Chapter 4
Results

4.1. Behaviour Studies of Translocated Rhinos

4.1.1 Behaviour in First 90 days after Release

Just after release, rhinos went exploring different areas of the Manas NP. Throughout this (90 days) period of settling, an intensive monitoring was undertaken for the released rhinos. During this period, adult males (R1, R2 and R5) (n=3) were observed 294 times. Adult females (R3, R6, R13 and R8) (n=4) were located and observed 362 times and calves (R7, R14 and R11) (n=3) were located and observed for about 235times respectively.

Table 4.1 Activities observed in Adult Males (R1, R2 &R5)

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Wallowing (%)	Walking (%)	Resting (%)
R1	23	95	42	5	20	11	22
R2	30	118	39	8	22	16	14
R5	20	81	52	9	14	17	9

As per the analysis, it was observed that among adult males (R1, R2 and R5), the grazing proportion was maximum with R5 (52%) and lowest with R2 (39%). Browsing was lowest with R1 (5%) while maximum browsing proportion was observed with R5 (9%) among adults. Adult male R2 preferred waterholes in grassland of Chorfuli and Swampy areas of Katajhar and maximum wallowing activity (22%) was observed there. Walking activity was maximum with R5 (17%) and minimum with R1 (11%) among adult males. The proportion of resting was maximum with R1 (22%) and minimum with R5 (9%) among adult males (Table 4.1) (Fig 4.1).

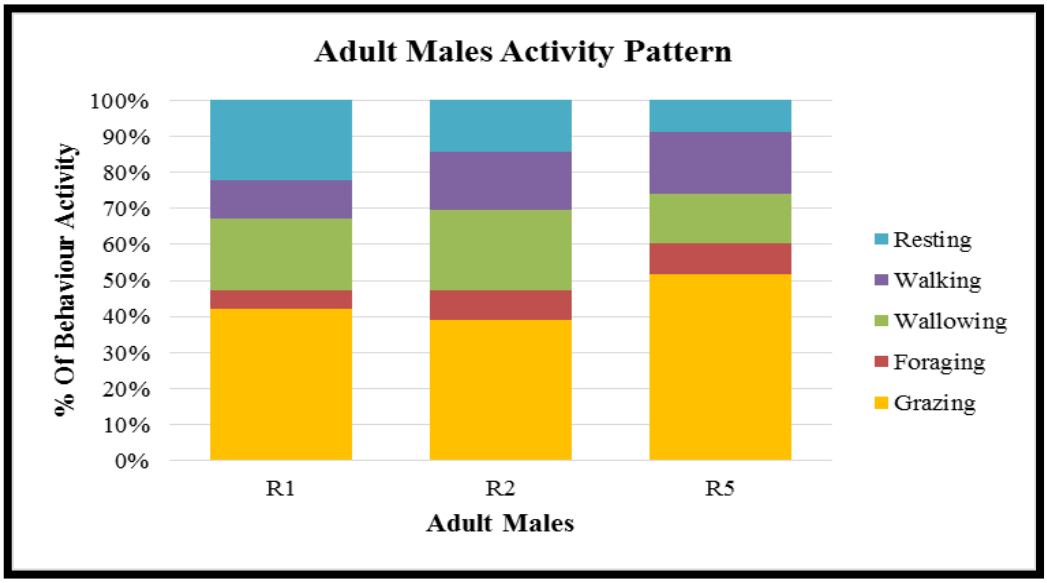

Fig. 4.1 Adult Males' (R1, R2, &R5) Activity Pattern

As per the analysis among adult females (R3, R6, R13 & R8) the grazing proportion was maximum with solitary adult female R8 (50%) and minimum with R3 (43%). Adult female R3 was separated from her female calf just after 26 days from

release. Another two adult females R6 had 46% of grazing activity and R13 had 48% of grazing observed. The same pattern of browsing activity (7%) was observed with adult females R3, R6 and R8. The lowest browsing was observed with adult female R13 (4%). Wallowing activity was maximum with R3 (18%) while minimum with R13 (9%) among adult females. Walking was maximum with R13 (33%) while minimum walking activity was observed with R6 (18%) among adult females. Adult females R3 and R6 displayed 12% resting activity each and minimum resting activity was observed with solitary adult female R8 (2%) (Table 4.2) (Fig 4.2).

Table 4.2 Activities observed in Adult Females (R3, R6, R13&R8)

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Wallowing (%)	Walking (%)	Resting (%)
R3	24	99	43	7	18	19	12
R6	33	135	46	7	17	18	12
R13	19	82	48	4	9	33	7
R8	11	46	50	7	15	26	2

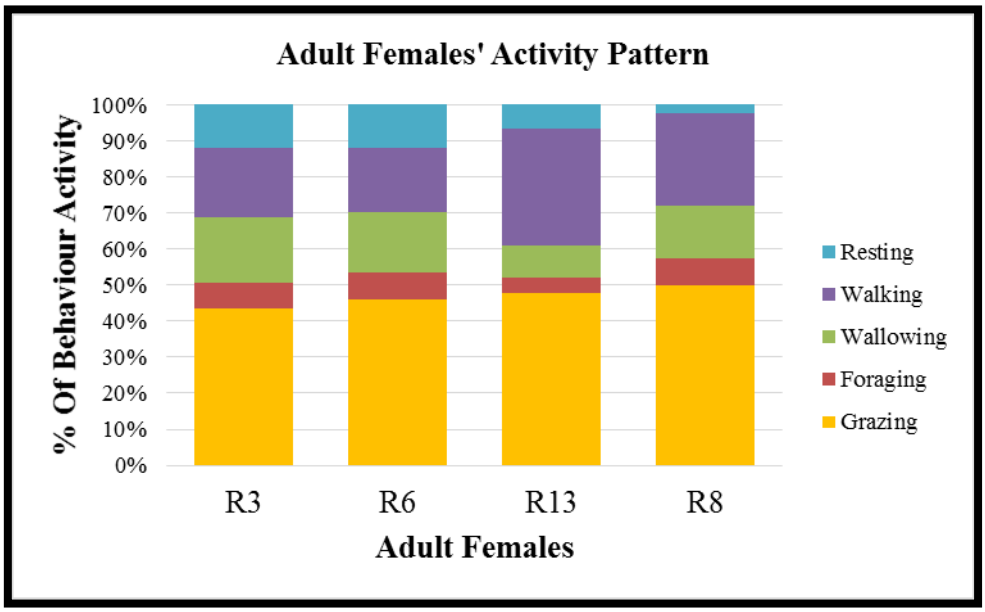

Fig. 4.2 Adult Females' (R3, R6, R13 & R8) Activity Pattern

There were slight variations in activity pattern observed among rhino calves (R7, R14 & R11). Male rhino calves (R7 and R14) always associated with their mothers while female calf (R11) got dissociated from her mother after release at MNP and lived alone. Grazing activity of male calf R14 had maximum (46%) and other two calves (R7 and R11) displayed equal proportion of grazing activity (44%).

