with *Capparis decidua* tree. Within the four square kilometer intensive study area, only the sampled Interdunal site had around 20 *Capparis decidua* trees within 2500m² area and hence I had the maximum sightings of burrows within this area. Very few *Capparis decidua* tree remain in the study area as the villagers use them as poles for construction of their houses. With the loss of *C. decidua* tree this, species is loosing its burrow sites and hence becoming locally extinct. *G. gleadowi* is superior in tiding over acute droughts because of its ability to consume halophytes and its efficient renal system. During such extreme conditions it is known to replace species like *Tatera indica* and *M. hurrianae* (Prakash 1981, 1996). If the same trend of removal of *C. decidua* continues, *G. gleadowi* might replace *M. hurrianae* in the study area. Since there were very few sightings of *M. hurrianae*, no statistical comparison of microhabitat could be done with *G. gleadowi*.

5.3 Increase in niche space of *G. gleadowi* during summer

Seeds and granivores form an important component of the desert system (Brown *et al.* 1986). The primary productivity in the desert is limited by water and within this ecosystem the annual plants (primary producers) contribute a major segment of the productivity of the habitat since they can complete their life cycle within a brief period, when moisture is available (Brown *et al.* 1986). The success and failure of reproduction in the desert rodents has been found to correlate with the presence and absence of these winter annuals in the environment (Beatley 1969).

When one interprets the niche dimension of *G. gleadowi* from the Factor analysis results (Figure 4.5) a very interesting picture emerges. The winter niche dimension in the Stabilised dune was found nested within its summer niche space. During summer the species was found to use areas having relatively higher vegetation cover. They also showed a preference for areas having higher percentage of mature and young leaves. Because of a few short spells of rain in March, fresh shoots of *Panicum turgidum*, *Lasiurus indicus*, *Crotolaria burhia* and *Dipterygium glaucum* were available. The above pattern is quite similar to that observed by Prakash (1981) in *M. hurrianae*.

Insects form a major part of the diet of *M. hurrianae* only in summer (Prakash 1977) while for *G. gleadowi* it is a major part of their diet throughout the year (Roberts 1977). Since with the advent of summer the number of locusts and beetles also increases, the species may be ranging more to predate on them. During this study the insect availability could not be quantified. Further studies are required to look at the proportion, insects occur in their diet during different seasons. It is quite unlikely that the increase is because of addition of young ones to the population since the species litters sometime between May- June.

In order to confirm the increase in space use during summer, one could toe clip a few individuals and assign each a particular toe code. Then track plots can be made at different distances from the place where the toe clipped rodent was released. The home ranges of these individuals for both the seasons can be calculated by identifying each individual from their toe impressions on the track plots. Radio telemetry methods will be of great use if one is interested in finding out areas where the spends most of its time. Only then can one try and answer the question why that particular area is being used more. This will also help to check whether the seeds in the dunes are randomly distributed or clumped, thereby giving insights into patch use by the individual.

5.4 Conclusion

The present study shows *G. gleadowi* to be the most common species as it is found in all the three habitats. It uses areas with less ground cover, lower mean vegetation height and lower number of hummocks compared to *G. nanus*. It has also been found to use areas with loose/less compact soil.

G. nanus was restricted to Stabilised and interdunal area. It used areas with relatively more ground cover, higher mean vegetation height and more number of hummocks. It was also found using areas with more compact soil. Its relative abundance was found to be more in the Stabilised dune possibly because of higher vegetation, more compact soil and relatively less disturbed compared to the interdunal area.

As expected, there was an increase in the niche dimension of *G. gleadowi* during summer. Due to scarcity of food resource during summer the species was found to use areas with more vegetation, probably in order to feed on stems, rhizomes or insects. More studies

on the food habits, patch use and ranging pattern of *G. gleadowi* and *G. nanus* is required in the near future.

M. hurrianae was found only in the interdunal area. It showed a strict association with *C. decidua* tree as its burrows were situated under them. Due to collection of *C. decidua* wood by the villagers for construction of their houses, very few trees are left in the area. This species may be getting locally extinct because of anthropogenic pressure.

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APPENDIX 1: Mean \pm Standard error for all microhabitat variables

	Habitat	Mean Vegetation Height	% Bare Soil	% Vegetation	% Dung	Density	Distance from nearest Mound	Distance from nearest <i>Capparis</i> or <i>Calotropis</i>	Number of Mounds
Winter	Stabilised dune	25.04 \pm 0.80	84.32 \pm 2.10	15.54 \pm 2.03	0.14 \pm 0.14	53.78 \pm 2.61	2.08 \pm 0.08	4.00 \pm 0.00	19.76 \pm 1.27
	Barren Dune	12.85 \pm 2.05	100.00 \pm 0.00	0.00 \pm 0.00	0.00 \pm 0	13.48 \pm 4.44	6.00 \pm 0	3.98 \pm 0.03	0.00 \pm 0
	Inter Dune	12.04 \pm 0.56	85.34 \pm 1.79	14.48 \pm 1.76	0.17 \pm 0.17	47.59 \pm 4.91	3.59 \pm 0.37	3.55 \pm 0.15	19.83 \pm 2.28
Summer	Stabilised dune	23.53 \pm 0.46	92.46 \pm 0.90	7.46 \pm 0.90	0.08 \pm 0.08	50.17 \pm 1.73	2.11 \pm 0.07	4.00 \pm 0	18.17 \pm 0.93
	Barren Dune	12.21 \pm 1.93	99.77 \pm 0.17	0.23 \pm 0.17	0.00 \pm	7.97 \pm 2.53	6.00 \pm 0	3.98 \pm 0.02	0.00 \pm 0
	Inter Dune	14.26 \pm 0.67	87.92 \pm 1.88	12.08 \pm 1.88	0.00 \pm 0	43.33 \pm 3.77	2.25 \pm 0.20	3.39 \pm 0.14	22.62 \pm 1.89

