Chapter - V

RANGING AND MOVEMENT PATTERN

INTRODUCTION

Knowledge of home range and seasonal movement is a basic requirement for the management of a species. Burt (1943) is credited with the first differentiation of home range and the territory of mammals. He defined home range as the " area traversed by the individual in its normal activities of food gathering, mating and caring for the young. Occasional sallies outside the area, perhaps exploratory in nature should not be considered as part of the home range".

Blair (1953) defined home range to include the total area covered in an animal's normal daily activities. Jewell (1966) further regarded a home range as an area with a certain productivity that met the energy requirements of the individual or group that occupied it. It therefore bore a relation to the density at which a given population existed. However, Smuts (1975), studying plains zebras *(Equus burchelli)* in the Kruger National Park, could not demonstrate a relationship between population density and home range size.

Several factors may govern the size and configuration of a home range. These include population density (Burt 1943; Stickel 1954; Robinette 1966), structure of the environment including season, topography (Robinette 1966; Burt 1966), patchiness of vegetation (Jewel 1966), social behaviour (i.e. mating behaviour and territoriality) (Stickel 1954; Calhoun and Casby 1958; Robinette 1966), heredity (Robinette 1966), diet (Grubb and Jewell 1974) and sexual and age-specific dimorphism (Seton 1909; Eisenberg 1966; Sanderson 1966; Fitch and Shirer 1970; Ralph and Pearson 1971;

Harestad and Bunnell 1981). The findings of Gill and Wolf (1975) and Davies and Houston (1981) indicate that in evolutionary terms, the size of home range or territory is determined by energy requirements and not *vice versa.* McNab (1963) stated that the size of the home range in mammals is determined by the rate of metabolism, "A large mammal has a larger home range than a small mammal, because it uses more energy and therefore, needs a greater area in which to find this energy".

Although a relationship is established between home range size and diet or some other variables such as body size, this does not necessarily solve the problem of which is cause and which the effect (Davies and Krebs,1978).

Generally home ranges are nonexclusive and overlapping. In contrast territories are non overlapping areas from which other individuals are actively excluded and the area becomes available for the sole use of an individual or a group. However the degree of "territoriality" varies enormously between species. In some there is almost complete overlap of home ranges (Brown 1963), while in others defence of areas and exclusion of conspecific is common. Although territoriality may be limited to a particular part of the home range, such as a mating area or feeding area (Kaufmann 1962), it can also encompass the entire home range.

Few studies on equine home range are available which are mainly from Africa and North America. The Asian wild ass are the least studied and to date the only information on the home range and territory of the Asiatic wild ass (*E.h. kulan*) is from U.S.S.R (Bannikov 1978).

As mentioned in Chapter I, one of the main aims of this study was to collect baseline information on the ranging pattern of the wild ass. This would also provide information on seasonal variation in the movement, ranging pattern of a dominant

stallion (KM) and an ostracized stallion (JJ), a family band (MH) and an all-male herd (BH).

The aim of collaring individuals from two different herds was to understand the 24 hour, ranging pattern and to see if there was any difference between the nocturnal and diurnal ranging patterns.

METHODS

The home range study was conducted between June 1989 to January 1992, covering all three seasons monsoon (July-October), winter (November-December) and summer (March-June).

Although radio collaring was included in the original plans of the project, delay in obtaining permissions for collaring adequate number of individuals postponed the telemetry study by a year. Consequently information on ranging patterns was collected by focal animal sampling and group scans in Narali, the intensive study area.

Focal animal sampling (0600 to 1800 hrs) was conducted on two stallions, a dominant male KM and an ostracized male JJ. Full day group scan (0600 to 1800 hrs) on a family band (MH) was conducted for two years and on all-male herd (BH), for a period of one year. These scans were conducted for three continuous days every month. The wild ass were followed on foot and in monsoon on camel back whenever required.

No specific time criteria was followed, as and when the wild ass moved, their movement was plotted onto a gridded (0.25 km^2) toposheet (Survey of India) of 1:50,000 scale for every scan day. The distance moved by the wild ass was calculated from the toposheet using the distance measurer. The whole day scans were considered

for calculation of average mean daily movements. A total of 115 scan day movements were plotted.

Locations of wild ass were plotted on to the 1:50,000 toposheet of the study area. Besides locations from the 115 scan day studies, incidental wild ass locations were obtained as and when the study area was covered. Locations obtained while doing surveys for population counts within the study area were also considered.

The home range was constructed by connecting the outer locations to form a convex polygon (Mohr,1947). The area of the home range was calculated using a planimeter. In all, three years cycle were worked for MH, two years for KM and one year cycle for BH and JJ.

Initially in 1989, 500m by 500m grids in the study area were marked by placing 4m high flag poles for identification.

Radio Collaring

It was decided to instrument six mares from six different herds. Monitoring them would provide information on ranging patterns of the entire herds and interactions between herds. Tranquillizing was mainly done on foot, a camel also was used for the same but was a futile effort. Dist.Inject Gun (Mod. 60N) with an orange charge (range of 60 to 70 m.) was mainly used to fire the darts.

The drug M99/immobilon was used for tranquillization and the dosage given was 1.5ml. The target area on the body was the rump. Once the tranquillized animal was located, parameters such as morphometric measurements, body-weight, body temperature were recorded. An attempt was made to age the animal. A colour activity collar was fitted around the neck. When the entire operation was over the drug

Revivon was injected (1.5 ml.) to reverse the effect of the tranquilliser. The entire procedure took approximately 30 minutes after the mare was darted .

Once the shot was fired the animals scattered in all directions and a team of 7 to 12 people would go in different directions to locate the darted animal. On the mudflats locating the animal was not a problem the visibility was good. However, in the scrubland it took over 30 minutes to locate the animal. Time for locating was crucial as the drug gets recycled within an hour in some cases (see section on problems below).

In all, 15 days were spent on the tranquillising operations and two mares were collared. One was fitted with a yellow collar in October, 1990 having a frequency of 151.050 MHZ and the other was fitted with a blue collar in April, 1991 having a frequency of 151.025 MHZ (Make - Telonics).

The animals were tracked using a unidirectional H-type and a Yaggi antenna, receivers (Telonics and Wildlife Inc.Instruments, Illinois) and a set of headphones (Plate V.1). On a flat terrain, a better range of reception was obtained by tying the antenna to a long bamboo pole (12 ft.).

The yellow collared mare was tracked for 15 months, during which 148 day and 92 night locations were plotted. The Blue collared mare (BC) (Plate V.2) was tracked for 10 months, and 148 day and 67 night locations were plotted. The locations were plotted on to a 1:50,000 toposheet of the study area.

Triangulation was difficult especially in the Rann with no topographical features. This was overcome by taking direct sightings by homing in at the collared mares. The night tracking was spaced out in such a way that over a month the locations were obtained for all the hours (1900 to 0600 Hrs) of the night.

Problems faced during tranquillising operations: One of the problems faced was locating the darted animal. As mentioned earlier the animals scattered in all directions and locating the animal within an hour was crucial. On one occasion a mare was darted from a vehicle on the mudflat but she ran into the scrubland and could not be located for 45 mins. By the time she was located the effect of the drug had worn off and the animal escaped. The Yellow collared mare was located two and a half hours after darting, the effect of the drug had not worn off and the procedure of collaring could be completed.

Home Range Estimation

The minimum convex polygon method (Mohr, 1947) defines an animal's home range by connecting the outermost location points on a map. It is the simplest and most conservative method, enclosing only the area the animal is known to have frequented (Hayne 1949; Jennrich and Turner 1969).

This method is used in other studies of zebras, burros (*Equus asinus*), feral ponies and horses (*Equus caballus*) so comparison of my results with those of other studies of Moehlman (1974), Woodward (1976), Norment and Douglas (1977), Seegmiller (1977), Morgart (1978), Dunn (1984) was possible.

The following tests were applied using a statistical package SPSS/PC (Norusis 1984). Spearman's rank correlation coefficient to test whether there was correlation between summer movement and the preceding year's rainfall. Paired t-test was used to compare the diurnal and nocturnal home range size of YC. One-Way ANOVA was run to compare the movement and home range within the seasons and amongst the family band MH, the dominant stallion KM, ostracized stallion JJ and the all-male herd BH. Duncan's Multiple Range Test was used for variation and comparison among

animals' movements. Two factor analysis of variance (ANOVA) without replication (Zar 1984) was applied to test the difference in home range size among years and seasons, among the wild ass groups.