Table 4.3 Activity observed in Rhino Calves (R7, R14 &R11)

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Wallowing (%)	Walking (%)	Resting (%)
R7	36	146	44	9	17	17	13
R14	11	46	46	15	11	24	4
R11	10	43	44	9	0	47	0

Browsing activity was maximum with male calf R14 (15%) and 9% browsing was observed with another male calf R7 and female calf R11 each. Wallowing activity was observed only with male calves R7 (17%) and R14 (11%) while their female counterpart did not show wallowing activity. Walking activity was observed maximum with female calf R11 (47%) while among male calves R14 displayed 24% walking activity and R7 only 17% walking. Resting activity was restricted to male calves and no resting activity was observed with female calf R11. Among male calves,13% resting was displayed by R7 while 4% resting activity was displayed by R14 (Table 4.3) (Fig 4.3).

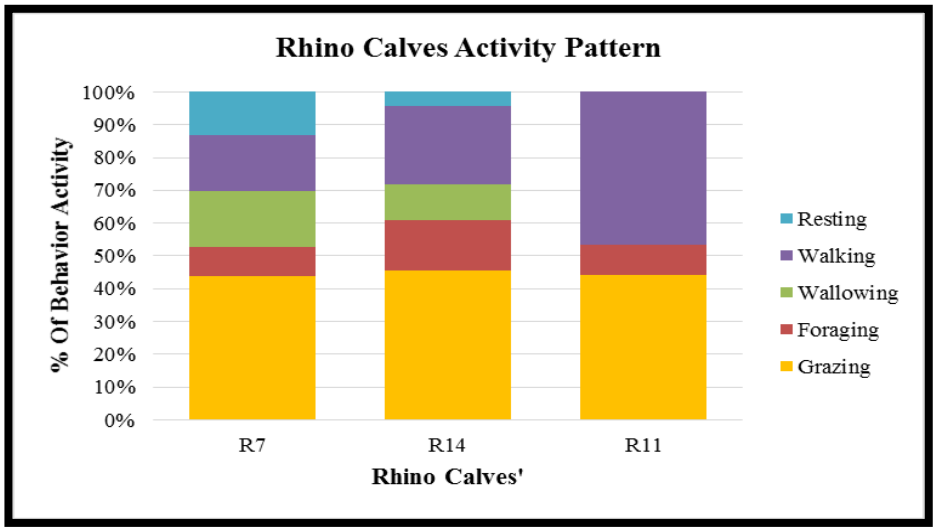

Fig. 4.3 Rhino calves (R7, R14 & R11) Activity Patterns

As per the analysis, it is observed that grazing activity of adult males (R1, R2 and R5) 44.3±3.9. The adult females (R3, R6, R13 and R8) and calves (R7, R14 and R11) were about 47±1 and 45±1 respectively. Adult females were found in more

grazing activity as compared to adult males and calves. Browsing was highest with calves 11±2 while adult males browsing were 7.5±1.1 and adult females 7±1.

Average maximum wallowing activity was 18.5±1 observed with adult males. During this period, maximum wallowing was observed among males from morning 8:00 - 16:00hours but sometimes short duration (1-2 hours) wallowing early morning (5:00-7:00 hours) and evening (18:00-19:30hours) observed among adult males. Adult female's average wallowing was 15±2 and 9±5 with calves. They were observed to wallow 9:00-14:00 hours in mid-day. Wallowing incidences were very minimum during mornings and evenings among adult females and calves. Resting activity was maximum with adult males (15.1±3.1) and minimum with adult females (2±2). The calves displayed a resting average of 6±4 (Fig.4.4).

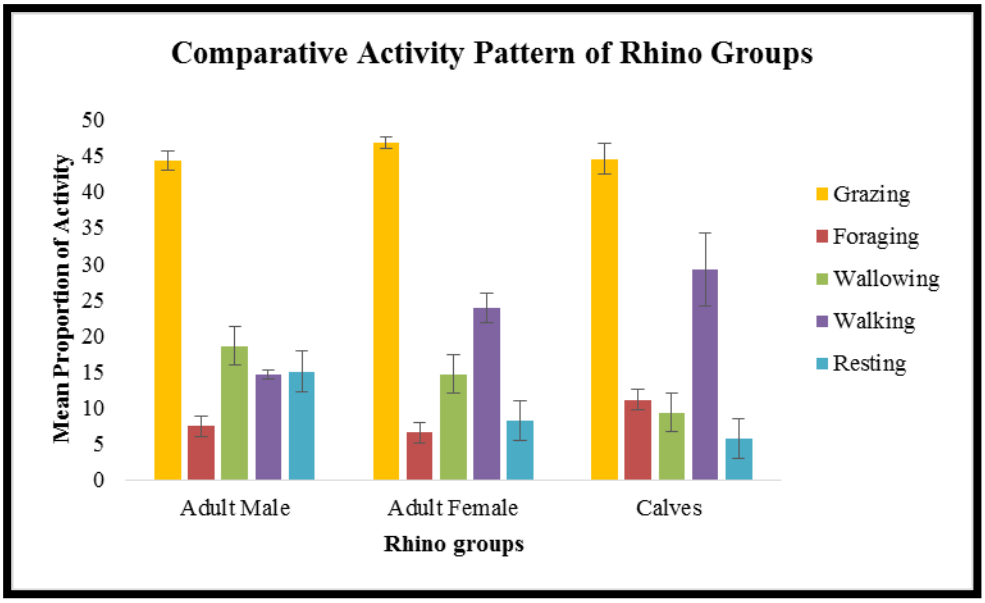

Fig. 4.4 Average Activity Pattern of Rhinos

As per the analysis, it is observed that there was insignificant activity pattern observed among adult males (R1, R2 and R5) with adult females (R3, R6, R13 and R8)

(χ^2 = 5.28, df = 3, NS). Among three groups of rhinoceros (adult male, adult female and calves), behaviour observation was not found significant during the period of 90 days after release at Manas NP (χ^2 = 5.86, df = 6, NS).

4.1.2 Seasonal Activity Pattern of Rhinos

MNP falls under four distinct seasons i.e. pre-monsoon, monsoon, retreating monsoon and winter (Borthakur, 1986). It was observed that rhinos change their behaviour according to the season. Different behaviour patterns in the rhinos in relation with seasons are discussed below.

4.1.2.1 Pre- monsoon

During pre- monsoon period, rhinos were tracked 1326 times and observed 1089 times. Adult males (R1, R2 and R5) were observed 425 times (32%), adult females (R3, R6, R13 and R8) 398 (30%) and calves (R7, R14 and R11) were observed 266 (20%) times out of the total effort. The researcher was unable to locate and observed rhinos for 237 (18%) of times due to difficult terrain, dense vegetation and when rhinos were inside water.

In pre-monsoon, maximum grazing activity was observed with R5 (adult male) (50%). Other adult males, R1 and R2 showed 48% and 32% of grazing respectively. Browsing was maximum with R2 (16%) among adult males. Adult males, R1 and R5 showed 11% and 9% browsing respectively.

Wallowing activity was observed maximum with R2 (31%) among the adult males. The adult males R1 and R5 exhibited 27% and 19% wallowing activity respectively in this season.

Walking activity was observed maximum with adult male R5 (16%) and equal proportions of walking (11%) was observed with other adult males R1 and R2.

