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Social organization and determinants of spatial distribution of Khur (*Equus hemionus khur*)

N. Shah & Q. Qureshi

Abstract

Khur (*Equus hemionus khur*) is an endangered species for the most part restricted in little Rann of Kutch (India) and surrounding areas. We investigated factors influencing spatial distribution and social organization of Khur. The spatial distribution is largely influenced by distribution of food patches and water in this ecosystem. The inter group distances were smaller in resource rich areas in comparison to resource poor areas ($p = 0.017$). The group sizes are larger in areas having higher productivity ($r = 0.85$) and rainfall ($r = 0.88$). Four social units are observed in Khur (a) Family group (median = 17), (b) All male group (median = 17), (c) Territorial stallion and (d) displaced stallion. The family group and all male group are very fluid showing fission and fusion in group sizes (CV = 73 % to 63 % respectively). The maximum home range overlap was between family group and territorial stallion. The territorial stallion defends water sources, productive grassland and scrubland. Khur's social organization is territorial harem owing to high predictive availability of resources in space and time and mares preference for areas having good resources.

Key words: Khur, India, ecological resources, group size, social organization

Introduction

The Khur (*Equus hemionus khur*) was once widespread in western arid landscape of Indian sub-continent is now restricted to Rann of Kutch in India (SPILLET 1968, GROVES 1974, DUNCAN 1992, SHAH 1993, ROBERTS 1997) (fig. 1). The Rann of Kutch is described as "a desolate area, sun baked, saline clay desert, shimmering with the images of a perpetual mirage" (WIKRAMANAYAKE et al. 2002). This endangered species is listed in schedule I of India's Wildlife Protection Act (1972) and Endangered category of IUCN. The Khur population was estimated to be 4000 in 1946 (Ali, 1946) which declined to 700 in early 1970s due to disease (Surra) and consecutive severe droughts (GEE 1963, SHAH 1993, Forest Department Records). Since then population have shown increasing trend, 720 in 1976 to 4000 in 2004 (SHAH 1993, SHAH 2004, Forest Department Records). The protection of Wild Ass habitat in form of Sanctuary (22° 55' N to 24° 35' N and 70° 30' E to 71° 45' E) (1973), helped build-up the population. Khur's distribution range is expanding (fig.1) with increase in Population (SHAH 1993).

Dry land farming, salt works and seasonal fishing are main occupations of people of the region; about 22 percent of India's salt is produced here (SHAH 1993, SINHA 1993). The change in economic scenario in the region is largely attributed to increase in human population thereby also accelerating the resource requirement leading to changes in land use from dry land farming to irrigation. The perception of people towards Khur and other wildlife has also changed over time. Rann of Kutch Sanctuary is almost surrounded by Narmada Canal, which was built to provide water for drinking and irrigation (GOYAL et al. 1999). Livestock graze in this area throughout the year. Maximum livestock density is reached during monsoon (mid-June - September) due to the arrival of migratory livestock in the area. The salt mining and the transportation of the salt (uncontrolled vehicular movement) in this area affect the habitat conditions. The ecologically insensitive changes in landscape configuration, increasing Khur population and agricultural crop depredation by wild animals have made conservation in the region challenging.

