SPACE AND HABITAT USE BY A SMALL RE-INTRODUCED POPULATION OF GREATER ONE-HORNED RHINOCEROS (*Rhinoceros unicornis*) IN ROYAL BARDIA NATIONAL PARK IN NEPAL - A PRELIMINARY REPORT

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ABSTRACT

In 1986, thirteen rhinoceros were reintroduced to the Karnali floodplain in the southwest corner of Royal Bardia National Park in Nepal. We studied space and habitat use by nine radiomarked animals during a period of 16 months in 1990-1991 based on 1170 radiolocations. Yearly home range size was 28.7 km^2, which was about ten times larger than the home range size of the donor population in Chitwan National Park. Individual home ranges overlapped considerably, except that adult males appeared to avoid each other. Seasonal home range sizes were similar (ca 15 km^2) in all three seasons (winter, hot and monsoon) and showed a high degree of overlap, but with seasonal shifts in activity centers. No differences in space use were detected between one adult male and adult females with and without calves. Khair-sissoo forests, floodplain grasslands and moist riverine forests received preferential use during the whole year, whereas sal forest, mixed hardwood forests, Wooded Grassland and Phanta were avoided. Floodplain grasslands were used most intensively during the monsoon. During the winter and hot seasons, habitat exploitation shifted successively to khair-sissoo and moist riverine forests. The large home ranges of the Bardia animals may be due to a dispersed distribution of seasonal habitats and farm crops, superimposed by human disturbances, rather than inferior habitat quality per se.

INTRODUCTION

The Greater One-horned rhinoceros (*Rhinoceros unicornis*) is now restricted only to small, isolated populations on the Indian sub-continent. In Nepal, the species was nearly eliminated during the 1960s due to habitat destruction and heavy poaching. Less than 80 individuals survived in the Chitwan valley before the area was protected and declared a National Park in 1973. With adequate protection the population has now increased to nearly 400 individuals (Dinerstein and Price, 1991). In the past few years, a number of rhinos have been reintroduced from Chitwan to other parks and reserves in India and Nepal. The main purpose of such translocations is to safeguard the species against disease and other environmental calamities such as seasonal floods (Mishra and Dinerstein, 1987).

Thirteen individuals were reintroduced to Royal Bardia National Park in the western lowland (Terai) in 1986 (Bauer, 1988). The purpose of this paper is to report preliminary data on seasonal movement and habitat use by this small population four years after their release, based on 16 months of radiotracking. We also compare the size of home ranges of the Bardia animals with that of the original donor population in Chitwan where similar field studies were carried out during 1986-88. Information on the initial dispersal pattern following release is also given, based on qualitative data collected by the National Park staff (Wegge, *et al.*, 1990).

STUDY AREA

The study was carried in the south-west corner of the Royal Bardia National Park (81° 20' E and 28° 35' N, Fig. 1). The 55 km^2 study area consists basically of a narrow floodplain along

the large Karnali river. About one third extends southwards outside the Park boundary to the Indo-Nepal border.

The Park contains populations of tiger *Panthera tigris*, leopard *Panthera pardus*, sloth bear *Melursus ursinus*, five species of deer (*Axis* spp., *Cervus* spp. and *Muntiacus muntjak*), two species of crocodile, Gangetic dolphin, *Platanista gangetica* and a rich avifauna of 143 recorded species (Bolton, 1976). The vegetation is dominated by floodplain grasslands and four forest types: 1) sal *Shorea robusta*, 2) khair-sissoo *Acacia catechu-Dalbergia sissoo*, 3) riverine, and 4) mixed hardwood forests. Previously disturbed and cultivated sites are made up of wooded grasslands and "phantas" (open grassland) with mostly short grasses like *Imperata cylindrica*. The floodplain is dominated by tall grasses, particularly *Saccharum spontaneum*, *S. bengalensis* and *Phragmites karka*. Before it was gazetted as a wildlife reserve (1976) the present park was intensively used by domestic livestock. With protection from grazing, the understory vegetation, including grass cover, has recovered markedly (pers. obs.).