As compared to other activities, resting was found to be very less. Maximum resting activity was observed with R2 (9%) among the adult males. R1 displayed 4% resting and R5 with 6% in resting among adult males (Table 4.4) (Fig.4.5). Variations of activity pattern among adult males were observed insignificant (χ^2=12.863, the *P* value was .11664).

Table 4.4 Adult Males' (R1, R2 & R5) Activity in Pre-Monsoon

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Resting (%)	Walking (%)	Wallowing (%)
R1	51.25	205	48	11	4	11	27
R2	35	140	32	16	9	11	31
R5	20	80	50	9	6	16	19

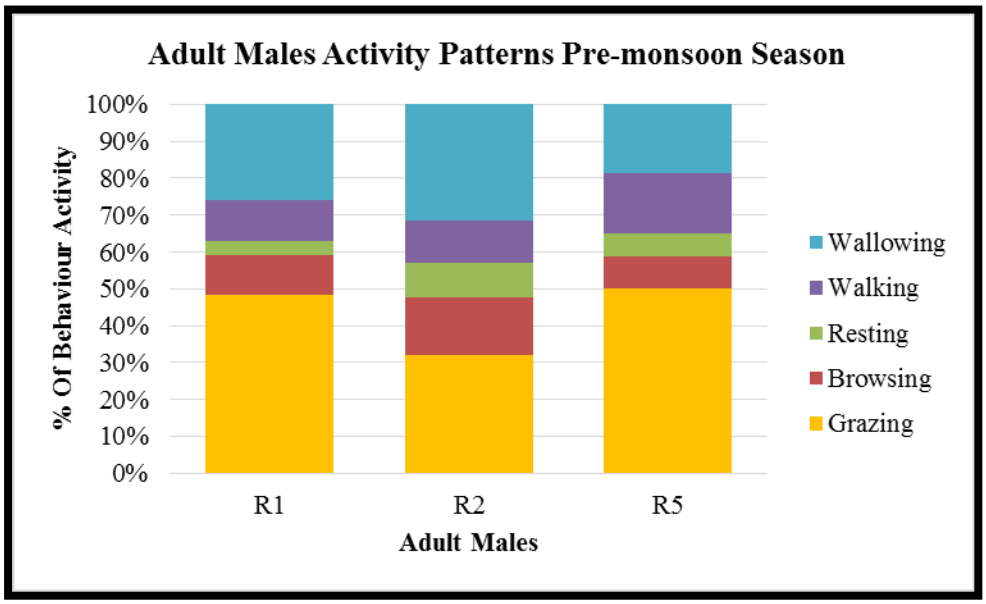

Fig. 4.5 Adult Males' (R1, R2 &R5) Activity Pattern in Pre-Monsoon Season

As compared to adult males, grazing activity was maximum with adult females. Adult females with calves R6 (64%) and R13 (60%) had more grazing activities than solitary adult female R8 (53%). However, adult female R3, whose female calf got separated after 26 days from the release at MNP, had also same grazing activity (64%) with other adult females with calves.

Browsing was absent in adult females with calves but was observed with solitary female R8 (7%). Both adult females R3 and R6 showed 11% resting activity each.

Resting was minimum with R13 (4%) and solitary female R8 displayed only 6% resting activity among adult females.

Walking activity was maximum with R13 (23%) among adult females. An equal proportion of walking (13%) was observed with adult females R3 and R6. Solitary female R8 displayed 19% walking activity.

Wallowing proportion was almost equal with R13 (13%), R3 (14%) and R6 (12%). It was observed maximum with solitary female R8 (15%) among adult females (Table 4.4) (Fig. 4.6). Although some behaviour variation was observed among females overall behaviour pattern among adult females was insignificant (χ^2=20.2234, *P* value 0.629).

Table 4.5 Adult Females' (R3, R6, R13 & R11) Activity in Pre-Monsoon

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Resting (%)	Walking (%)	Wallowing (%)
R13	12	48	60	0	4	23	13
R3	22	88	64	0	10	13	14
R6	38	152	64	0	10	13	12
R8	28	110	53	7	6	19	15

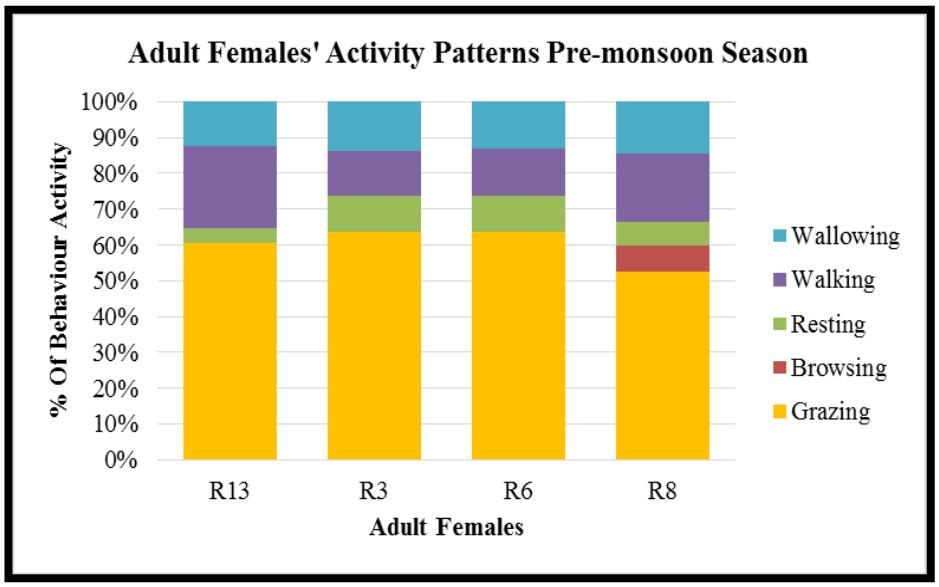

Fig. 4.6 Adult Females' (R3, R6, R13 & R8) Activity Pattern in Pre-Monsoon Season.

Grazing proportion was maximum with calves (R7, R14 and R11) than adult males (R1, R2 and R5) and adult females (R3, R6, R13 and R8). R11's (Female calf) grazing account was 60%, male calves R14's 65% and R7 showed 57% of grazing.

Browsing was 7% with (male calf) R7 and (female calf) R11 while 5 % browsing was observed with R14 (male calf).

Resting was maximum in male calf R7 with 12%. Walking was maximum with female calf R11 (26%) and another male calf R14 with 15%.

The proportion of wallowing activity was maximum with male calf R7 (14%) and minimum with female calf R11 (Table 4.6) (Fig.4.11). There were significant behaviour variations observed among calves (χ^2=23.555, *P* value 0.0027 result was significant at $p<.05$).