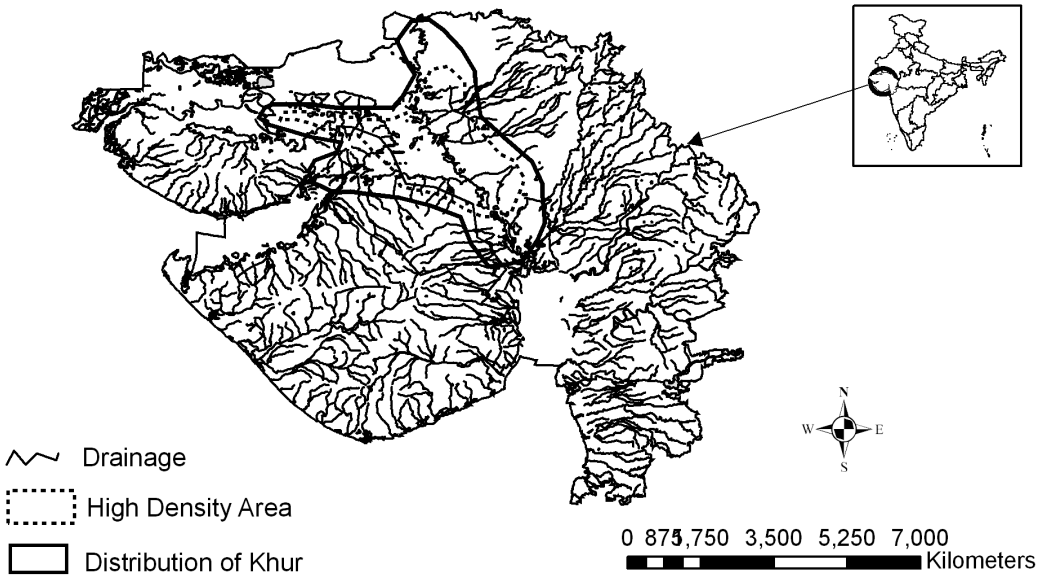

Fig 1: Distribution of Khur (*Equuus hemionus khur*) in India.

The Khur studies have largely confined to status assessment (ALI 1946, GEE1963, Forest Department Records). We have been working on Khur ecology and conservation since 1989 (SHAH 1993, 1996, 1998, 1999, 2004, SINHA 1993, PRASAD et al 1994, GOYAl et al. 1999). The main aim of this study was to assess the factors responsible for Khur habitat occupancy and social organization.

Methods

The vegetation map was prepared using LANDSAT (1999, 30m pixel, GLCF website). The satellite data was geo-rectified to maximum of one pixel RMS (Rest Mean Square) error. The unsupervised and supervised, hybrid classification procedures were used for vegetation analysis. The vegetation maps of MEHER HOMJI (1972) and PATEL (1999) were used for evaluating vegetation types. Monthly Normalized Difference Vegetation Index (NDVI) values of AVHRR (1 km Pixel) were used to evaluate the seasonal variability in forage availability. The climate data pertaining to temperature and precipitation was adopted from NEW et al. (2002), records of Nimaknagar bromine plant and records of the five districts surrounding the sanctuary.

The Khur distribution data was collected from 1989 to 2004 (SHAH 1993, 1996, 1999). The detail habitat use information was collected at two levels (a) extensive habitat occupancy: the entire sanctuary and area within 5 km was covered, by 636 km of foot transect and 1250 km of vehicle transects. The location of groups and vegetation type was mapped on 1:50,000 scale map, group structure was also recorded (SHAH 1993) (b) Intensive habitat use by radio collared, identified individuals and groups; Two mares were radio collared, five stallions were individually identified and monitored for 3 years. The vegetation information for habitat availability was extracted from vegetation map and random versus used plots (10 m radius) (SHAH 1993).

The activity pattern and social organization data is based on scan and focal sampling method (ALTMAN1974). Total of 1347 hours/year of data was collected on mixed group, all male group

and stallions using spotting scope and binoculars. Collared mares were monitored for 24 hours twice every month for two years (SHAH 1993).

The vegetation mapping and spatial analysis was done using ERDAS Imagine 8.0, IDRISI KILIMANJARO and ARC View 3.2. The statistical analysis was done using SPSS 8 and S-Plus 4. The determinants of spatial occupancy, movement pattern, group structure were analyzed using regression tree method, hierarchical cluster analysis, parametric and nonparametric ANOVA, parametric and non parametric measures of correlations, t-test, Z-test and chi-square analysis (SOKAL & ROHLF 1981, ZAR 1984).

Results

Habitat Occupancy

The spatial distributions of Wild Ass groups were influenced by productivity of habitat. Three distinct resource clusters were identified in the landscape by hierarchical cluster analyses that were found to be significantly different ($p = 0.05$) (fig. 2, 3). Regression tree identified three distinct clusters; Group I (resource rich) having NDVI greater than 123 and average precipitation greater than 47 mm in the month of June, Group II (medium resource) having NDVI value less than 123 and Group III (Poor resource) having low NDVI and rainfall less than 47 mm in the month of June (fig. 2, 3). Wild Ass group sizes showed strong association with NDVI ($r= 0.85$) and Rainfall ($r = 0.88$). The inter group distance also indicate significant difference between three grades of resources, namely resource rich, medium and poor ($F = 4.5$, $p = 0.017$, table 1). Resource rich and poor areas showed different growth rates, 5.8 % and 4.2 % per annum respectively (fig. 4).