RESULTS

Day Range Length

The availability of resources as well as occupancy of areas by different herds led to variation of the mean diurnal movement of the wild asses. Apart from this every wild ass herd had to restrict their movement within a limited available area thereby prevent overlapping into the areas of the adjoining bands. The main movement of the animals was from the vegetative zone to croplands/water holes and back through fixed paths/routes.

The daily movement for the family band ranged from 3.72 to 5.18 kms. in 1989, from 3.89 to 4.47 kms. in 1990. The distance moved by the all-male herd ranged from 4.37 to 6.41 kms. in 1990, for the dominant stallion it ranged from 7.65 to 10.5 kms. and for the ostracised stallion from 4.50 to 6.54 kms. in 1989-90 (Table V.1).

The mean daily movement showed significant difference within a season among different animals ($F=19.84$, $P=0.0001$). No variation was observed between seasons ($F=0.084$, $P=0.919$). There were no interactions between animals and seasons ($F=2.135$, $P=0.058$). A significant negative correlation was obtained in the summer mean daily movements of the family band with that of the preceding monsoon ($r_s = -1$, $P= 0.0001$, $n=3$). With increase in rainfall the movement reduced.

There was no significant difference in day range length ($F=1.85$, $df=3$, $P=0.164$) of various animals in summer. In winter there was a significant difference ($F=11.665$, $df=3$, $P=0.00001$) in the diurnal movement. The dominant stallion showed a significant

difference in movement (Duncan's range test, $P<0.05$) with that of the family band, ostracised stallion and all-male herd. The family band and ostracized stallion also showed a significant difference in their movement pattern ($F=11.574$, $df=3$, $P=0.001$) (Table V.1).

Family Band (Narali and Waghaki)-MH: In the years 1989 and 1991, the herd showed consistency in diurnal movement. Mares and young used a defined path and moved at a slow pace from morning to evening, consisting of straight lines/zig-zags/curves. Each day's trails more or less remained same during summer, monsoon and winter. Mean daily movement of the family band was less than the dominant stallion (KM) which herded the same family band (MH).

Dominant Stallion-KM: The movements of the dominant stallion showed no consistency (1989 winter-1990 monsoon). Each day's trail and distance was more or less the same during summer and winter. Day range length was larger in the monsoon. The breeding period coincided with the rainy season, and thus it constantly had to herd the family band. It often moved around its territory during the monsoon to keep other males from entering the area.

Ostracized Stallion-JJ: The ostracised male had a comparatively smaller day movement (1989 winter-1990 monsoon) than that of the dominant stallion. It occupied the Free zone area (an area accessible by any stallion or bachelor males). This zone was between the ranges of two dominant stallions KM and *Bandio*. Not much difference was observed in the ostracised male's movement in summer and winter. A larger movement was obtained in monsoon (though it was less than that of the dominant

stallion KM). Whenever mares from the dominant stallion KM moved out of KM's territory - the ostracized stallion would herd them for a short duration (few hours/days/hours).

All-Male Herd (BH) in Jesra: The all-male herd showed erratic movements in winter and summer. In monsoon it had a comparatively smaller day range length.

Home Range Size

Results for this was from the data collected from the scan studies and incidental sightings and also from monitoring the two collared mares. The yellow collared mare (YC) belonged to the family band (MH) of the intensively studied band in Narali. Blue collared mare (BC) was a member of the Koparni family band.

Seasonal Home Range: The home ranges of the family band (MH) ranged between 4.25 and 12.45 km^2 in 1989-90, between 5.55 and 8.49 kms^2 in 1990-91 and between 4.50 and 11.43 kms^2 in 1991-92 (Table V.2, Figures V.1 to V.3).

Home ranges of the dominant stallion KM ranged between 4.18 and 5.80 km^2 in 1989-90, between 5.16 and 5.34 kms^2 in 1990-91 and between 2.68 and 5.16 kms^2 in 1991-92. The range size of ostracized stallion JJ was between 1.83 and 7.08 kms^2 in 1989-90. The all-male group BH home range size was between 5.05 and 13.37 kms^2 in 1990-91 (Table V.2, Figures V.4 to V.6).

There was no variation among the home range sizes of wild ass groups within ($F=2.3959$ $df=3$, $P>0.05$) and amongst ($F=3.6012$, $df=2$, $P>0.05$) the seasons of 1989-90. There was no difference in the home range sizes among the years (1989-92) ($F=0.731$, $df=2$, $P>0.10$), although a significant difference was obtained for the seasons

(F=6.210, df=2, P<0.10) in the family band MH. No correlation was obtained in the summer ranges of the MH with that of the preceding monsoon rainfall (r_s=-0.5, P=0.333, n=3).

Home Range of Collared Mare (YC): YC had a deep wound due to the impact of the dart which had penetrated along her dorsal-line, it took the wound three months to heal. This could probably be the reason for her erratic movement. YC was also observed moving with the all-male herd for 15 days following tranquillization.

YC's range stabilized sometime in mid November 1990 and showed similarity to that of the family band range. In December 1990 she was not located in the family band range and was found in the Koparni range, 10kms from Narali. She returned to her Narali range after a fortnight.

Very few locations were obtained in 1990-91 for the winter day range of YC which thus was small (2.75 kms^2). The winter diurnal range was 4.56 sq.km, in 1991-92 this was nearly the same, as that of the family band home range 5.05 sq.kms.

YC's summer range was more or less similar to that of the family band. Monsoon range extended in E-W direction and was similar to that of the family band's monsoon range.

YC's and the family band's diurnal home range showed no significant difference in sizes for all three seasons (paired t=0.59, df=3, P=0.596; Table V.3, Figure V.7). This can be expected as YC was a member of the family band and would hence have a similar home range.

There was no difference in diurnal and nocturnal home range sizes (1990-92) of YC (paired t=1.51, df=3, P=0.229). 24 hour (night and day) range size of YC was significantly higher than that of diurnal home range size (paired t=6.19, df=3, P=0.009).

24 hour (night and day) ranges of YC was also significantly larger than the family band day home range (paired t=4.54, df=3, P=0.02) (Table V.2, Figure V.7). Consideration of day range alone, will underestimate the home range size.

Home Range of Blue Collared (BC): The adult mare BC (blue collar) was tranquillized in April 1991 in Koparni area, no immediate erratic movement was shown by her as had been observed in case of YC. BC remained with her herd for 3-4 months before she shifted her range to Narali (10 kms.) and then to Krishnanagadh (20 kms) (Figures V.9, V.10).

By the onset of monsoon, BC mare shifted her range from her resident herd in Koparni. BC's monsoon range in 1991 was in two parts; at the beginning of monsoon in July was 20.42 sq.kms. was between Kuda village and the Bromine factory's chimney (Figure V.9, Table V.3).

From August to October 1991 BC was in Nimaknagar-Narali-Waghaki areas (Figure V.9) where YC mare and her herd resided. The home range of BC in Narali (YC's range) was 10.78 sq.kms (Figure V.9, Table V.3). By the end of monsoon BC shifted her range further to East, in Krishnanagadh and Malwan area (Figure V.10, Table V.3). This shift was due to human disturbance as BC was chased by the people in the jeep on the 6th November 1991, and she joined the Krishnanagadh herd, which was the largest herd (n=53). Here the croplands were very close to the Rann, therefore accessible to the wild ass. BC was still a part of this large herd till January 1992 when the study ended.

Annual Home Ranges: The ranges and locations of the animals was within 2 to 3 kms radius from water sources. There was no relationship between daily movement and home range size (r_s=0.059, n=16, P=0.414).

Annual home ranges of the all-male herd (BH) was 18.57, dominant stallion (KM) was 8.0, ostracized stallion (JJ) was 8.77 and YC was 16.11 kms^2 (Table V.4, Figures V.4 to V.6). The annual range of the family band was 18.9 for 1989-90, was 15.88 in 1990-91 and was 16.10 kms^2 in 1991-92 (Table V.4, Figures V.1 to V.3).

The annual home range of BC mare was not calculated as her ranges shifted between and within the seasons (Figures V.9, V.10). The radio telemetric study commenced with BC as a member of the Koparni herd but later she was observed with the Krishnanagadh herd.

Home Range Overlap and Fidelity

The seasonal home range overlap of the family band, for 1989-90, 1990-91 and 1991-92 were 11.24%, 17.04% and 8.43% (Figures V.1 to V.3). The overlap of annual home ranges was maximum between the family band MH and the dominant stallion KM (27.25%) and least between the family band MH and all-male herd BH (7.17%).

Overlap between the ostracized stallion JJ and family band MH was 25.14% and between the ostracized stallion and dominant stallion was 25.43%. Maximum overlap was seen in the ranges of the ostracized stallion with the family band, YC and dominant stallion because their peripheral areas overlapped.