Table 4.6 Rhino Calves' (R7, R14 & R11) Activity in Pre-Monsoon

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Resting (%)	Walking (%)	Wallowing (%)
R11	11	45	60	7	2	26	4
R14	14	55	65	5	4	15	11
R7	42	166	57	7	12	11	14

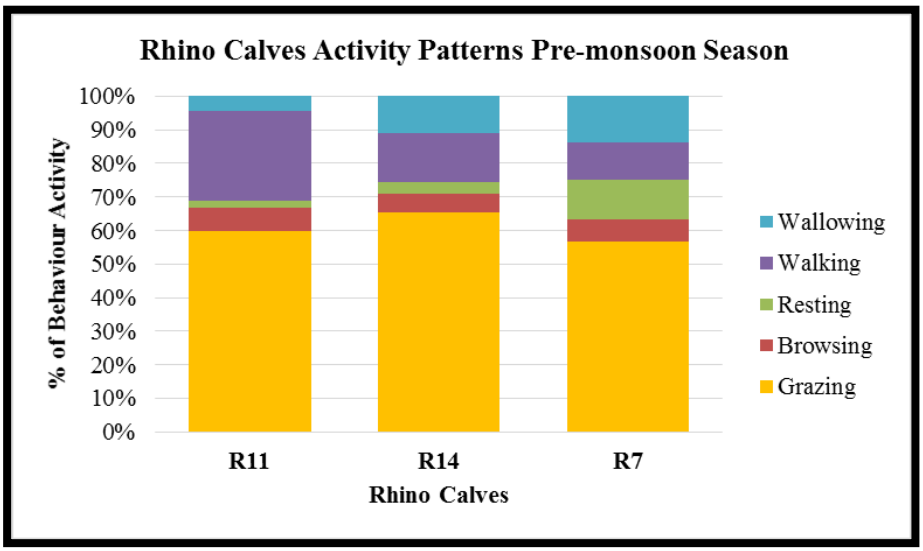

Fig. 4.7 Calves' (R7, R14 &R11) Activity Pattern in Pre-Monsoon Season

Average grazing activity was 43±6 with adult males (R1, R2 and R5), 60±2.6 with adult females (R3, R6, R13 and R8) and 61±3 with calves (R7, R14 and R11). Average browsing was 12±2.07 with adult males, 2±1.8 with adult females and 6±0 with calves.

The resting average was maximum with adult females (8±1.5). Adult males and calves had an almost equal average of resting with 6±3.

Wallowing was 25±6.3 with adult males, following adult females average 15±0.4 and 10±3 with calves. Adult females and calves equal walking average 17±5 while walking average of adult males were 13±1.6 (Fig 4.8).

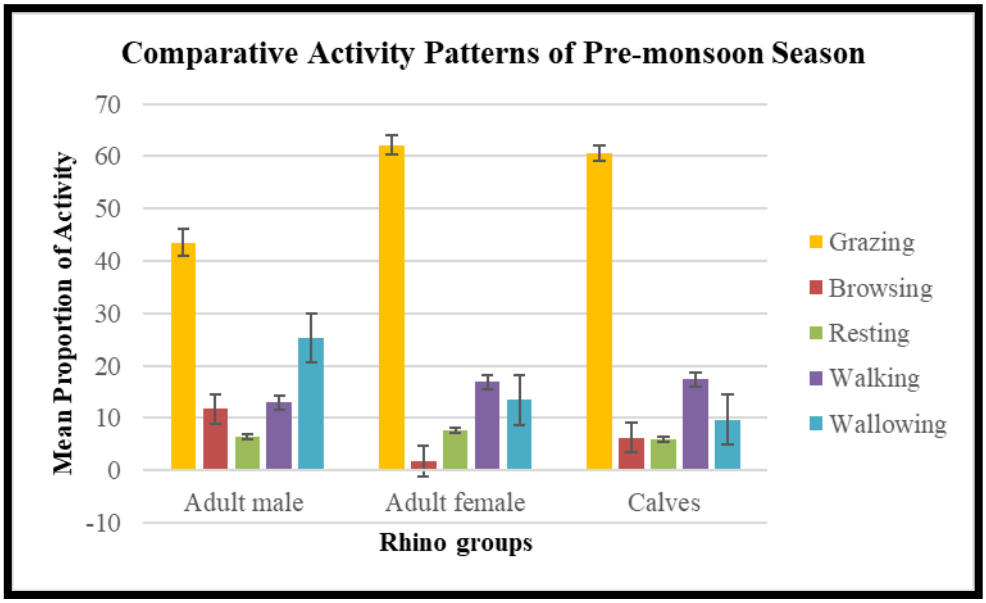

Fig. 4.8 Comparative Activity Pattern of Rhinos (Pre-monsoon)

4.1.2.1.1 Temporal Activity Pattern of Rhinos during Pre-monsoon

As per the analysis of data, grazing activity was 19% with adult males (R1, R2 and R5) in the morning hours (06:00-10:00 hours). In the mid-day hours (10:00-14:00 hours) 3%, at afternoon (14:00-18:00 hours) 15% while in the evening till morning (18:00-6:00hours), only 7% grazing activity was observed. The proportion of wallowing activity was 9% in the morning hours while in the mid-day period it was 7% and at afternoon 9%. During evening to morning (18:00-06:00), only 1% wallowing activity was observed. Browsing was observed 5% in morning hours and 1% in the mid-day and 2% in the afternoon. 2% browsing activity was observed in the night hours. Walking activity was 3% in the morning hours, 2% in the mid-day hours and 5% in the afternoon hours. During night hours, 3% walking activity was found. The proportion of resting

activity was comparatively low and only 2% resting activity was observed in the morning hours, 1% in the midday hours and 3% in the afternoon hours. No resting was observed during the night hours (Table 4.7) (Fig. 4.9).

Table 4.7 Adult Males' (R1, R2 & R5) Temporal Activity in Pre-monsoon (In %)

Activity	18:00-6:00	6:00-10:00	10:00-14:00	14:00-18:00
Grazing	7	19	3	15
Browsing	2	5	1	2
Resting	0	2	1	3
Walking	3	3	2	5
Wallowing	1	9	7	9

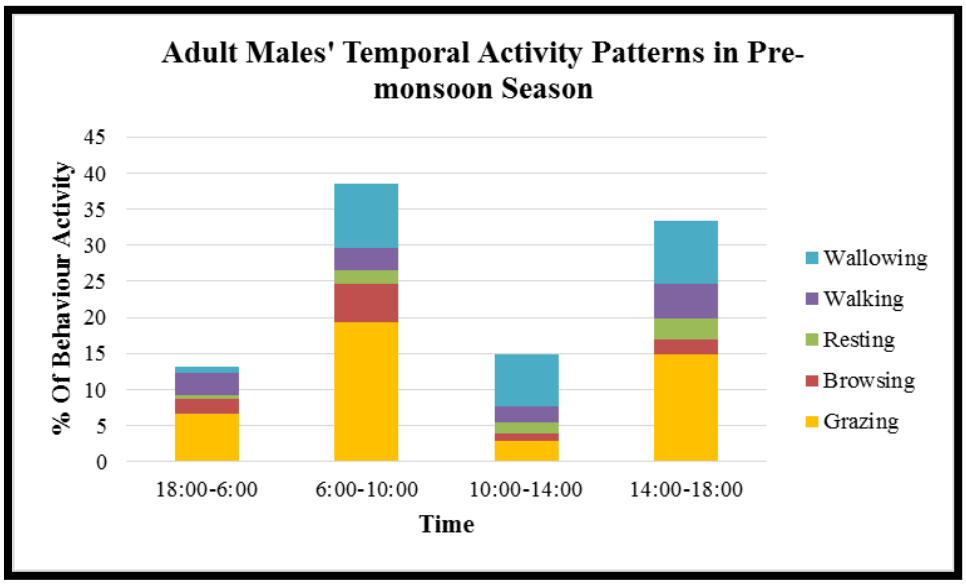

Fig. 4.9 Adult Males' (R1, R2 &R5) Temporal Activity Patterns in Pre-monsoon Season

The proportion of grazing activity of 25% in the morning hours and 27% in the afternoon hours was observed with adult females (R3, R6, R13 and R8). Grazing activity was 8% during night hours and 5% at mid-day hours with adult females.