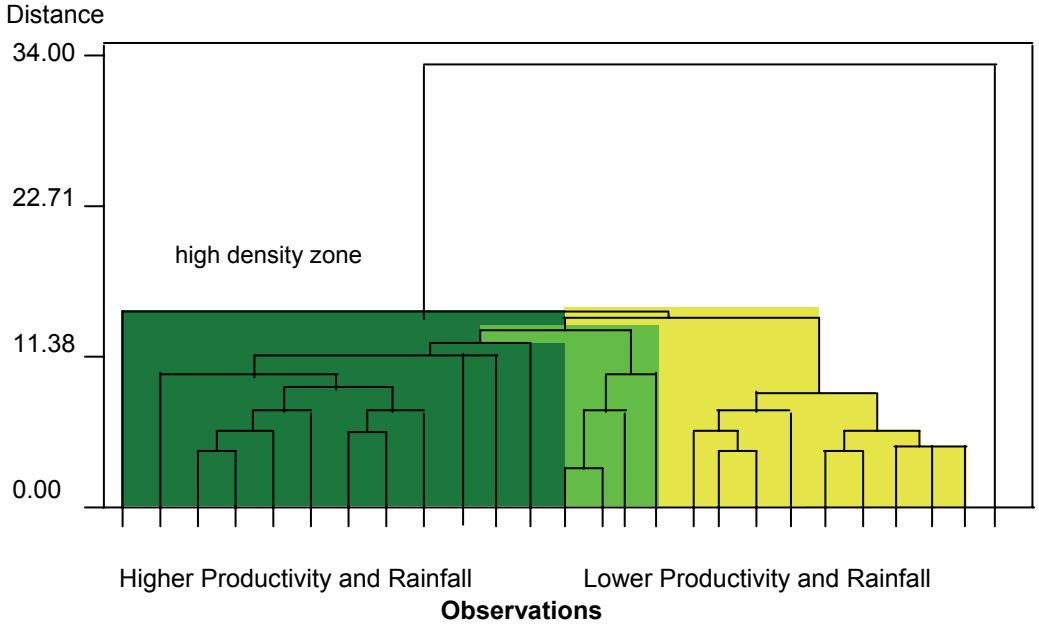

Fig. 2: Cluster of Khur groups indicating productivity (NDVI) and rainfall gradient responsible for three distinct spatial units, resource rich (dark green), medium (light green), and poor (yellow) ($p = 0.05$).

The mean daily movement of different social units differed within each season (F = 20, p = 0.001, table 2). Dominant stallion had maximum movement while family group had the least movement (table 2). The dominant stallion showed decrease in diurnal feeding time during breeding season (10%), with no difference observed in feeding and moving activities in family group and all male groups. The summer movement was found to be influenced by preceding year's rainfall (r = -1, P = 0.001).