Dinerstein (1979a; 1979b; and 1980) provides more detailed information on flora, fauna and animal/habitat relationships in this part of the park where the present study is being conducted.

STUDY ANIMALS AND METHODS

The 13 animals were captured, translocated and released in February (4) and in December (9) 1986, all at the same release site in the upper floodplain near Lalmati (Fig. 1). The founder population consisted of 2 adult males, 5 adult females, 3 subadult females and 3 subadult males. One adult male died 0.5 km from the release site after 7 days mainly due to infection of wounds caused during translocation. Another sub-adult male was killed by a local poacher after 39 months in a forest across the Karnali river. No other losses have occurred. The Bardia population now consists of a total of sixteen individuals: 3 adult males, 3 solitary adult females and 5 females with calves (Wegge, *et al.*, 1990). All five calves were born during 1987-1990 following breeding in Bardia.

During the 1990 dry season, 9 of the 11 adults were captured using the same immobilizing drugs as reported by Dinerstein, *et al.*, (1990). The drug dose was increased to 2.5-3 mg of etorphine mixed with 1.5 cc of acepromazine to ensure rapid immobilization.

Animals were equipped with radio collars in the 142 Mhz frequency range and monitored by portable receivers and yagi antennas. On average all animals were tracked 3 times per week. During the dry season (December-June) most tracking was done from the road using a car or bicycle. In the monsoon, tracking was only possible by the use of elephants. Animals were mostly located by triangulation or by cross-bearings at closer distances (<200 m). When using elephants, animals were normally located to within sighting distance. The tracking periods were divided into three seasons: winter season (November, December, January and February), hot season (March, April, May and June) and monsoon season (July, August, September and October).

We collected 1170 radio locations from 9 rhinos between February 1990 and July 1991. Data from one adult male (frequency number 337) is mostly excluded from the material as this animal has moved out of the study area and now resides mostly on the Indian side of the border. We monitored the animals intensively for 10-17 months. One radio collar (number 256) ceased to function after 10 months, and two other animals (females: 235 and 357), tore off their collars after 12 and 13 months, respectively. Similarly, an adult male (275) lost its collar in a fight with the "Indian" male (337), but the collar was replaced within a few days.

Radio locations were plotted on aerial photos (scale 1:35000) and later transferred to topographic maps. Seasonal and yearly home ranges were drawn as convex polygons

according to the "modified minimum area method" (Harvey and Barbour, 1965) as modified by Wegge and Larsen (1987), and their sizes estimated by a planimeter. Yearly home ranges of adult animals in Chitwan (1 male and 4 females) collected by Dinerstein and Jnawali (unpubl.) were calculated by the same method.

The animals were grouped into three classes (solitary females, females with calves, and adult males) to see if there were any differences in habitat use and movement pattern between these classes.

A detailed habitat map had previously been made for the middle portion of our study area (Dinerstein, 1979a). We have extended this map to cover nearly half of the study area. We followed Dinerstein's classification, but modified his nomenclature slightly. In this central 30 km^2 part of the study area, the following vegetation types and relative coverages were identified: sal forest (23.0%), khair-sissoo forest (18.8%), moist riverine forest (11.4), mixed hardwood forest (4.6%), floodplain grassland (7.0%), wooded grassland (6.5%), phanta (3.5), river and river beds (15.2%) and agriculture (10.0%).

RESULTS

Dispersal After Release

Some animals dispersed widely after release (Fig. 2). One female (now frequency number 377) travelled ca 40 km south-eastward outside the Park boundary within five days. One week later she moved southwest across the Indian border and the Karnali river and stayed there until early 1990. In April, 1990, she appeared west of Bagaura Phanta within the Park where she was captured and radio-collared. Immediately after capture she again moved back to the Indian forest for so to return to the Park about 4 weeks later. Since then she has remained inside the study area north of the border where she gave birth to a male calf in August, 1990.