Browsing proportion was observed with adult females (R8) during morning, mid-day and afternoon. There was no resting activity observed in midday hours.

Proportionately, resting activity in adult females (R3, R6, R13 and R8) were 1% in morning, 2% in the afternoon and 1% was in night hours. The proportion of walking activity was 9% in the morning hours, 3% in the mid-day hours, 2% in the afternoon and 3% was in the night hours. Wallowing activity was observed 2% in the morning hours, 6% in the mid-day hours and 9% in the afternoon hours (Table 4.8) (Fig. 4.10).

Table 4.8 Adult Females' (R3, R6, R13 & R8) Temporal Activity in Pre-monsoon (In %)

Activity	18:00-6:00	6:00-10:00	10:00-14:00	14:00-18:00
Grazing	8	25	4	27
Browsing	0	0.3	0.3	0.3
Resting	1	1	0	2
Walking	3	9	2	3
Wallowing	0	2	6	9

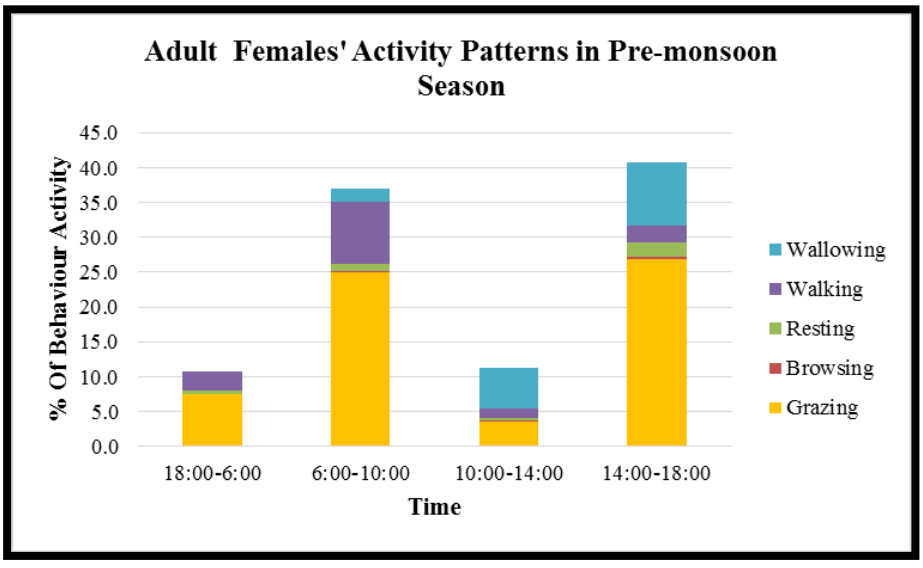

Fig. 4.10 Adult Females' (R3, R6, and R13 &R8) Temporal Activity Patterns in Pre-monsoon Season

Rhino calves were (R7, R14 and R11) following similar temporal patterns with adult females (R3, R6, R13 and R8). Grazing activity was found maximum with calves during the afternoon period (14:00-18:00 hours). In the morning (06:00-10:00 hours), grazing activity of calves were 22%, while in the mid-day (10:00-14:00 hours) and evening to morning (18:00-06:00 hours), an equal proportion of grazing activity (7%) was observed. Wallowing activity was observed 3% in the morning period, 9% in the mid-day and 7% in the afternoon period. Browsing was 2% in the morning and 3% in the afternoon. No browsing activity was observed in the morning and mid-day period among the calves. 4% walking was observed in the morning, 6% in mid-day and 9% in afternoon period. Only 1% walking was observed during the night. The proportion of resting activity was lowest and only 2% resting activity was observed in the morning and afternoon (Table 4.9) (Fig. 4.11).

Table 4.9 Rhino Calves' (R7, R14 & R11) Temporal Activity in Pre-monsoon (In %)

Activity	18:00-6:00	6:00-10:00	10:00-2:00	2:00-6:00
Grazing	7	22	7	24
Browsing	0	2	0	3
Resting	0	2	0	2
Walking	1	4	2	6
Wallowing	0	3	9	7

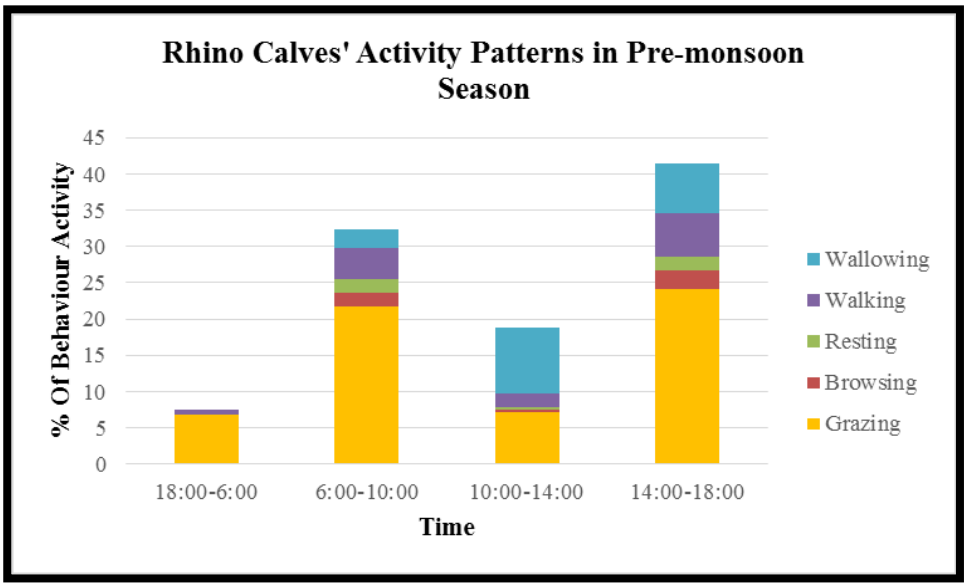

Fig. 4.11 Rhino Calves' (R7, R14 &R11) Temporal Activity Patterns in Pre-monsoon Season

During this period, all adult males (R1, R2 and R5) displayed overall 3±0.2 mean behaviour activity in night hours. Adult females (R3, R6, R13 and R8) displayed 2±0.1 and rhino calves (R7, R14 and R11) 2±0.4 mean behaviour activity during night hour. Adult males displayed mean activity of 8±0.1, adult females 7±0.1 and calves (6±0.4 in the morning hours.