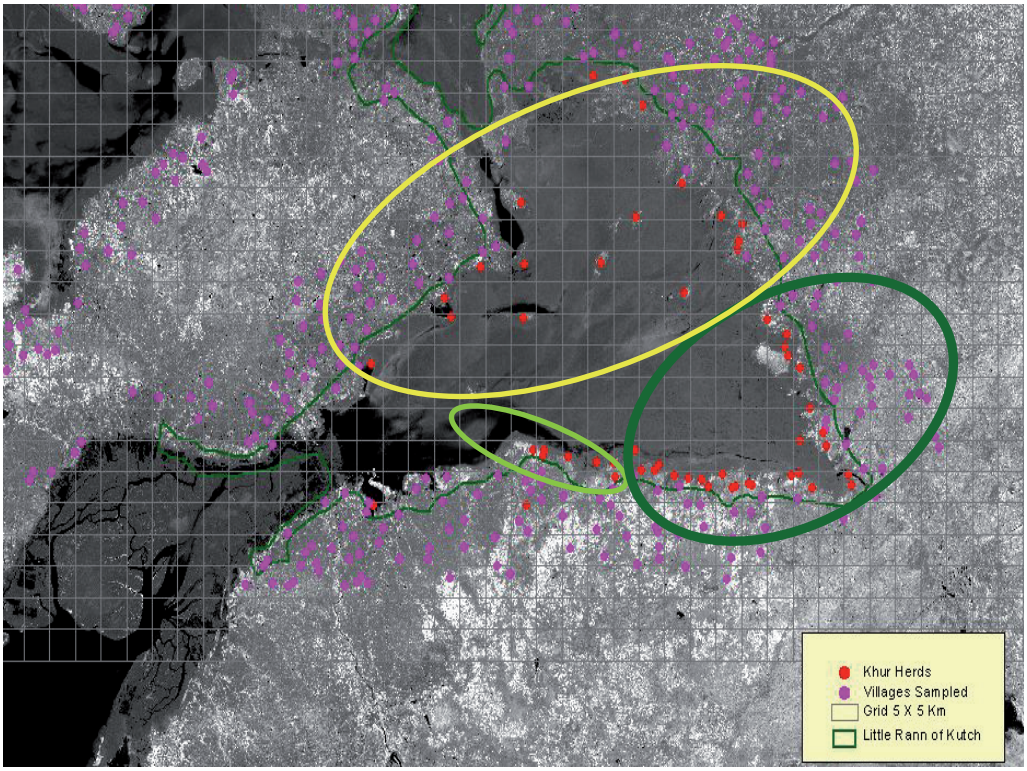

Fig. 3: Distribution pattern of wild ass herds in three resource types, (a) resource rich (dark green), (b) medium resource (light green) and poor resource (yellow).

Social Organisation

Four social units were observed in wild ass: family groups (median = 14, range 1 to 129), all male groups (median = 17, range 7 to 24), dominant stallions and displaced stallions (fig. 5). The adult sex ratio was 51 males per 100 females, while foal sex ratio was found to be equal. Rainfall and resources play an important role in the mare conception and foal recruitment into the Khur population. The year following good rainfall and high productivity recorded higher foal to female ratio. The intensively monitored groups also indicated seasonal variation in group size and structure (K-W = 135, p = 0.001). The normal monsoon and drought period showed marked differences amongst group sizes (table 3).

The family groups and all male groups are very fluid showing high variability in group sizes due to fission and fusion, the Coefficient of Variation (CV) was 73 % and 63 % respectively. The mean CV in resource rich and resource poor areas do not show any difference (t = 0.39, p = 0.69).

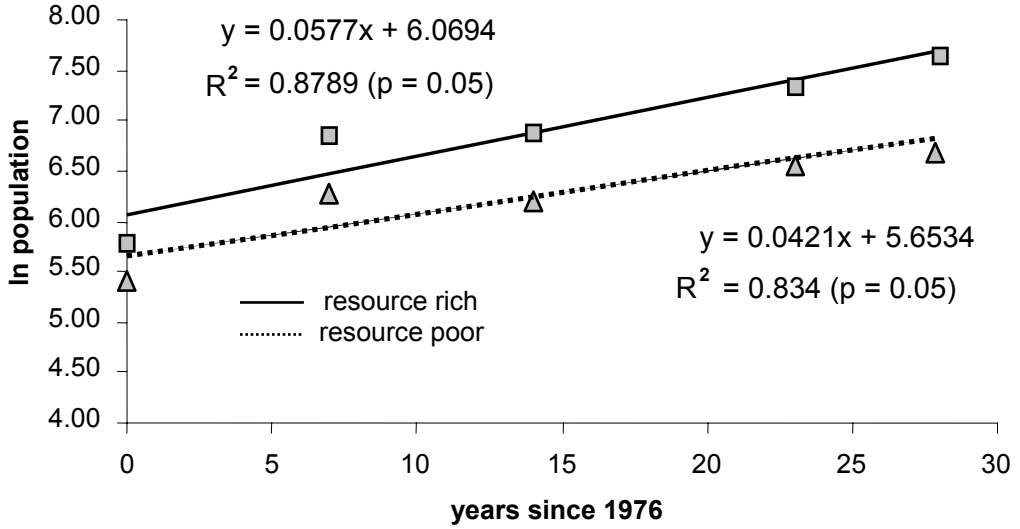

Fig. 4: The population growth rate in resource rich and poor area of Little Rann of Kutch.