The ostracized stallion JJ occupied the free zone area between two herds in Nimaknagar and Waghaki (Figure V.5) i.e. areas of two dominant stallions KM and *Bandio*. The peripheral range of the ostracized stallion was once a part of its original range when it used to be a dominant stallion with the family band MH. The ostracized

male was observed to leave its range i.e. the free zone during late summer 1990 and 1991, as this area was resource poor. In the breeding season i.e. in monsoon he returned twice (1990 and 1991).

The all-male herd BH range showed little overlap with that of MH and YC, while there was no overlap with the dominant stallion KM and ostracized stallion JJ's home ranges. However, there were some observations where the bachelor males entered the territory of the dominant male stallion KM. They also moved on the periphery of KM's range.

The day and night ranges of YC overlapped in summer and monsoon. While in winter, the overlap was almost negligible as its night range differed in the core area use than that of the day (Table V.3, Figures V.7, V.8). The low winter overlap between day and night ranges was due to differential use of open scrubland in day and the croplands at night, provided good fodder during winter.

BC showed an overlap with her Koparni herd from summer 1991 till early monsoon 1991. BC showed an overlap with the family band, YC, dominant stallion and to some extent with the all-male herd during monsoon 1991 (August,September and October) (Figure V.9). In the 1st week of November, BC shifted her range to Krishnanagadh (Figure V.10) and showed remarkable overlap with the residing herd.

Wild ass showed a remarkable fidelity in seasonal use of home ranges. The dominant and ostracized stallions the family band and its member YC showed high fidelity to their home ranges. The all- male herd showed fidelity to seasonal range use in summer and monsoon, while in winter it shifted to the Rann habitat (Figure V.6). YC showed fidelity to the core area in its 24 hour home range except that the core area size differed among seasons (Figures V.7, V.8). BC did not show fidelity to the ranges as the seasonal range showed negligible overlap.

DISCUSSION

The ranging patterns of an animal is governed by several factors which include resource availability, environmental factors such as rainfall, social structure and external disturbances. In the Rann the three main seasons are summer, monsoon and winter. Since the area falls in the arid tract of the country, precipitation is low and there are frequent years of drought. This makes the availability of important resources such as food and water unpredictable. However due to the presence of crop fields, an alternative food resource is present.

Movement Patterns

Wild ass herds occupy the vegetative zone between the barren Rann and the agricultural fields. In summer and winter, the natural vegetation is sparse and so the animals move into the cropfields at night and return by dawn using definite paths as shown in the results. In the monsoon food is available not only from the cropfields but also from the natural vegetation which is evenly distributed.

Nevertheless, movement patterns, especially distance travelled, differs in the different groups. It was seen that the mean daily movement of the all-male herd was smaller than that of the stallions and was similar to the family band. This is contrary to what Berger (1986) observed in feral horses of Great Basin, the bachelors travel greater distances than the stallions (from family bands).

Information on movement patterns were obtained by direct sightings as well as interviews with villagers. Direct sightings at night, despite using a night vision scope was difficult as it was almost impossible to identify animals. Interviews showed that the all-male herds did move larger distances at night. A telemetric study is required to confirm their nocturnal movements.

No correlation was observed between day range length and home range size of the wild ass (present study). The feral horses of Great Basin showed a positive correlation (Berger,1986). Two most distant points of daily movement do have a correlation with the home range size, rather than taking the morning and evening fixes of the day range length.

The state of resources in summer is more likely to be related to the previous monsoon, and thus affect their movement, the wild ass tend to move larger distances in the summer following a poor monsoon and vice versa.

Home Range Seasonal Shifts, Overlap and Fidelity

Clutton-Brock and Harvey (1977, 1978) suggested that large home ranges result where resources are strongly clumped, widely dispersed or unpredictable in abundance. Altmann (1974) and Crook *et al.*(1976) have predicted extensive home range overlaps where several essential resources have very restricted distributions. Denham (1971) stated that clumping of populations should be high where predictability of resources is low. Seasonal shifts in home ranges of the family band and the dominant stallion was observed. These shifts occurred due to several reasons such as resource availability, rainfall and disturbance. The winter home range size showed an increase with increase in rainfall.

In summer the shift was mainly due to disturbances from plantation works. This was also the case in the winter of 1989-1990. Nature education camps organized by the Forest Department in December 1990, 1991 and 1992 also caused disturbances,that led to a shift in home range of the family band (MH).

During the monsoon of 1990 the east end of the annual range of the family band was flooded (rainfall: 350mm) and could not be used (Figure V.2). The following year

(1991) with poor rainfall (190) the same area was dry and the band moved in thus increasing its monsoon range (Figure V.3).

Seasonal home range size in the present study varies between 2.75 to 13.37 sq.kms. A comparison of the present study with those of other equine studies is given in Table V.5. The mean annual home range size was 13.46 sq.kms (SD=0.97, n=5) with density being 2.06 wild ass/sqkm. Tyler (1972) and Smuts (1975) reported home range sizes being independent of group size. Dasmann and Taber (1956), McNab (1963), Sanderson (1966), Maza *et al.*(1973), White (1980), and Berger (1984) reported that the home range size would increase as density decreases. In the present study more data is required to conclude that such factors operate in the wild ass habitat.

Norment *et al.*(1977) feels that size of home ranges which are not mutually exclusive are determined in size by the habitat and not influenced by density.

The studies on feral burros (*Equus asinus*), zebras, feral horses, *Equus caballus* and wild asses (*Equus hemionus*) conclude that seasonal variation do occur (Norment and Douglas 1977, White 1980, Penzhorn 1982a, Dunn 1984). The present study area being a salt mudflat with homogenous vegetation, differed from the habitats of the above mentioned equid species.

During monsoon food and water were available in plenty, and by late monsoon crops were also available. In winter natural resources become sparse but crops supplement their diet. It is only during the summer when the grass availability gets poor, the wild ass subsists on the *Prosopis juliflora* pods. In an area with resources fairly evenly scattered, seasonal shifts cannot achieve a significant gain (Cederland and Okarma 1988).

Maximum range overlap was seen between related individuals (family band, ostracised stallion, dominant stallion and YC). The all-male herd showed some overlap with the family band.

Range fidelity was seen in all individuals except the all-male herd. My observations of the all-male herd agree with that of Berger's (1986), on feral horses, that bachelors are not fidel to core areas and that fidelity increases only after obtaining a harem.

Fidelity could be explained by examining their social structure (Chapter VI) where the residential herds refrain from impinging into the adjoining herds. However, this needs to be studied in greater detail.

The most essential of all resources is water. Approximately 3 to 4 months after the monsoon most *talavs* within the range of the wild ass dry up and these *talavs* are also used by the salt pan workers. The only water source available since then through summer are the village *talavs* and the irrigated croplands which the wild asses visit during the night hours.

A water pipeline used to pass along the tar road between Kuda and Koparni (Figure V.9). The leakage in the line formed puddles at two points during the summer of 1991. These puddles were visited by BC and her Koparni herd, in the late night hours (2100-2400hrs) and at early dawn (0400-0500 hrs). Almost all locations were found within one and half kilometre radius of these two puddles. The leakages were repaired in June 1991 the range of BC also shifted.

Tyler (1972) reported that there were four requirements within any home range of New Forest ponies: a grazing area, shelter, water and shade. When these requirements are present close together, the home range is small.

The long period during which foals remain with their maternal herds probably enables foals to learn the locality of water holes, and good feeding areas which they may later utilize under adverse conditions.

The all-male herds were observed to range widely, certainly over greater areas than the breeding herds (Penzhorn 1982a). The knowledge gained by a bachelor could be important at a later stage, when as a dominant stallion he could herd his harem to alternative water holes, when those within their home range had dried up (Penzhorn 1982a). Geist (1971) demonstrated the importance of learning for mountain sheep *(Ovis canadensis)* to know suitable home ranges. A knowledge of the area beyond the usual home range would be beneficial to the animal (Penzhorn 1982a).

Table V.1: Seasonal mean daily movement (in kms.) of wild ass.

Seasons	Family Band (MH)	All-Male Herd (BH)	Dominant Stallion (KM)	Ostracized Stallion (JJ)
1989-90				
Summer	3.72 (0.899)	-	-	-
Monsoon	5.18 (0.369)	-	-	-
Winter	4.34 (0.289)	-	8.62 (2.87)	6.45 (0.738)
1990-91				
Summer	4.47	6.41 (1.018)	7.65 (0.577)	6.54 (1.218)
Monsoon	3.89	5.25 (0.779)	10.5 (1.462)	4.50
Winter	4.50	4.37 (0.746)	-	-
1991-92				
Summer	4.506	-	-	-

Figures in *parentheses* are the standard error.