During the mid-day hours, adult males displayed 3±0.2, adult females 2±0.2 and calves displayed 4±0.4 mean behaviour activity. In the afternoon hours, adult males displayed 7±0.1, adult females 8±0.1 and calves 8±0.2 mean behaviour activity during pre-monsoon season. Overall grazing peaks observed for all rhinos were in the morning and afternoon hours (Fig.4.12). Overall temporal behaviour among all age group of rhinoceros was observed insignificant (χ^2=1.227, *P* value was .975531)

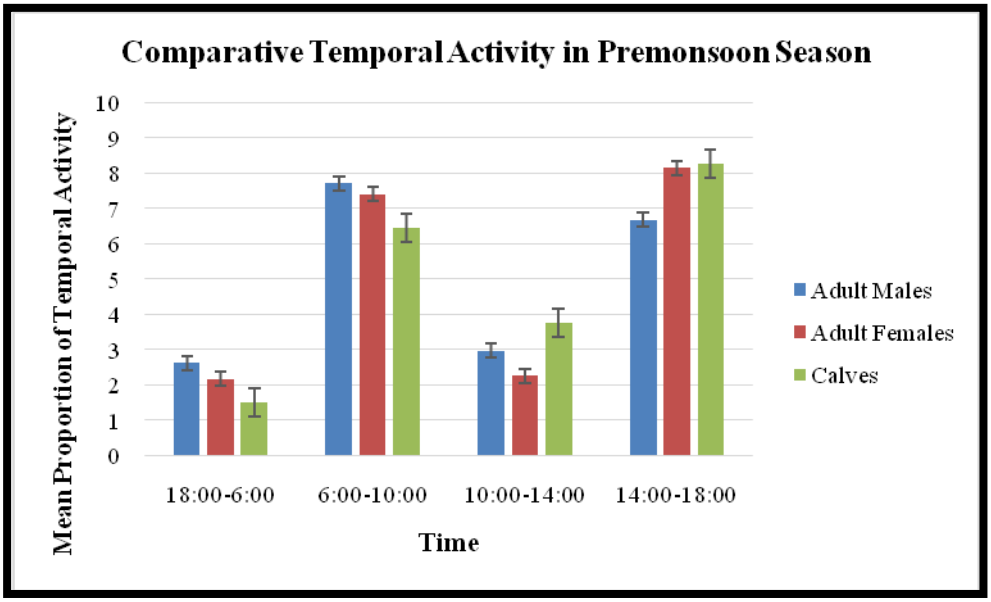

Fig. 4.12 Comparative Temporal Activity of Rhinos during Pre-monsoon Period

4.1.2.2 Monsoon period

During the monsoon period, rhinos were tracked 1840 times and out of total efforts, they were observed for about 1323 times (71%). In this period, adult male rhinos (R1, R2 and R5) were observed about 654 times (49.43%), adult females (R3, R6, R13 and R8) were observed about 367 times (28%) and calves (R7, R14 and R11) were observed 302 times (23%).

Out of all activities in the monsoon period, grazing activity was maximum with adult male rhinos (R1, R2 and R5). Adult male R1 exhibits 61%, R2 47%, and R5 53% of grazing activity during the monsoon period. Browsing was minimum and only 1% was observed with R2 among adult males. The proportion of resting was also minimum and only 2% resting activity was observed with adult males R1 and R2 respectively. No resting activity was observed with another adult male R5. The adult males were quite explorative and 12% walking activity was exhibited by R1, 24% by R2 and 25% by R5.

Wallowing proportion was the second highest activity among adult males. R1, R2, and R5 displayed 25%, 27% and 23% wallowing activity respectively (Table.4.11) (Fig 4.13). The overall pattern of behaviour of adult rhinoceros was found to be insignificant (χ^2=7.776, the *P* value was .4554).

Table 4.10 Adult Males' (R1, R2 & R5) Behaviour during Monsoon Season

Sl No	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Resting (%)	Walking (%)	Wallowing (%)
R1	99	394	61	0	2	12	25
R2	52	207	47	1	1	24	27
R5	14	53	53	0	0	25	23

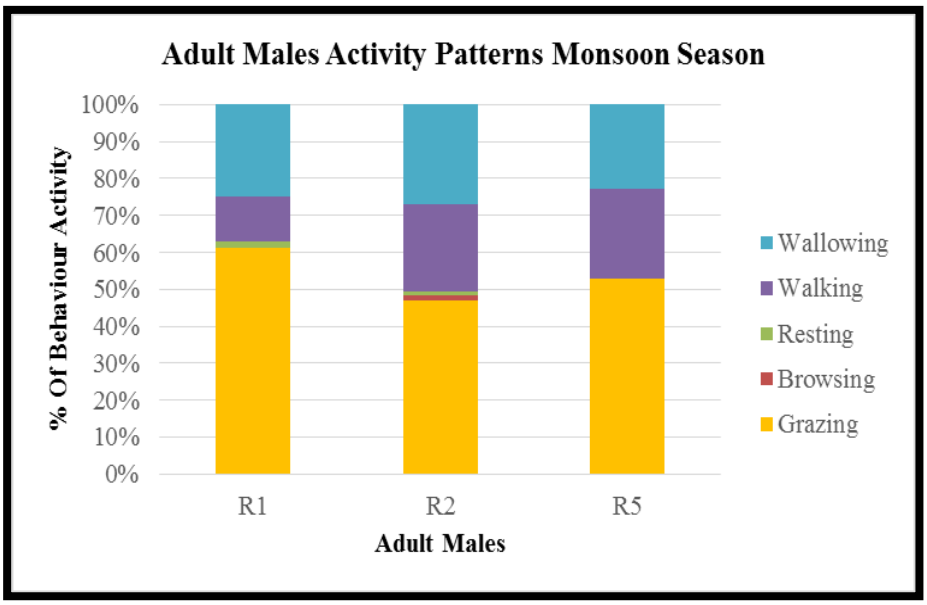

Fig. 4.13 Adult Males' (R1, R2 &R5) Activity Patterns in Monsoon Season

Proportions of grazing were maximum with adult females with calves (R3, R6 and R13). Grazing proportion was maximum with adult female R3 (77%). It was 75% with R6 and 65% with R13. Solitary adult female (R8) displayed only 59% of grazing.

Browsing activity was not observed among adult females during the monsoon period. Resting proportion was 9% with R13, 2% with R3, 1% with R6 and 3% resting proportion observed with R8 among adult females. Walking activity was maximum in R8 (28%) and R13 (18%) among adult females. Resting proportion was 9% with R3 and 14% with R6. Wallowing activity was almost equal among adult females. Wallowing proportion was 8% with R13, 12% with R3, 10% each with R6 and R8 adult females (Table 4.11) (Fig.4.14). Adult females' overall activity pattern was significant (χ^2=25.553, *P* value 0.0124 result was significant at $p<.05$).