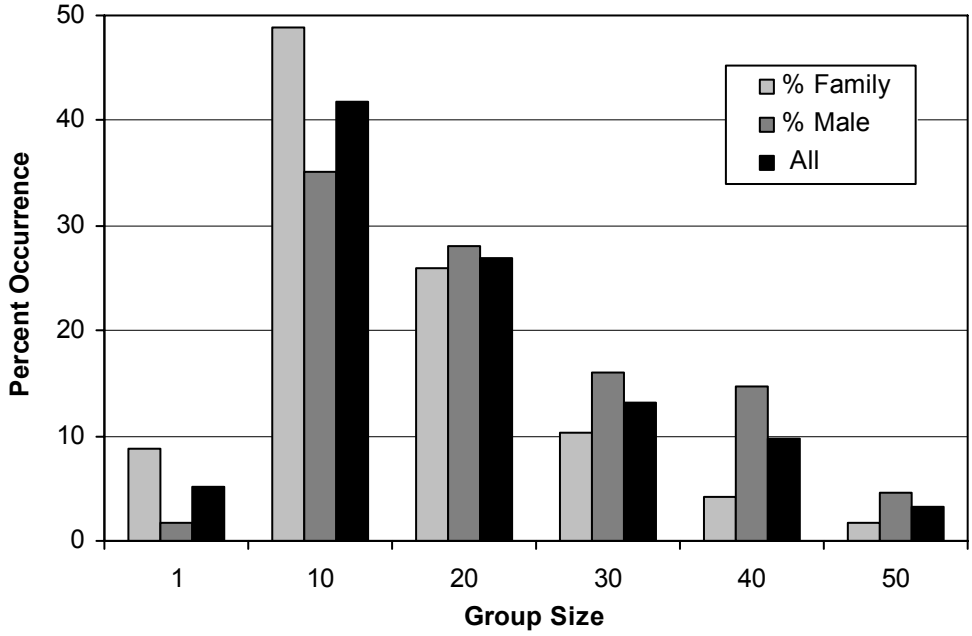

Fig. 5: The percent occurrence of group sizes of Khur female groups, males and both sexes together (All).

The annual composite home range of family groups was 20 km^2, all male groups 19 km^2, stallions 8 km^2 and displaced stallions 9 km^2. The maximum home range overlap was between family group and dominant stallion (28 %). The dominant stallion showed no overlaps with all male groups, he shared the marginal habitat of the displaced male (25 %). In breeding season

all male groups have largest composite home range (13 km^2) while displaced stallion had smallest range (2 km^2). Two dominant stallions monitored intensively had exclusive territories with good productive grassland and water body. During good rainfall years there was significant difference in association of dominant stallion with family group (Z = 5, P = 0.001) but no difference was observed during drought years (Z = 2, P > 0.05). The two dominant stallions (Kharmore and Bandio) maintained year round territories.

Table 1: Inter herd distance of Khur in areas having different resource conditions

Resource	Mean distance (km)	SE
rich	6.5	0.5
medium	8.2	1.7
poor	10.7	1.3
overall	**8.6**	**0.7**

Table 2: Seasonal mean diurnal daily movement of different social units of Khur

Social unit	Mean daily movement (km)		
	summer	mosoon	winter
Family band MH	4.5	3.9	4.5
Stallion KM	7.7	10.5	8.6
Displaced stallion JJ	6.5	4.5	6.4
Bachelor herd BH	6.4	5.3	4.4

In summer which is resource poor and non breeding season family group and dominant stallion have shown 80 % overlap. Maximum home range size was of all male groups (11.3 km^2) and dominant stallion covered least (4.1 km^2) area. Family group showed fluid group structure but were fiddle to their site and overlapped their range with one or more stallion. Wild ass groups showed remarkable fidelity in seasonal use of home ranges.

Discussion

The study aimed at factors influencing the distribution pattern and social organization of wild ass in Little Rann of Kutch; the salt mudflat. Khur population is largely confined to fringes of salt encrusted desert with small numbers distributed on various islands or *bets*. The vegetation is largely xerophytic, and habitat can be classified into grassland largely dominated by annuals with mesic areas having perennials, scrubland largely comprising of exotic *Prosopis juliflora* and native *Prosopis cineraria, Salvadora* spp*, Acacia* spp*., Sueda* and *Zizyphus* , barren Rann (saline mudflat) fallow land and cropfields. The principal crops grown in this area are pearl millet, sorghum, cotton, groundnut, castor, sesame, and wheat (GHOSH 1991).

The precipitation is seasonal with 90 % of it being confined between June and September. Annual rainfall ranges between 250 to 500 mm occasional highs of as much as 1200 mm has been recorded (GHOSH 1991, Shah 1993). In monsoon the landscape gets inundated (0.5 to 1 m in depth) due to sea water ingress and several seasonal rivers emptying in the low lying salt desert (SHAH 1993, SINGH et al. 1999). The southern and eastern part of Sanctuary receives higher rainfall and is also more productive.