Table V.2: Seasonal home range sizes of *E. h. khur*.

Seasons	MH (km^2)	BH (km^2)	KM (km^2)	JJ (km^2)
Summer 1989	4.25	-	-	-
Monsoon 1989	12.45	-	-	-
Winter 1989-90	9.60	-	5.72	6.09
Summer 1990	8.43	11.30	4.18	7.08
Monsoon 1990	8.49	13.37	5.80	1.83
Winter 1990-91	5.55	5.05	5.34	-
Summer 1991	4.50	-	-	-
Monsoon 1991	11.43	-	5.16	-
Winter 1991-92	5.05	-	2.68	-

MH = Family Band; BH = All-Male Herd; KM = Dominant Stallion;
JJ = Ostracized Stallion

Table V.3: Seasonal home range sizes of two radio collared mares.

Season	YC Day Range(km^2)	YC Night Range(km^2)	YC 24 Hour Range(km^2)	BC 24 Hour Range(km^2)
Winter 1990-91	2.75	7.35	11.40	-
Summer '91	6.97	10.85	14.00	11.0
Monsoon '91	9.12	8.45	15.20	31.20
Winter '91-92	4.86	5.00	8.58	12.90

YC = Yellow Collared Mare (a member of MH);
BC = Blue Collared Mare (a member of Koparni Herd)

Table V.4: Percent annual home range overlap between between different wild ass groups.

Animal Code/Seasons	Annual Home Range Size sq.km	Seasonal Home Range Overlap sq.km
MH Summer 1989-Monsoon '90	18.9	2.125
MH Summer 1990-Monsoon '91	15.88	2.708
MH Summer 1991-Monsoon '92	16.106	1.358
KM Winter 1989-Summer '90	8.00	3.243
JJ Winter 1989-Summer '90	8.77	1.456
YC Winter 1989-Summer '90	16.11	1.931
BH Winter 1990-Summer '90	18.57	0.558

MH = Family Band; BH = All-Male Herd; KM = Dominant Stallion;
JJ = Ostracized Stallion; YC = Yellow Collared Mare (a member of MH)

Table V.5: Comparison of home range data from various equine studies.

Mean Home Range Size (sq.km.)	**Mean ♂ Home Range Size (sq.km.)**	**Mean ♀ Home Range size (sq.km.)**	**Maximum Density Animals/sq.km.**	**Location of Population**	**References**
7.44 ± 1.22 (10)	5.28 ± 1.26 (5)	9.60 ± 1.66 (5)	4.32	Tin Mountain Death Valley N.M.	Dunn (1984)
9.90 ± 2.23 (11)	8.76 ± 2.42 (6)	11.35 ± 4.22 (5)	3.8-4.9	Butte Valley Death Valley N.M.	White (1980)
10.0 ± 1.22 (48)	12.3 ± 2.25(23)	8.65 ± 0.95 (25)	0.77	Wildrose Canyon Death Valley N.M.	Mohelman (1974)
68.1 ± 5.69 (24)	72.1 ± 7.64(14)	62.5 ± 8.63 (10)	0.54	Wildrose Canyon Death Valley N.M.	Norment and Douglas (1977)
19.2 ± 3.66 (14)	15.2 ± 2.35 (8)	24.3 ± 7.90 (6)	3.3	Bill Williams Mountains-Arizona	Seegmiller and Ohmart (1981)
30.06 ± 6.1 (15)	28.7 ± 4.6 (9)	30.5 ± 14.30 (6)	0.41	Lower Colarado River - Arizona	Woodward (1976)
2.86 ± 0.37 (21)	2.62 ± 0.67 (6)	2.72 ± 0.413(15)	2.55	Bandelier National Monument	Morgart (1978)
13.46 ± 0.97 (5)	11.78 ± (3)	15.98 ± (2)	2.06	Rann of Kutch	Present Study

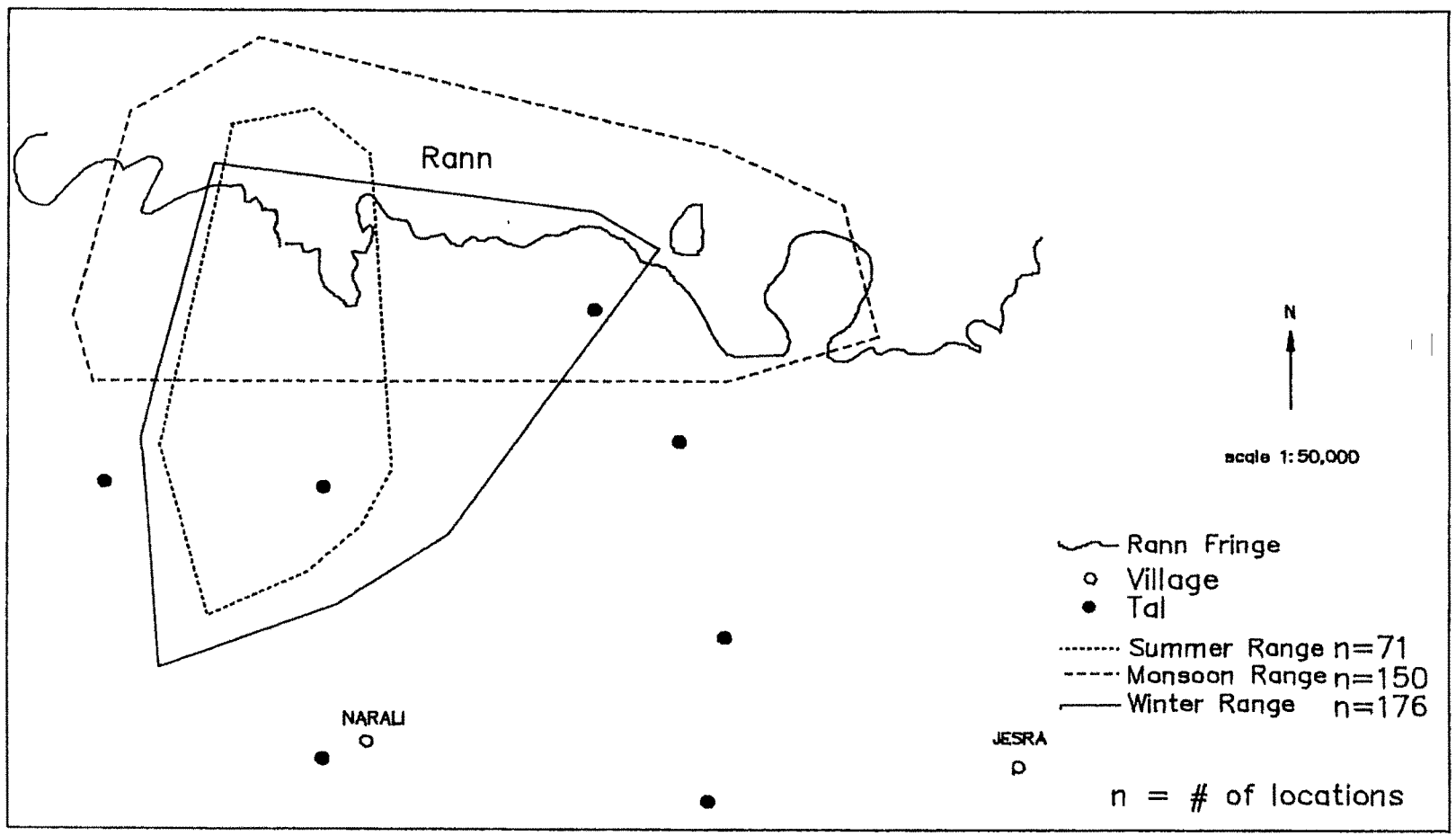

Figure V.1 : Seasonal Home Ranges of Family Band (MH) (1989–90)