	Habitat	Number of Hummocks	Soil compactness	% Bud stage	% Flower	% Fruit	% No leaves	% young leaves	% mature
Winter	Stabilised dune	4.43 \pm 0.51	3.31 \pm 0.52	0.03 \pm 0.01	0.06 \pm 0.02	0.12 \pm 0.02	0.11 \pm 0.03	0.06 \pm 0.02	0.26 \pm 0.06
	Barren Dune	0.00 \pm 0	0.71 \pm 0.33	0.00 \pm 0	0.00 \pm 0	0.06 \pm 0.04	0.14 \pm 0.07	0.10 \pm 0.06	0.01 \pm 0.01
	Inter Dune	1.18 \pm 0.08	3.91 \pm 0.63	0.00 \pm 0.00	0.00 \pm 0	0.04 \pm 0.01	0.02 \pm 0.01	0.01 \pm 0.01	0.07 \pm 0.01
Summer	Stabilised dune	4.70 \pm 0.39	2.40 \pm 0.37	0.01 \pm 0	0.00 \pm 0	0.08 \pm 0.03	0.05 \pm 0.01	0.06 \pm 0.03	0.07 \pm 0.01
	Barren Dune	0.00 \pm 0	0.61 \pm 0.25	0.03 \pm 0.01	0.03 \pm 0.01	0.05 \pm 0.03	0.04 \pm 0.02	0.07 \pm 0.03	0.06 \pm 0.03
	Inter Dune	1.19 \pm 0.07	3.91 \pm 0.59	0.01 \pm 0.1	0.00 \pm 0	0.02 \pm 0.01	0.02 \pm 0.01	0.09 \pm 0.02	0.12 \pm 0.03

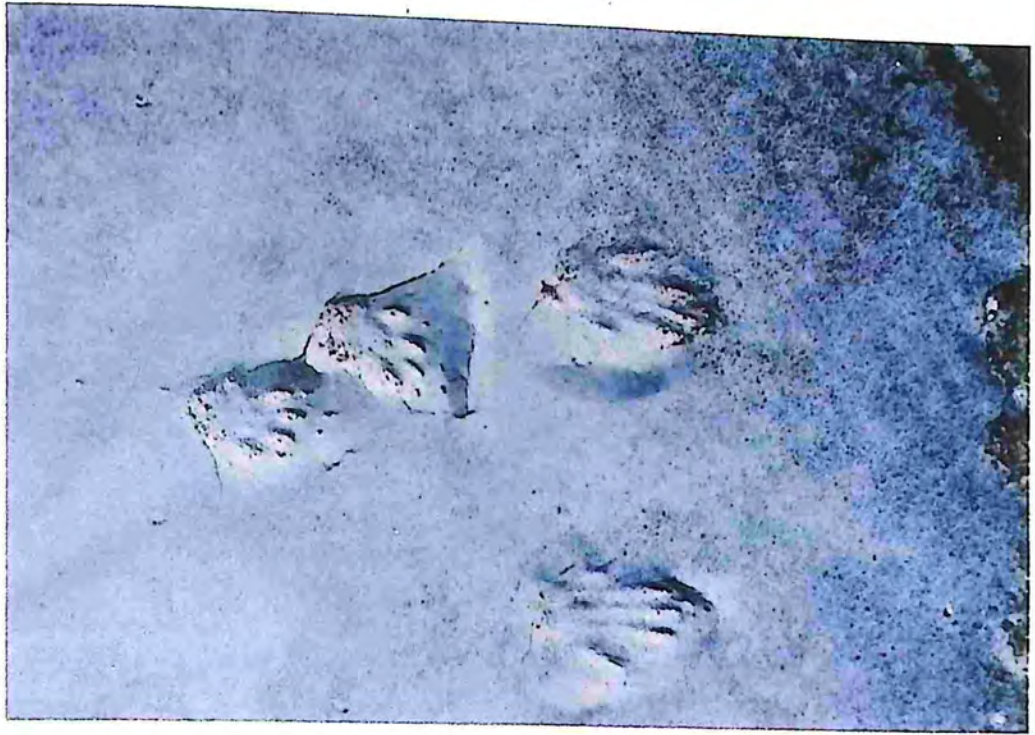


Figure 4.1: Tracks of *G. gladowi* (Left- Fore foot, Right – Hind foot)



Figure 4.2: Tracks of *G. nanus* (Left- Fore foot, Right – Hind foot)