Table 4.11 Adult Females' (R3, R6, R13 & R8) Behaviour during Monsoon Season

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Resting (%)	Walking (%)	Wallowing (%)
R13	23	92	65	0	9	18	8
R3	25	100	77	0	2	9	12
R6	37	146	75	0	1	14	10
R8	8	29	59	0	3	28	10

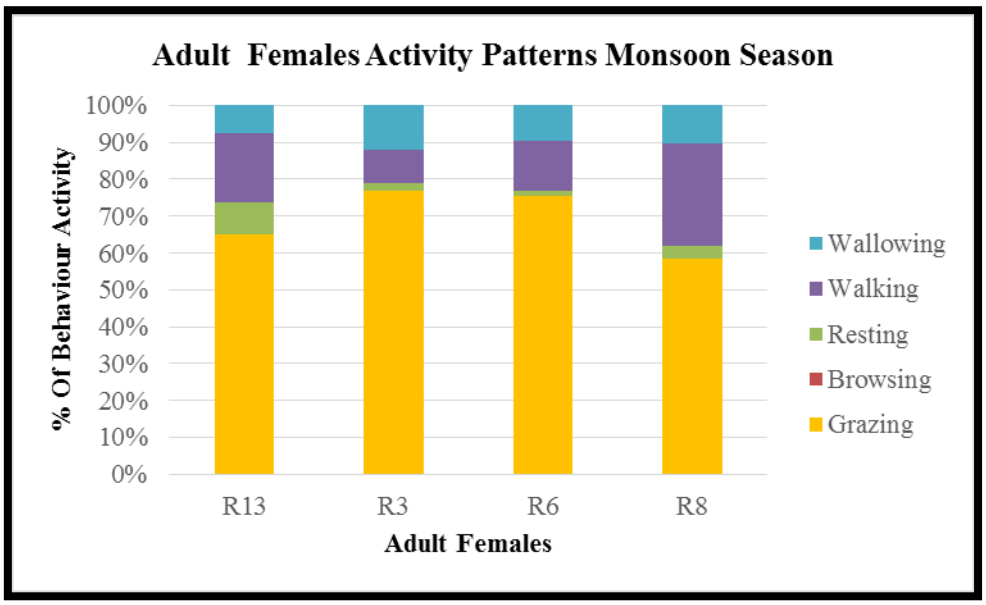

Fig. 4.14 Adult Females' (R3, R6, and R13 &R8) Activity Patterns in Monsoon Season

The behaviour of female calf R11 was relatively different than that of the other two male calves R7 and R14. Grazing proportions of female calf R11 were 42%. While male calves' grazing proportions were fairly more than female calf. R7 and R14's grazing proportion was 68% and 66% respectively. The proportion of browsing activity was not found with female calf R11 but it was 5% and 11% with male calves R7 and R14 respectively. Resting proportion was 5% with female calf R11, 8% with R14 and 3% with R7. Maximum walking activity was observed with female calf R11 (50%). Male calves had 11% each walking proportions. Wallowing was observed minimum with female calf R11 (3%) and male calves had 8% each wallowing proportion (Table 4.12) (Fig. 4.15). Behaviour variation among calves observed significant (χ^2=63.078, *P* value 0.00001 result was significant at $p<.05$).

Table 4.12 Rhino Calves' (R7, R14 & R11) Behaviour during Monsoon Season

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Resting (%)	Walking (%)	Wallowing (%)
R11	10	38	42	0	5	50	3
R14	22	85	68	5	8	11	8
R7	45	179	66	11	3	11	8

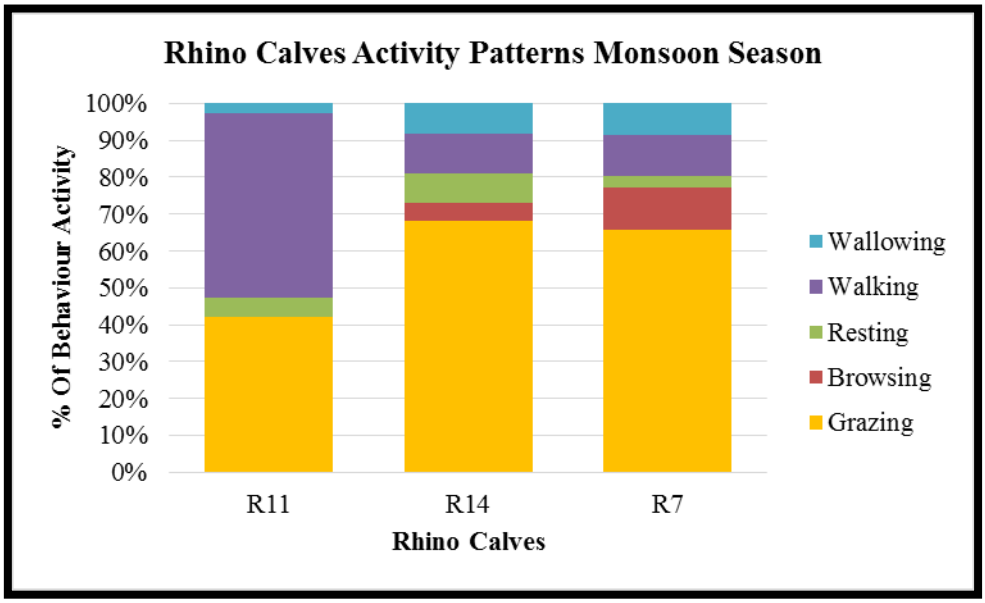

Fig. 4.15 Rhino Calves' (R7, R14 &R11) Activity Patterns in Monsoon Season

During monsoon season, average grazing proportion of adult males (R1, R2 and R5) was 54±4.2. Adult females' (R3, R6, R13 and R8) average grazing proportion was 69±1.2 and calves (R7, R14 and R11) had grazing average of 59±1.4. Browsing was absent with adult females while it was 1±0.5 with adult males and 5±3.2 with calves respectively. Resting average was 1±0.5 with adult males, 4±2 with adult females and

6±1.4 with calves. Walking activity average was 20±4 observed with adult males and 17±4 with adult females. Calves had a 24±1.1 walking average. Average wallowing activity with adult males was 25±4. Females and calves had wallowing averages of 10±1 and 6±1.9 respectively (Fig. 4.16).

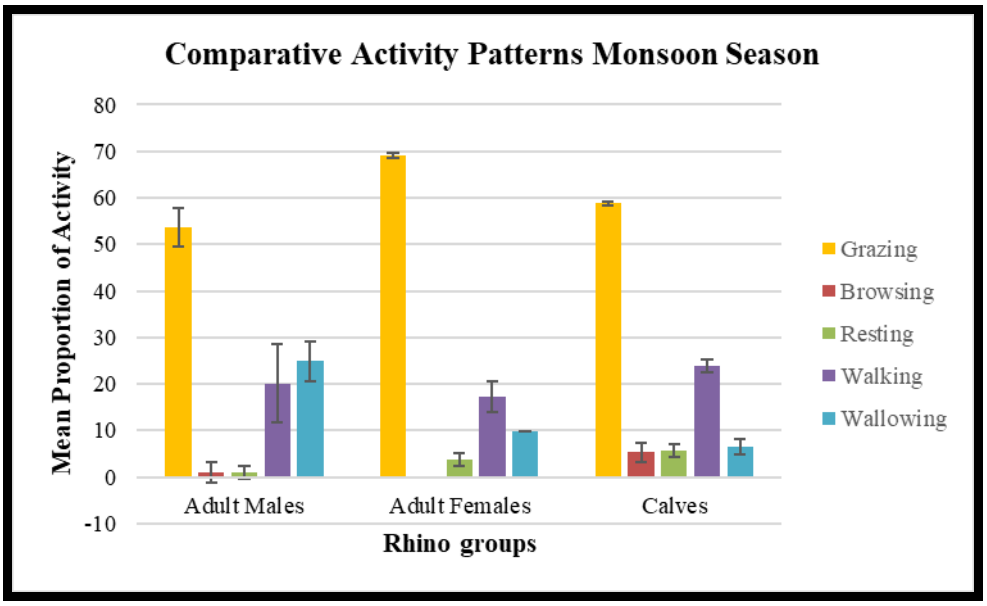

Fig. 4.16 Comparative Activity Pattern of Rhinos in Monsoon Period

4.1.2.2.1 Temporal Activity Pattern of Rhinos during Monsoon

During monsoon period, grazing activity was maximum (28%) among adult males (R1, R2 and R5) in night hours (18:00 - 6:00 hours). Grazing activity was 12% in the morning hours (06:00 –10:00 hours) and only 3% in the mid-day hours (10:00-14:00 hours). In the afternoon, grazing activity was 13% with adult males. Browsing was only 1% during monsoon at morning hours. Resting was also 1% with adult males at night hours.