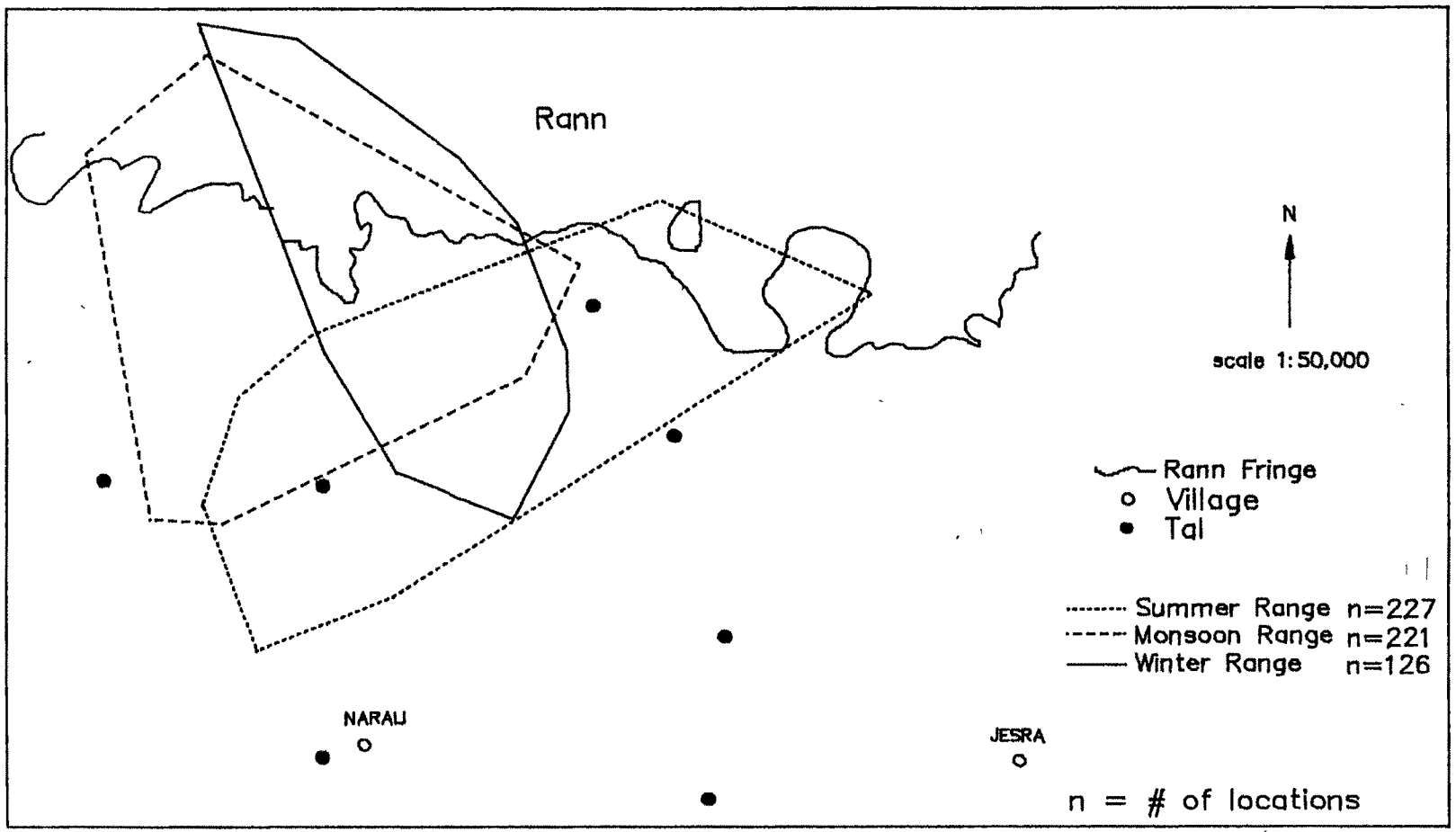

Figure V.2 : Seasonal Home Ranges of Family Band (MH) (1990–91)

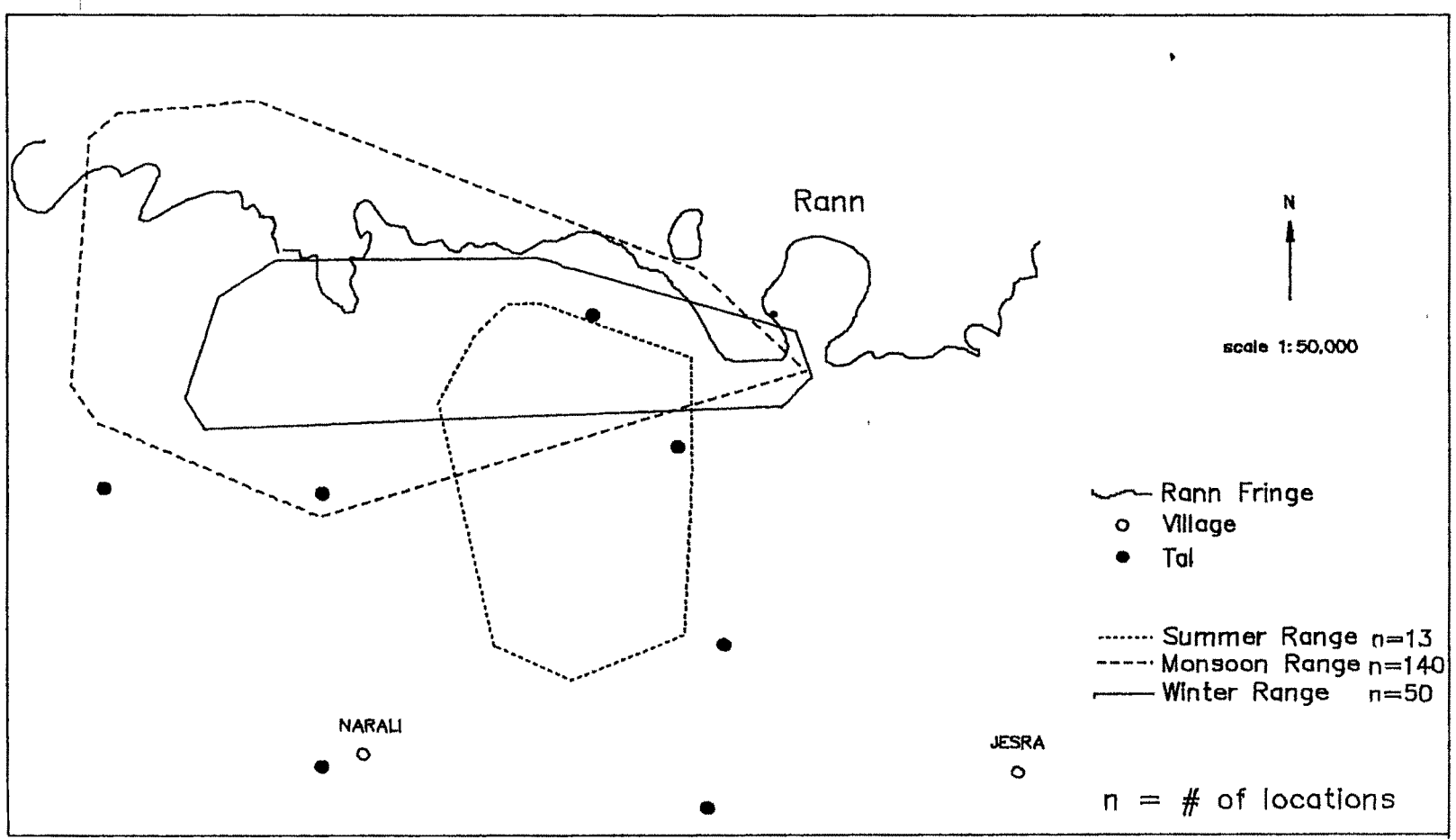

Figure V.3 : Seasonal Home Ranges of Family Band (MH) (1991–92)