Rann experiences periodical droughts once in four to five years and occasional drought periods lasting for two to three years (GHOSH 1991, SHAH1993, SINGH et al. 1999). Rains are largely source for surface water in ponds and pools during monsoon, which lasts till winter. During the resource crunch period in summer water is available either in village ponds, irrigated crop fields and water holes maintained by the wild ass sanctuary management. Sanctuary Management does food and water provisioning during drought years.

Rann is relatively free from large predators; there are records of Lion and Cheetah occupying this area in early 1800 (SINH 1995). Cheetahs were occasionally sighted in 1878, while lions were holding precariously till middle of 19th century (SINH 2005). Lion was the only large predator that could significantly prey upon Khur but their population in historical past was always low. The only other potential predators on Khur foals are wolf and jackal but no incidence of predation was recorded, although a few reports do exist. Few incidences of feral dogs attempting to kill foal was observed as well as reported by shepherds. The extent of predation is too low to exert any pressure on Khur population. Presently is largely a predator free system.

The distribution pattern of wild ass at macro level is influenced by the productivity of habitat and availability of water (fig. 2, 3 and tables 1, 2). There exists a very strong element of human and wild ass co-existence in the case of the Khur unlike the other species of the wild ass in Asia. The wild ass population density is the largest (fig. 3) in southern fringe and parts of eastern fringe. Groups were more closely packed (tables 1, 2; fig. 3) due to high productivity in these areas. The group spacing is more in medium and low resource productivity areas (fig. 3, table 2). The inter group distance is a response to availability of forage and water. The 70% of Khur population is found in southern and eastern part of the landscape that has high productivity and rest was found in low productivity northern and western fringes. The southern part (fig. 3) is also rich in agriculture productivity as part of crop fields are irrigated while in north and parts of eastern fringes largely rain fed agriculture is practiced and is less productive.

Four social units namely family group, stallion, all male group and displaced stallion were observed in the Khur which is similar to the other hemione species (KLINGEL 1977, GINSBERG 1988, MOEHLMAN 1998, FEH et al. 2001). In Rann of Kutch the movement pattern of each one of these four social units differed from each other in each season (table 2). There was no difference in the movement patterns of each social unit across different seasons. Family group moved less (table 2) and are largely centred on water holes. Wild ass need to drink water at least once in a day and are thus tightly bound to availability of water (STUBBE et al. 2005). Lactating mares make more frequent trips to water and spend more time drinking on these trips (GINSBERG 1988). Stallions had maximum movement (table 2) and significant decrease in diurnal feeding time (10 %) during breeding season was observed as they were involved in herding family group, attending to oestrous mares and defending territory against intruding males. Ginsberg (1988) observed lactating and pregnant Grevy's zebra mares using productive areas more than expected. Stallions show variation in movement largely due to territorial defence during breeding season. Preceding year's rainfall influences the movements of all social units. Increase in rainfall cause decrease in following summers movement pattern largely to acquire food and water.

The group size of family group and all male groups are very fluid with frequent group fission and fusion. Family group sizes are maximum in monsoon (median 17) which is resource rich breeding period followed by winter (median = 8) and resource poor summer (median = 5). The all male group are more inconsistent with smaller group size during monsoon (median = 13). KLINGEL (1998) observed 60 % of group size of Asiatic wild ass range between 2 to 20, with irregular fission and fusion (fig. 5, table 3). The family group largely restricted within 1.5 to 2 km from water holes with pronounced variation in group sizes. All male groups respond to resource depletion by having high variability in group sizes, despite it their groups are larger in size than that of family groups.

Table 3: Co-efficient of variation in group sizes between different seasons and drought year

% CV	Normal rainfall			drought		
Family band	summer	monsoon	winter	summer	monsoon	winter
Resource rich	64	56	73	73	143	69
Resource poor			74	112	141	102

The only long lasting social association is between foal and mother (KLINGEL 1972, 1977, 1998; MOEHLMAN 1974, 1998; FEH et al. 2001). In Rann of Kutch, high spatial fidelity has been observed in the *Khur* groups. The individuals of family group are fiddle to their site; though the group's structure is fluid the membership of group is consistent. Females do move between groups. One of the radio-collared mares moved 20 km away from her original group and had joined another group.

The intensively studied social units in southern fringe indicate high overlap of stallions Kharmore and Bandio with family group. During breeding season maximum range overlap was observed between family group and stallion (28 %) and least with all male groups (7%). The stallions have least overlap with displaced stallion and all male groups during breeding season. The displaced male occupied area between two stallion territories to which both stallions had an access. The area occupied by displaced stallion (Jhaka Jhumo) was once a part of his prime territory. The displaced male moved less in comparison to stallions.