Two other animals moved about 15 km north from the release site, spent one year near the gorge where the Karnali river enters the floodplain (Chisapani), and then moved south to the central part of the study area.

One subadult male travelled a total distance of about 30 km southwest of the Park during the three years after release, residing mainly near the Indian border. In March, 1989, this animal again moved north to a forest southwest of Chisapani (Sorkhol) where it was killed by local poacher.

One adult female (now frequency number 396) moved about 8 km eastward from release site to a forest (Sivpur) outside the park and gave birth to a calf in 1987. Three weeks before her capture in the floodplain she was also observed in the same forest. Since being instrumented, she has remained in the northern part of the floodplain.

Following the initial dispersal period, most animals now seem to have settled in more clearly defined ranges, although extensive movements still occur.

Home Range and Movement Pattern of Instrumented Animals

Average yearly home range size was estimated at about 29 km^2 (Table 1). By comparison, the average size of yearly home ranges of 5 animals in the Chitwan donor population was 3.1 km^2 (range 2.6-4.2 km^2), or only 11 % of that recorded among Bardia animals.

Table 1. Seasonal and yearly home range size (km^2) of eight adult radio-marked rhinoceros in Royal Bardia National Park 1990-1991.

Animal	Sex	N	Winter	Hot	Monsoon	Whole Year	Seasons tracked
424	F	174	20.4	15.9	18.3	29.2	4
357	F	110	11.2	14.8	12.1	19.5	3
256	F*	87	-	10.3	4.1	13.6	2
316	F*	171	31.6	13.8	31.4	52.8	4
235	F*	154	10.8	14.1	16.6	35.3	3
396	F*	157	14.8	10.4	15.5	19.5	3
377	F*	130	15.3	16.3	11.6	22.2	3
275	M	140	13.9	29.3	9.5	37.7	3
Mean Home Range Size:			14.8 s.d. (9.0)	15.6 (6.0)	14.9 (8.0)	28.7 (12.8)	

* = Female with calf

Seasonal home ranges were remarkably similar, averaging ca 15 km^2. No difference in size was detected between social groups in any of the three seasons (Table 2). The adult male appeared to have a larger yearly home range than females with and without calves, but the difference was not significant. Two animals were tracked during two consecutive hot seasons. They did not change ranges from one year to the next.

Table 2. Average home range size (km^2) of three different social groups in Royal Bardia National Park 1990-1991.

Social Group	N	Winter	Hot	Monsoon	Whole year
Solitary females	2	15.8	15.3	15.2	24.4
Females w/calves	5	18.1	13.0	15.8	28.7
Adult male	1	15.3	16.3	11.6	37.7

Instrumented animals stayed mainly within the 3-4 km wide floodplain along the Karnali river, rarely venturing inside the drier sal forest away from the floodplain. Home ranges were large, with substantial overlap between most individuals during all seasons. Only temporarily were animals recorded or seen together. The two adult males occupied separate portions of the study area, except for a fighting encounter during winter 1991. However, because a third adult male was unmarked, we do not know to what extent this animal interacted with the other two males.

Most animals shifted their activity centers between seasons, but their seasonal home ranges still overlapped markedly (Fig. 3). Six animals (females 424, 256, 235, 396, 357 and male 275) remained more or less within the same range in the central and northern part of the study area during most of the year, with a slight southward movement during winter. The male and one female (235) travelled particularly long distances (ca 15 km) between seasons.

The last two females (377 and 316), both with calves, resided mainly in the southern section, but moved slightly north during the hot season. One female (316) roamed over a larger area than the others. The longest distance moved by this animal between seasons was ca 21 km.