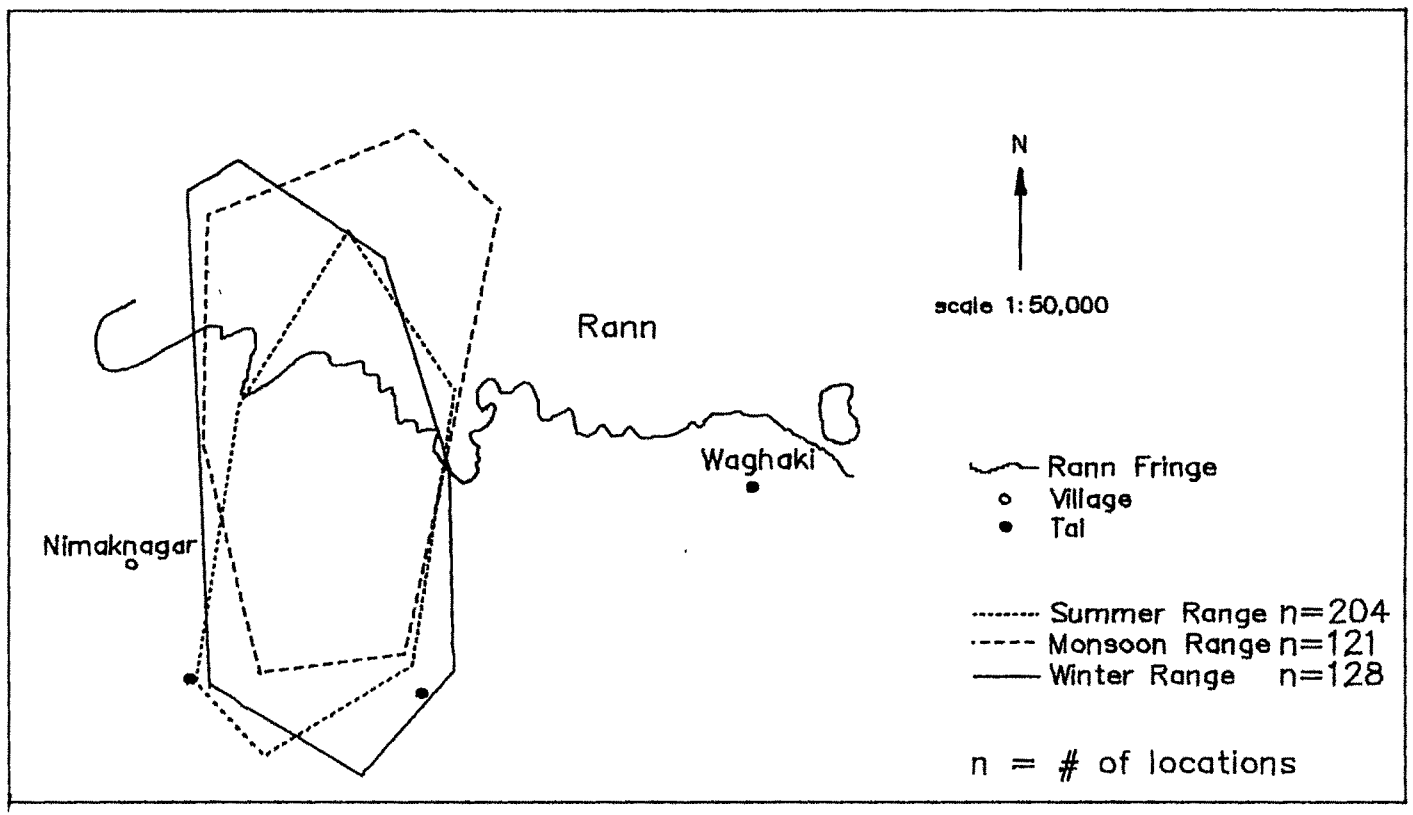

Figure V.4 : Seasonal Home Ranges of Dominant Stallion (KM) (1989–90)

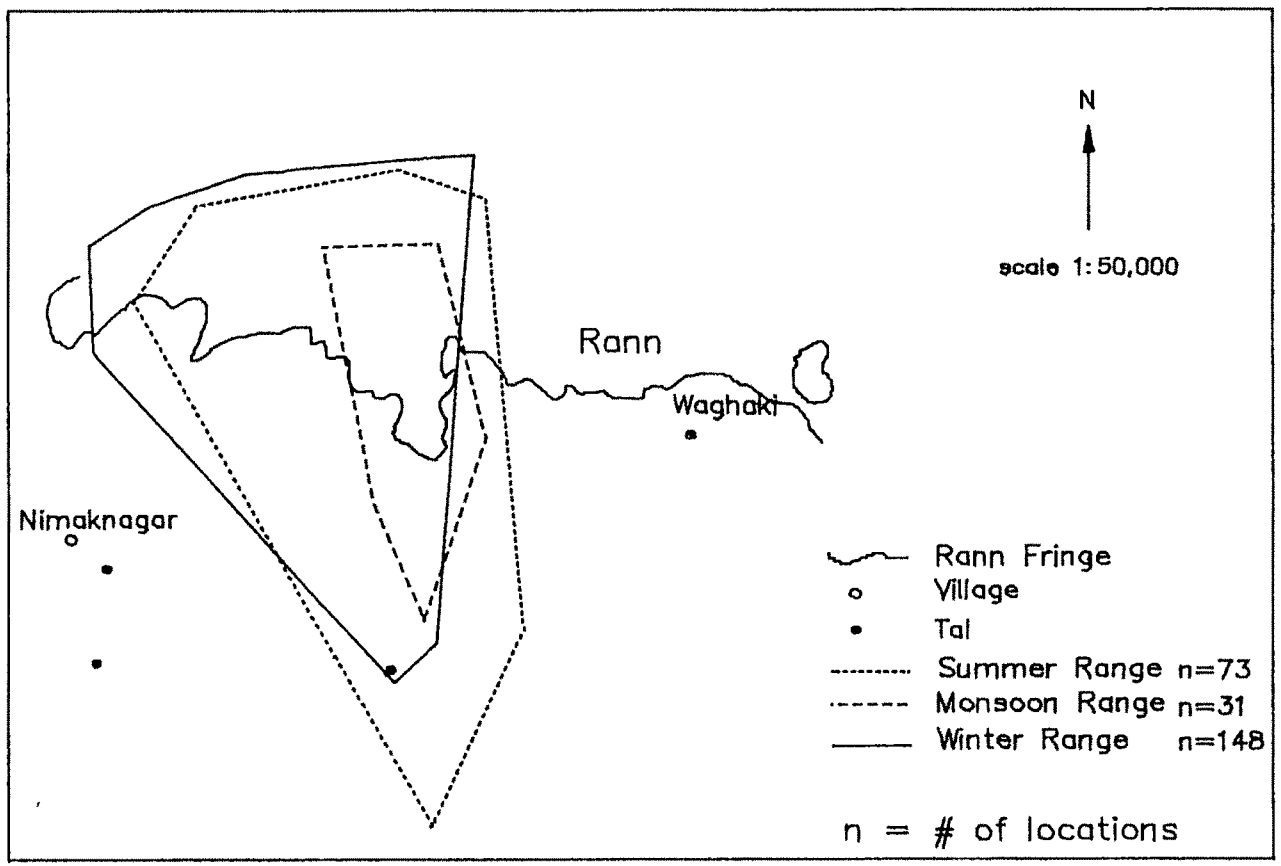

Figure V.5 : Seasonal Home Ranges of Ostracized Male (JJ) (1989–90)