All male groups moved less during resource rich monsoon season (breeding season). All male groups have least overlap with family group and stallions during breeding season. Their movement is inconsistent during winter and summer. PENZHORN (1982) and BERGER (1986) reported all male groups to range widely in comparison to breeding groups to gain knowledge of landscape and acquire resources. In non-breeding season, range overlap between all social units was comparatively large due to availability of water in stallion ranges. Stallions are less defensive of their territories during resource poor non breeding season. Khur showed remarkable fidelity in seasonal use of home range areas.

It was observed that dominant stallions occupied prime territories and less productive territories were held by young and displaced stallions. Territorial stallions soiled themselves with mud/slush during the breeding period, which could be a visual display. The stallion probably uses olfactory and visual markings like defecation and micturition on territory borders and other parts of its territory (KLINGEL 1977, 1998). Stallions were observed to keep watch on his group from vantage points. Stallion fights the male intruder and most of the time territory holder was a winner. The stallions displaced from prime territory tend to occupy part of their former range or occupy new area or wander around. The quality of territory seemed to be prime determinant of dominance amongst the stallions (fig. 6). Stallion herds the mares in his territory during breeding season and actively defends against intruding males. In all instances of herding of mares the stallion vocalized. In non-breeding season stallion defends his territory more than that of herding mares.

Mares choose areas having access to food and water and least harassment from males. Khur have gestation period of 11-12 months (MALHOTRA 1989, ASA 2002) and seasonal birth period with the peak in August. The long gestation period and simultaneous lactation and conception (pregnancy) have heavy energy demands on mares. To cope with energy requirements mares need access to productive areas and least disturbance in assimilation of food resources (fig. 6). The ecological pressures have more direct effect on mares than that of males. Mares are responding strongly to resource distribution and stallions are responding to female abundance and distribution (RUBENSTEIN 1986). The strategy of male territoriality will give lactating females access to resources needed to raise foals and maintenance of their own body condition. Males with access to water and maximum biomass attract post partum cycling females (GINSBERG 1988) (fig. 6, 7).