Habitat Use

The radio-collared animals were unevenly distributed on habitat types (Fig. 4, Table 3). They were rarely recorded in sal forest and in wooded grassland and never on phantas. Because animals were not tracked during night, no locations were recorded in cultivated fields. However, most animals were known to forage on agricultural crops during night-time, particularly in the early winter season. When agricultural land and phanta were excluded from the habitat coverage, significantly more observations than expected by chance were recorded in khair-sissoo, moist riverine forest, and flood plain grassland habitat types ($p<0.001$, all three, Chi Square Tests).

Table 3. Habitat use by eight adult rhinoceros in Royal Bardia NationalPark 1990-1991 (%). N=609.

Animal No	SL 25.2%	KS 20.6%	MRF 13.3%	MHF 6.5%	FPG 8.9%	WG 8.4%	RR 17.1
424	1.9	54.2	22.4	1.9	13.1	2.8	3.5
357	5.1	55.7	12.7	1.2	17.7	1.2	6.3
256	0.0	50.8	12.3	1.8	24.6	0.0	10.4
316	1.6	24.2	41.9	3.2	24.2	1.6	3.1
235	0.0	44.6	24.6	0.0	24.6	1.5	4.6
396	0.0	55.4	9.7	1.9	22.4	1.9	8.6
377	0.0	42.5	12.5	0.0	32.5	0.0	12.5
275	0.0	50.0	17.7	1.0	18.8	0.0	12.5
Mean	1.1	47.2	19.2	1.3	22.2	1.1	7.6

SL = sal, KS = khair-sissoo, MRF = moist riverine forest, MHF = mixed hardwood forest, FPG = floodplain grassland, WG = wooded grassland, RR = river and riverbeds

The strongest seasonal preference for khair-sissoo occurred during winter, while during the hot season moist riverine forest and river and river beds received proportionally more use than during other parts of the year (Fig. 5). Flood plain grassland was particularly important during the monsoon period, with less use during winter.

DISCUSSION

Home Range and Movement Pattern

Five years after their original release in Bardia, the animals were roaming over a large area with individual home ranges of nearly 30 km^2. Mean home range size of adults in the Chitwan donor population was only about 1/10 of that (this paper and Laurie (1978)). In Africa, home ranges of Black rhinoceros (*Diceros bicornis*) and White rhinoceros (*Ceratotherium simum*) were also reported to be much smaller (between 5.3 and 8.8 km^2) (Laurie, 1982) than what we have found for the re-introduced Bardia population.

The discrepancy between the large home ranges in Bardia and the small ranges in the Chitwan donor population may be due to differences in density, quality and spatial distribution of habitats or disturbances.

The newly released animals in Bardia may not yet have settled down. With its low number of animals (approximately 0.2 adults/ km^2 of available habitat) density is not expected to limit movement. Density of the Sauraha donor population in Chitwan was substantially larger, estimated at 6.4 animals/km^2 (Dinerstein and Price, 1991). However, considering the relatively long time since release (five years) during which initial erratic dispersal seem to have been replaced by more predictable movements, our preliminary data indicate that the present pattern reflects established home ranges rather than unsettled behaviour.

Habitat quality may not be as rich in Bardia as in Chitwan, thus triggering more extensive movements, particularly for food. However, the grassland floodplain is dominated by *Saccharum spontaneum*, a key food plant for rhinoceros (Dinerstein and Price, 1991). Our observations of seasonal habitat use support this. This habitat was strongly preferred during the hot and monsoon seasons. However, other preferred habitat types like moist riverine forest may be limiting. Compared with Chitwan, this habitat type does not occur in continuous, larger tracts, but is scattered in narrow depressions and smaller patches.

Disturbance during two weeks in late winter, when the Park is opened to villagers for cutting of thatch grass accompanied by large-scale burning, may trigger extensive movements of rhinos to more sheltered habitats. Also, several animals have established themselves partly outside the Park to the south. Permanent disturbance from human activity in this section of the study area probably acts to increase daily travel distances.