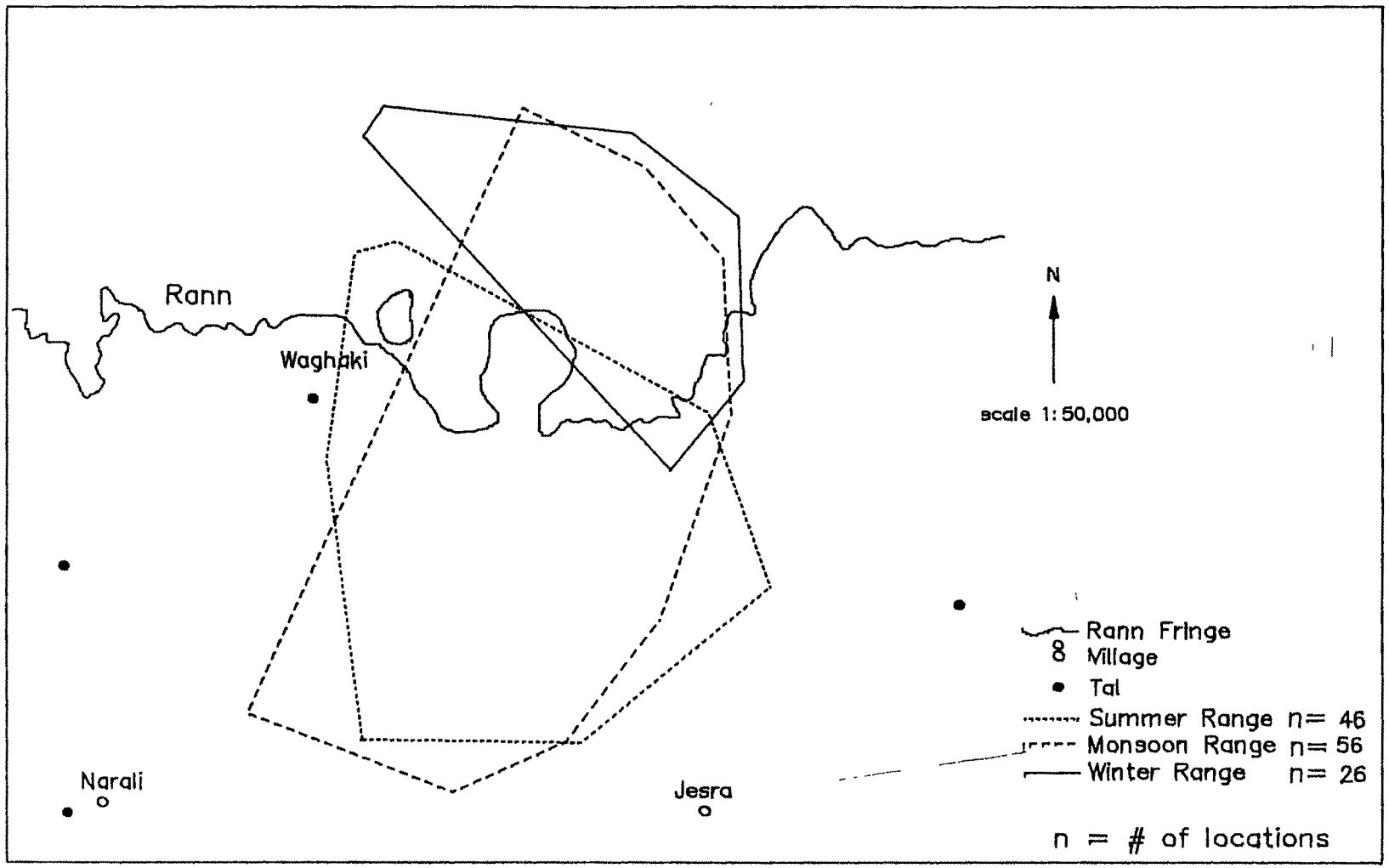

Figure V.6 : Seasonal Home Ranges of All-Male Herd (BH) (1990)

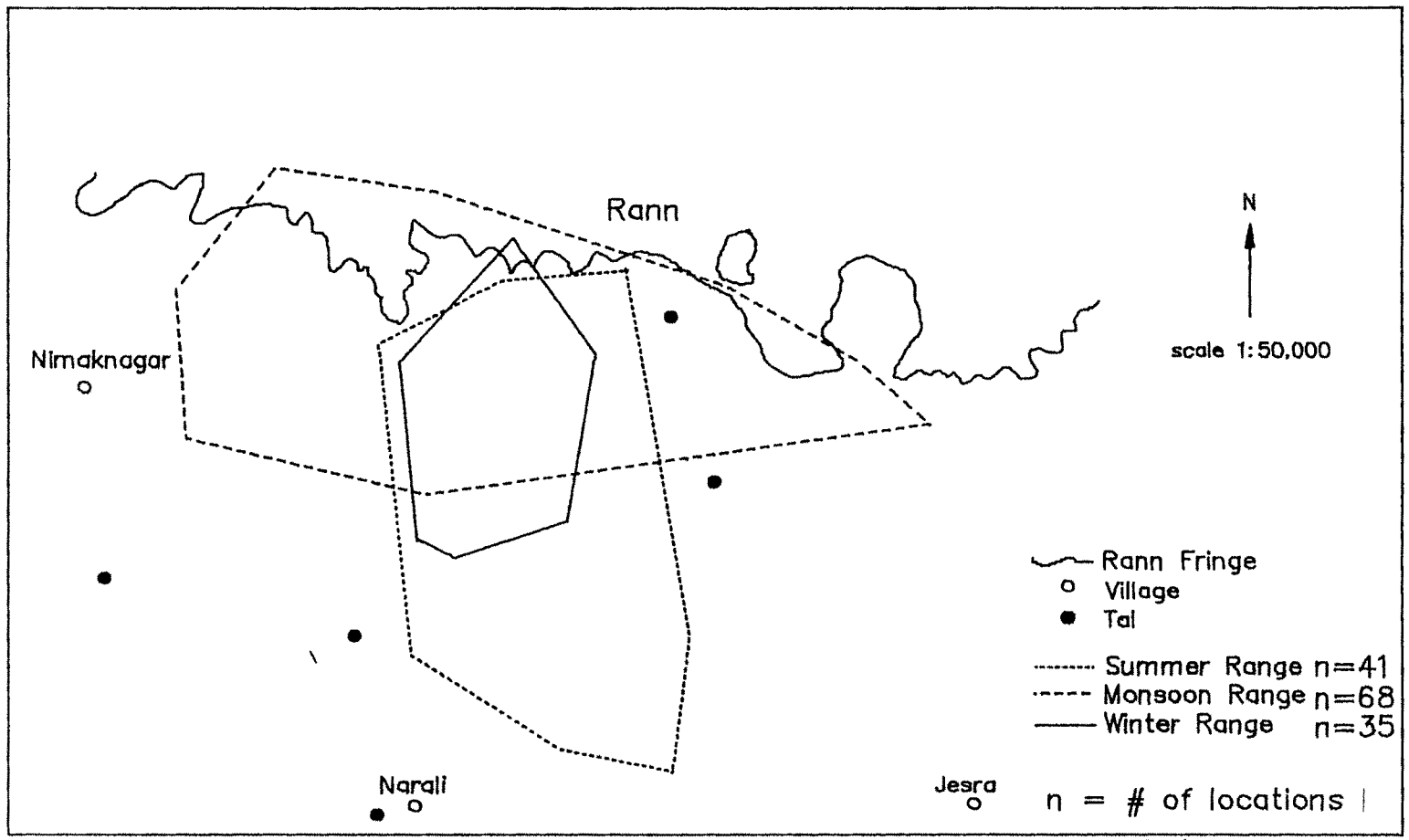

Figure V.7 : Seasonal Diurnal Home Ranges of Yellow Collared Mare (YC) (1990–91)

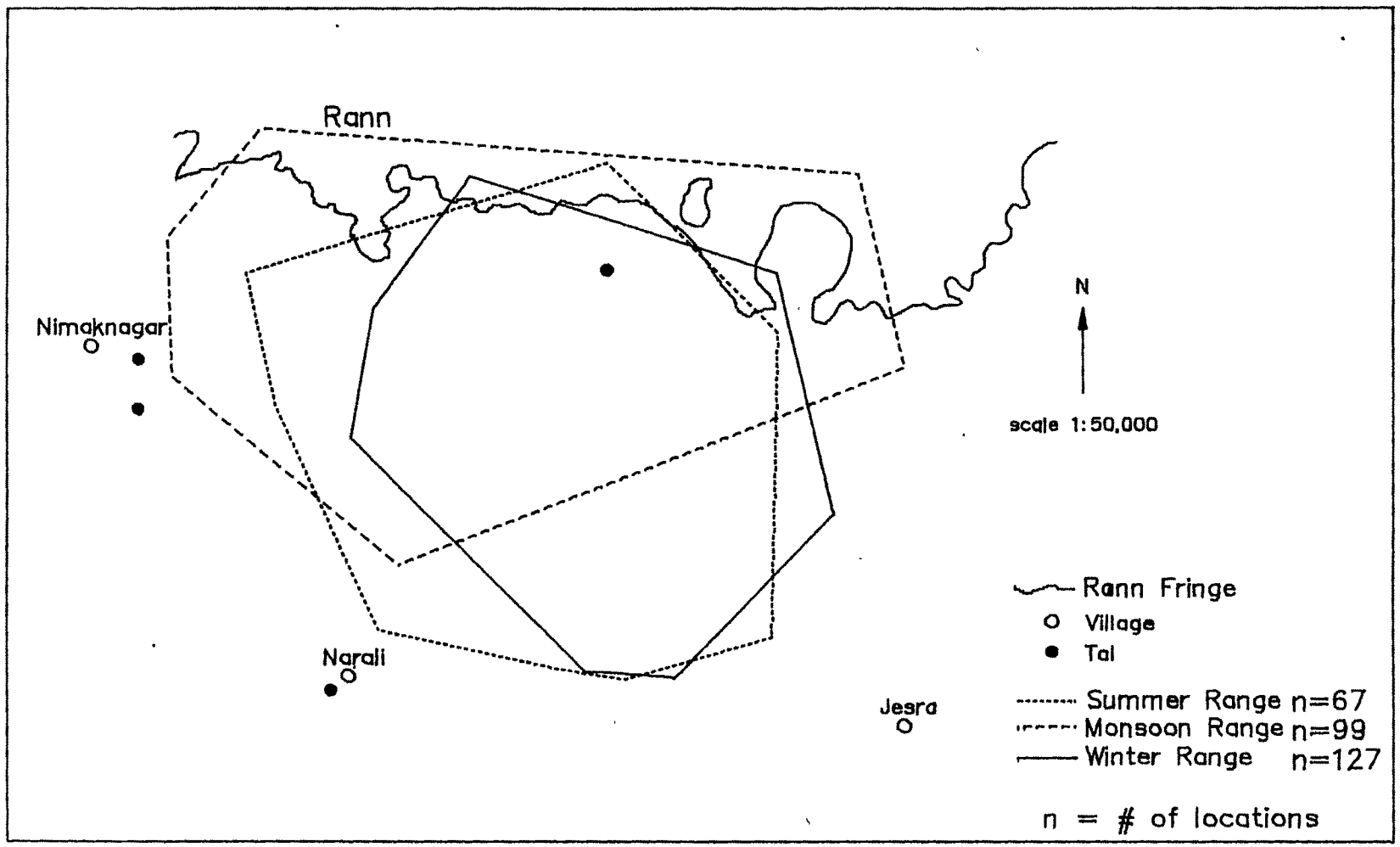

Figure V.8 : 24 Hours Seasonal Home Ranges of Yellow Collared Mare (YC) (1990–91)