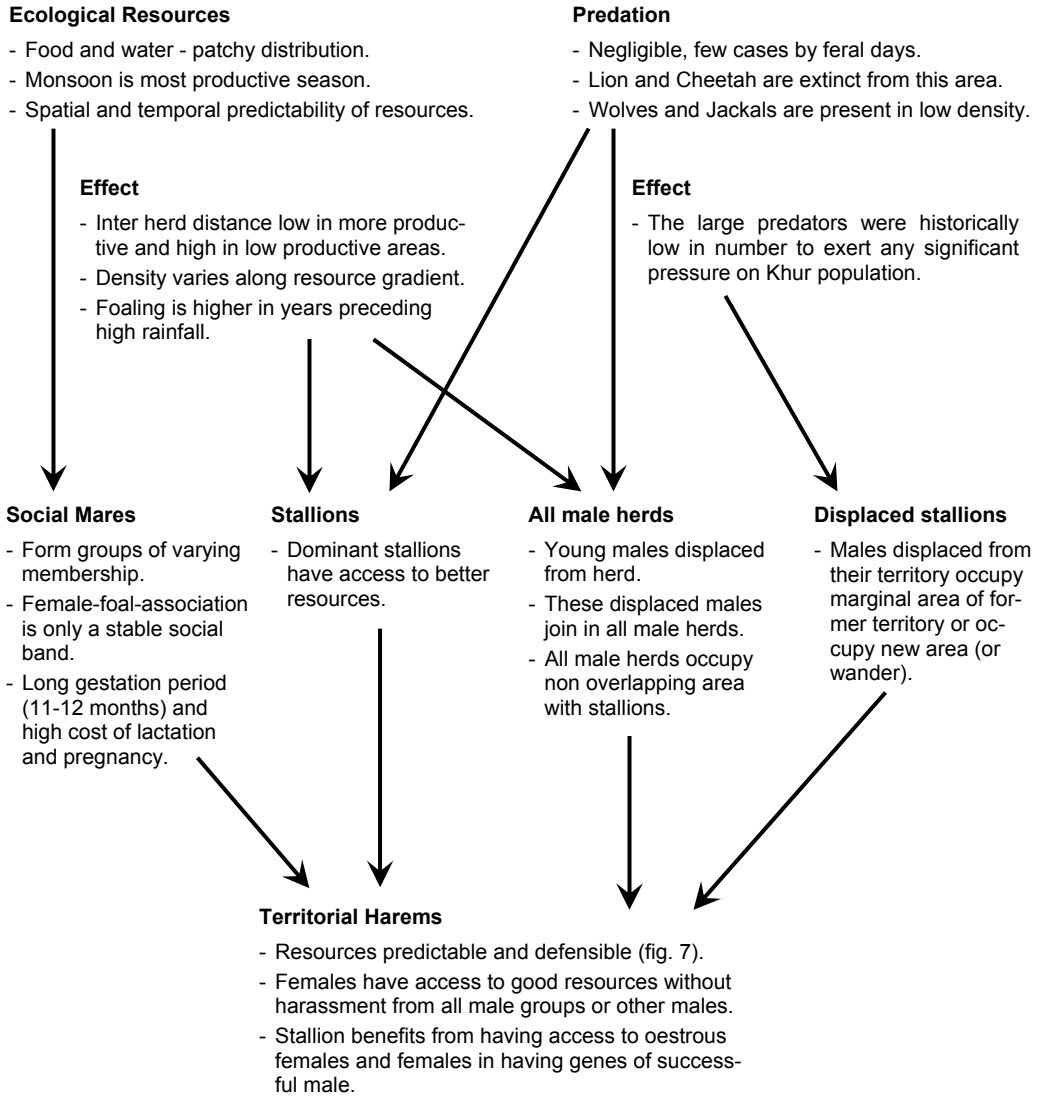

Fig. 6: Summary of factors seems responsible for social organization in Khur in Little Rann of Kutch.

On Wasraj bet social system is different in Khurs as stallions and family group move to this area in monsoon (breeding season) and seasonal territories were formed by stallions and they defend females during this time. After breeding season animals disperse from this area due to limited food and water availability. The spatially and temporally predictable resources in semi-arid environment can accrue advantage to stallion defending it and females choosing to benefit from it. The group living of family group and all male groups seemed to be in response to reduce competition for resources concentrated in large patches as predation pressure was negligible (JARMAN 1974, RUBENSTEIN 1978, 1986; CROOK et al. 1976).

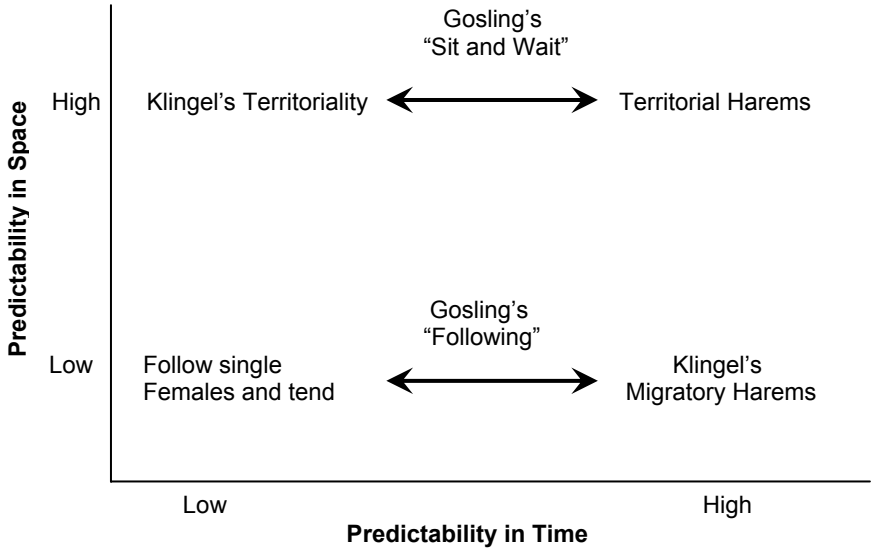

Fig 7: Summary of factors seems responsible for social organization in Khur in Little Rann of Kutch (adopted from GINSBERG 1988).

Five types of social organization is reported in equids, territorial males, migratory harems, harems with exclusive home ranges, territorial harem and males following individual females (GINSBERG 1988). The predictability of resource availability that in turn affects predictability in female movement will determine the social organization (KLINGEL 1975, GOSLING 1986, RUBENSTEIN 1986, GINSBERG 1988). The environment of Rann, ecology and social aspect of Khur dictate the best strategy adopted is territorial harem (fig. 6, 7).

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