Limited access to agricultural land may also increase overall range use. The donor sub-population in Chitwan at Sauraha occupies a dense mosaic of preferred habitats, where use of nearby agricultural fields constitutes an important part of their annual feeding cycle (Milton and Binney, 1980; Mishra, 1982; Jnawali, 1988). In Bardia, the Karnali river prevents crop raiding during most of the year outside the Park along the western border, and extensive sal forests similarly appear to restrict movement eastwards. Access to agricultural crops is mostly confined to the southern section, outside the Park near the Indian border. Hence, animals have to move from the central core area in the upper floodplain in order to exploit palatable farm crops. Habituation derived from their feeding habits in Chitwan has probably contributed to this southward movement in Bardia.

Habitat Use

During winter, there was a noticable shift in use from flood plain grassland to khair-sissoo habitats (Fig. 5). This change is probably due to declining food quality of the perennial grasses. Following flowering and seeding during the monsoon, most tall grasses lignify and do not sprout before disturbance by grasscutting and burning in late winter. Although *S. spontaneum* is unique by putting out new shoots during most of the year (Dinerstein and Price, 1991), regrowth is most pronounced following burning and cutting in late winter/early hot season. Khair-sissoo forests, with abundant understory species like *Murraya koenigii* and *Callicapra macrophylla*, provides shelter for resting, and the latter species is also a preferred food plant during winter (Gyawali, 1986).

During the hot season, revegetating tall grasses in the flood plain seem to attract animals again, with a concurrent decline in use of khair-sisso habitats. However, a more pronounced shift occurred in the increased use of moist riverine forests and river and river beds during this time. This shift is probably more related to shelter and temperature regulation than to food exploitation, as the moist riverine forests do not provide any particular food source highly sought by rhinos at that time (Gyawali, 1986). Browse species that are important in Chitwan during winter in this habitat type like *Murraya paniculata*, *Litsea monopetela* and *Coffea bengalensis*, are scarce or lacking in Bardia (unpubl.).

Sal forests, mixed hardwood forests and wooded grasslands received very little use. Neither habitat provides much food, as the understory vegetation is usually sparse with mainly

unpalatable species (sal forest) or composed of short grasses like *Imperata cylindrica* which only receive some use after sprouting.

The large home ranges and extensive movements of the small Bardia population is probably a result of the spatial distribution of habitats, rather than lack of habitat quality per se. In Chitwan, large tracts of grassland around compact blocks of Riverine forests within short distance of cultivated fields probably provide an optimum combination of seasonal habitats. In Bardia, the elongated shape of the flood plain, surrounded mainly by a river barrier and unattractive sal forest, results in a more dispersed spatial arrangement of seasonal habitats, particularly access to agricultural crops. The scattered distribution of moist riverine forests which seemingly lack important browse species like *Coffea bengalensis*, *Murraya paniculata* and *Litsea monopetela* may also contribute to the observed difference in space use between the donor population and the small, re-introduced population in Bardia.