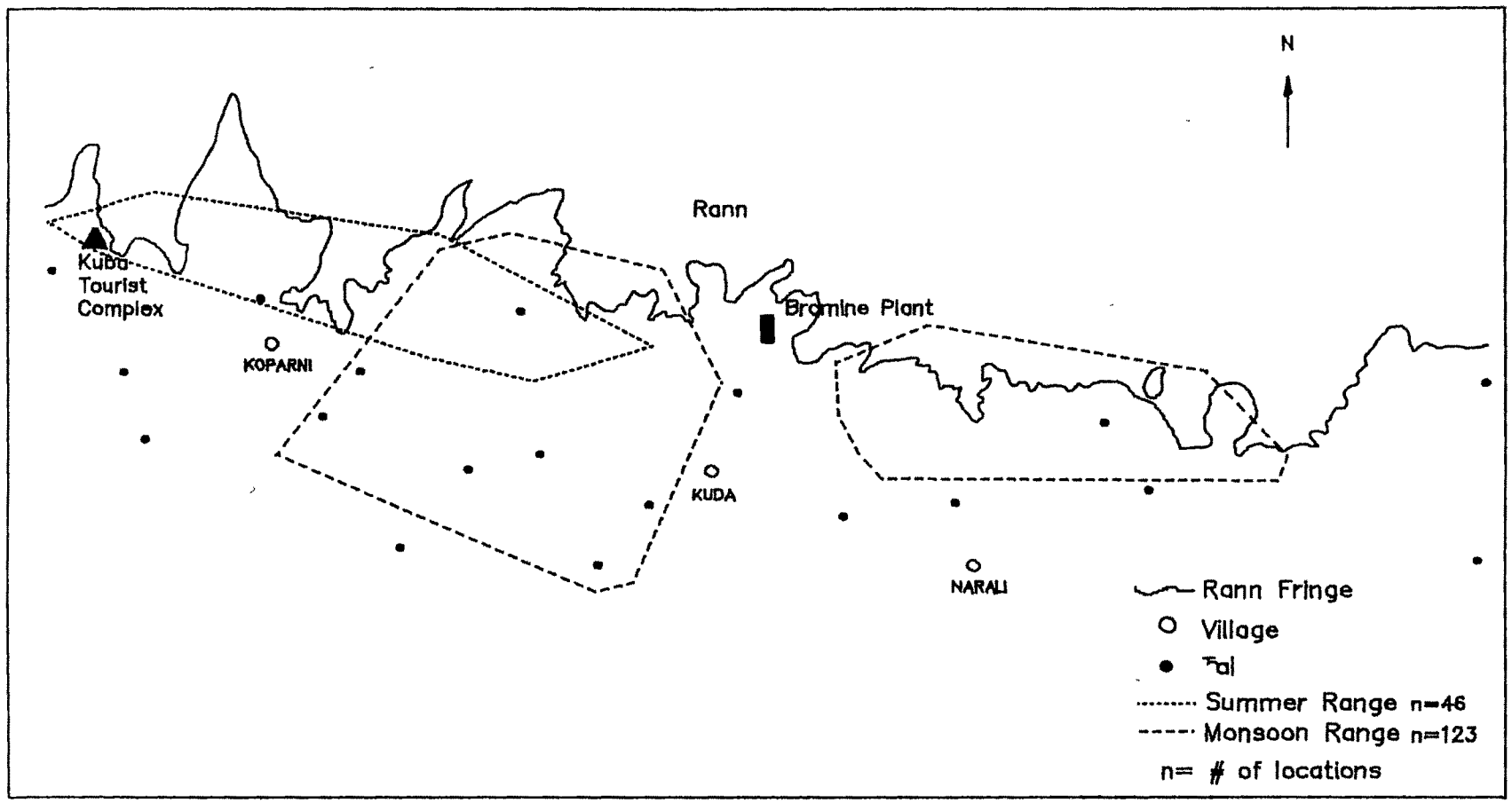

Figure V.9 : Summer and Monsoon Home Ranges of Blue Collared Mare (BC) (1991)

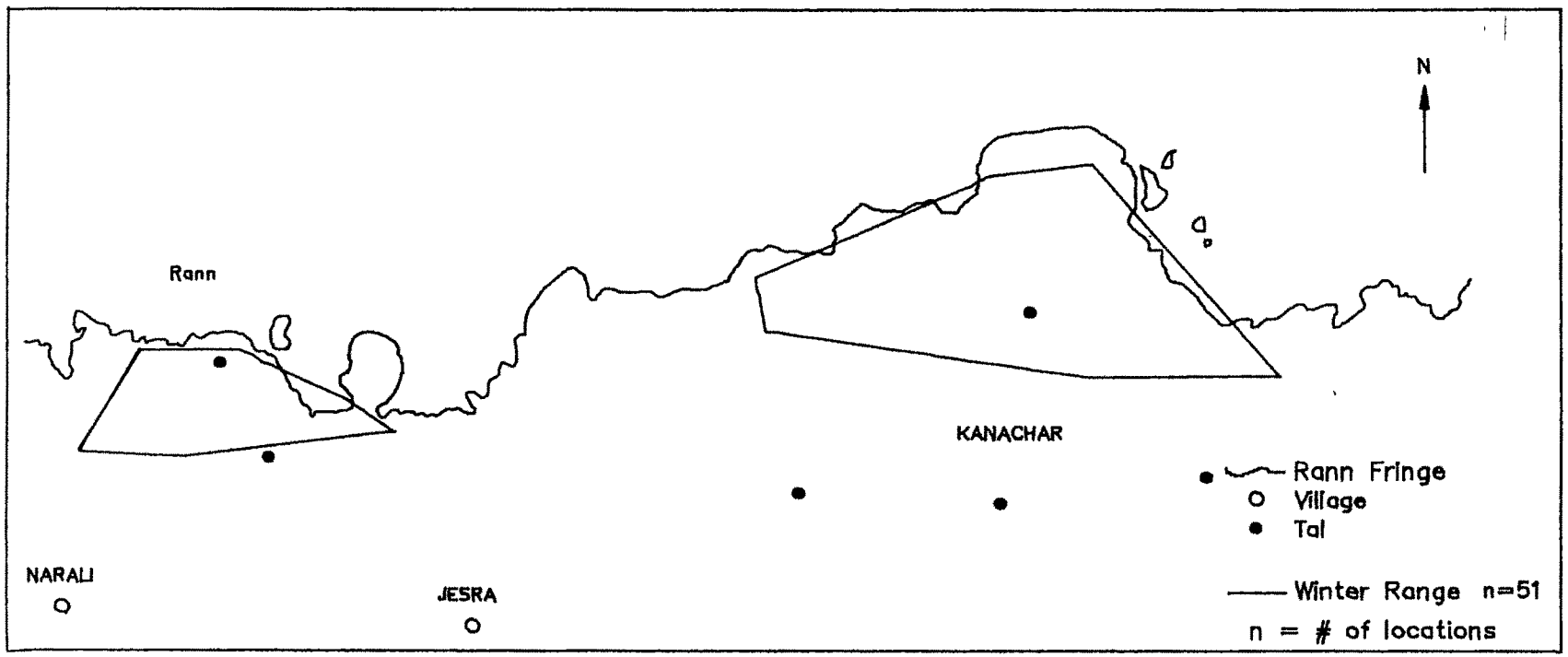

Figure V.10 : Winter Home Range of Blue Collared Mare (BC) (1991–92)

Plate V.1 Radiotracking.

PLATE V.2 Radio-Collared Mare