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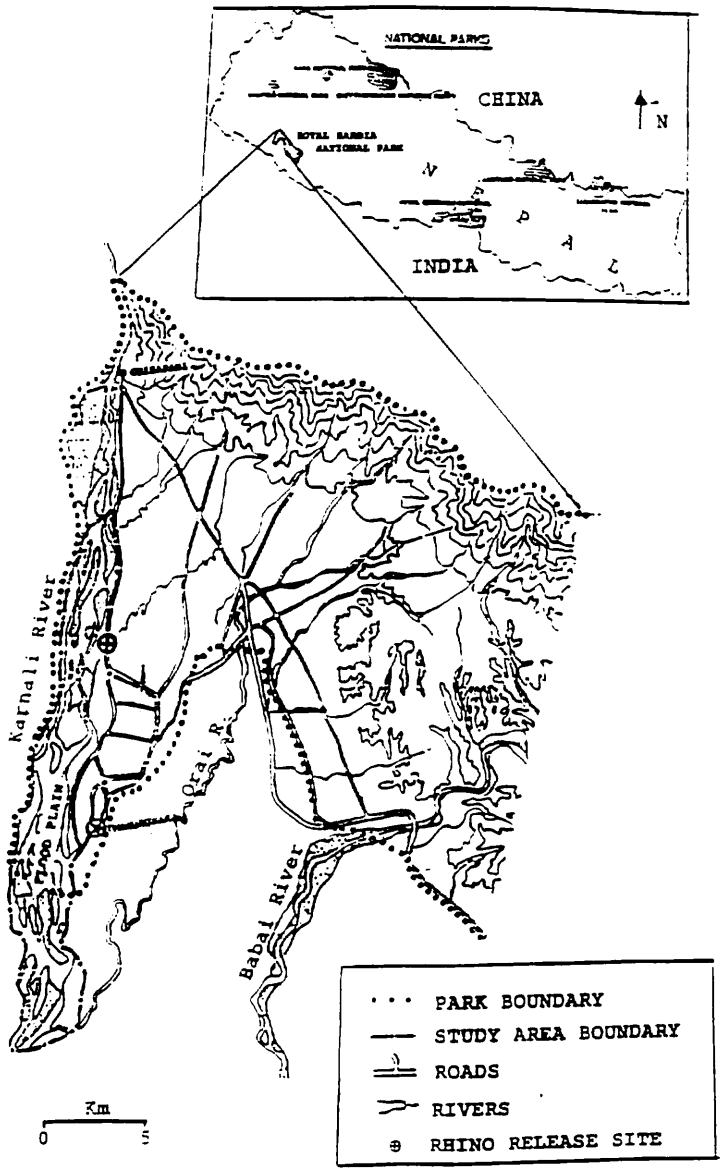


Fig. 1. Map of the western section of the Royal Bardia National Park showing study area.

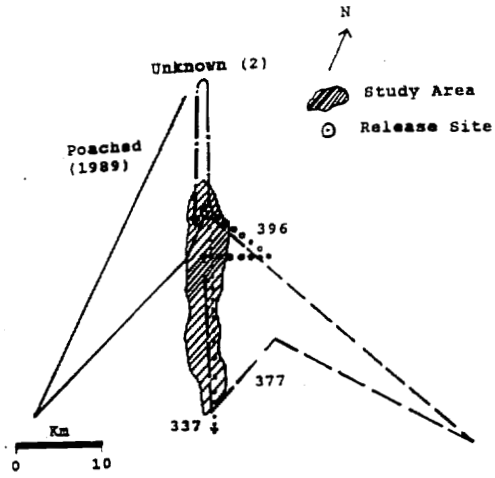


Fig. 2. Dispersal pattern of six R. unicornis after release in 1986. (Schematically reconstructed, see text).

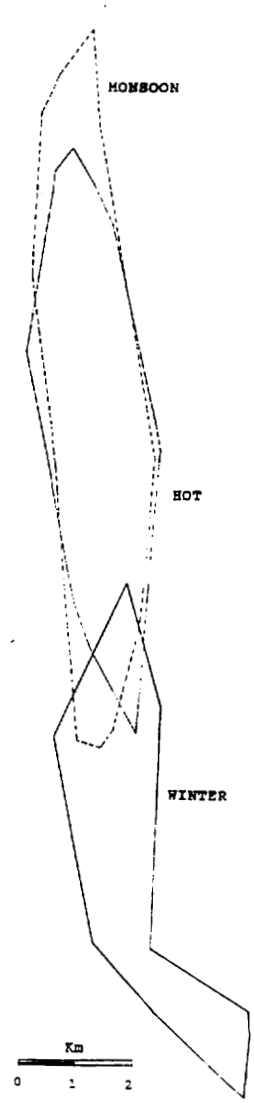
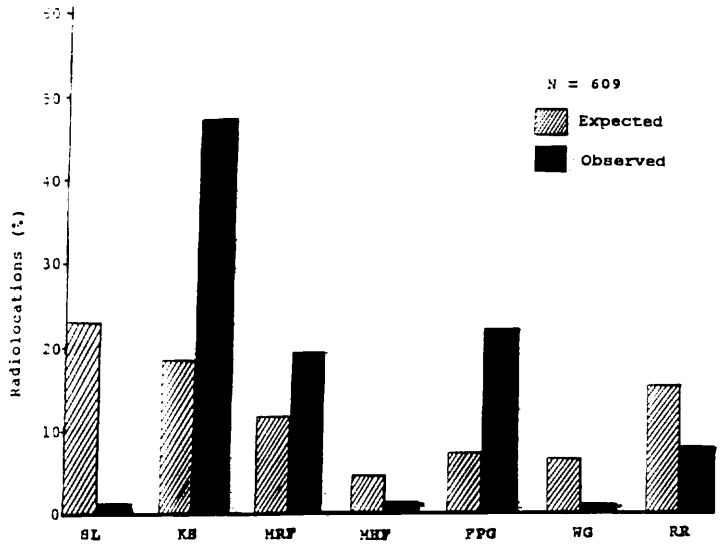


Fig. 3. Seasonal home ranges of one female R. unicornis with calf (frequency no. 235), Royal Bardia National Park 1990-1991.



SL = Sal forest, KS = Khair-sissoo forest, MRF = Moist riverine forest, MHF = Mixed hardwood forest, FPG = Floodplain grassland, WG = Wooded grassland, RR = River and riverbeds.

Fig. 4. Distribution of radiolocations among habitat types used by R. unicornis within the central part of the study area between February 1990 and June 1991.

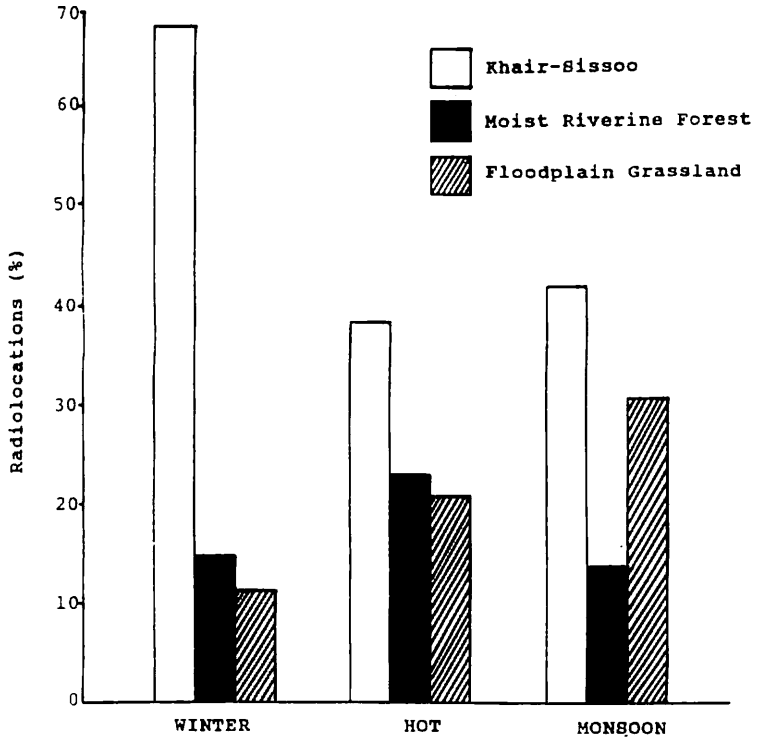


Fig. 5. Relative proportion of radiolocations on preferred habitat types within different seasons. Royal Bardia National Park 1990-1991.