In relation to grazing activity, walking activity was maximum during the night hours (9%). It was 3% in the morning hours, 1% in the mid-day time and 3% in the

afternoon. Wallowing activity was maximum among males in the morning and mid-day hours. In the morning hours, 11% wallowing was observed while it was 10% during mid-day hours. In the afternoon, 4% wallowing activity was observed among adult males (Table 4.13.) (Fig. 4.17).

Table 4.13 Adult Males' (R1, R2 & R5) Temporal Activity Proportions during Monsoon (In %)

Activity	18:00-6:00	6:00-10:00	10:00-14:00	14:00-18:00
Grazing	28	12	3	13
Browsing	0	1	0	0
Resting	1	0	0	0
Walking	9	3	1	3
Wallowing	1	11	10	4

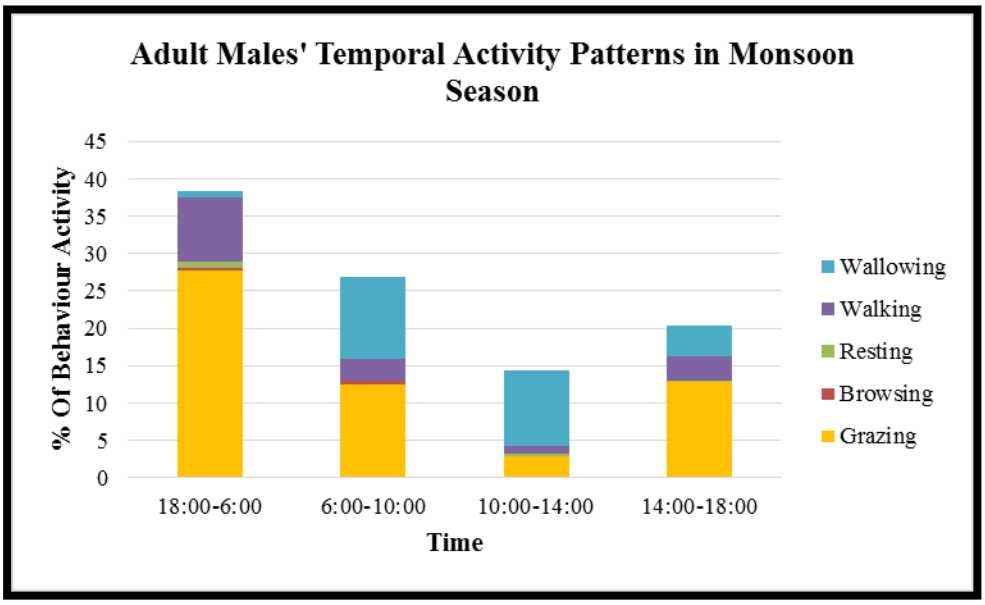

Fig. 4.17 Adult Males' (R1, R2 &R5) Temporal Activity Patterns during Monsoon Season

As per the analysis of recorded data, two grazing peaks were observed during 24 hours. They are 29% during afternoon hours (14:00-18:00 hours) and 20% in the night hours (18:00-6:00hours). During morning and mid-day hours, 17% and 5% grazing activity was observed respectively among adult females (R3, R6, R13 and R8). Browsing was not observed among adult females during the monsoon season. Only 1% resting activity was observed in the night hours and 3% in afternoon hours. Walking activity was 4% in the morning hours, 1% in the mid-day hours, 5% in the afternoon and 4% in the evening hours. Wallowing activity was 3% in the morning hours, 2% in the noon, 4% in the afternoon hours and 1% in the night hours (Table 4.14.) (Fig. 4.18).

Table 4.14 Adult Females' (R3, R6, R13 & R11) Temporal Activity during Monsoon (In %)

Activity	18:00-6:00	6:00-10:00	10:00-14:00	14:00-18:00
Grazing	16	14	7	26
Browsing	2	4	1	1
Resting	0	1	0	3
Walking	4	5	2	5
Wallowing	0	3	2	3

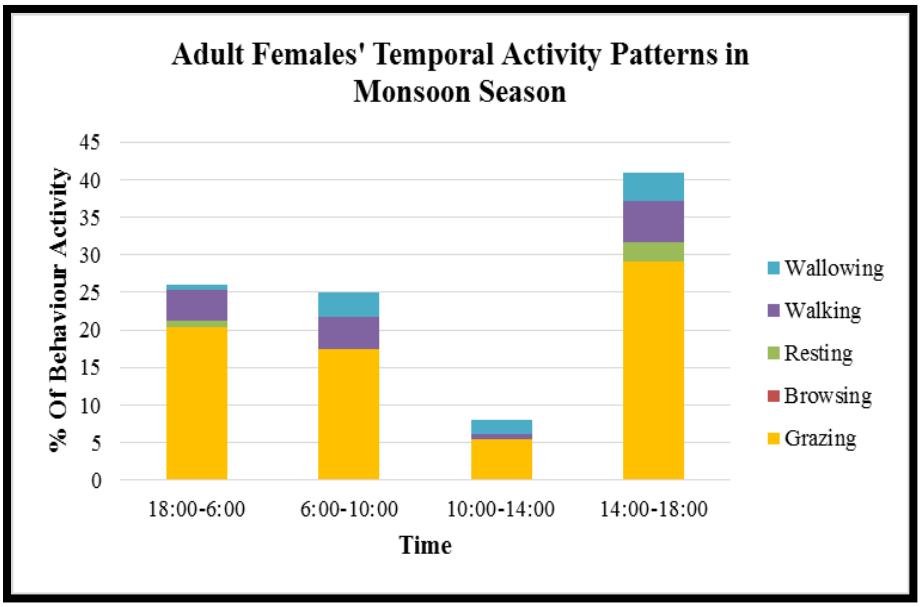

Fig. 4.18 Adult Females' (R3, R6, and R13 & R8) Temporal Activity Patterns during Monsoon Season

Temporal activity patterns of the rhino calves (R7, R14 and R11) were almost similar to that of adult females (R3, R6, R13 and R8). Maximum grazing activity was observed during the afternoon hours (26%) and minimum in the mid-day hours (7%). During morning hours, 14% and 16% at night hours grazing were observed among rhino calves. In contrast to adult females (R3, R6, R13 and R8), rhino calves (R7, R14 and R11) displayed more browsing activity. It was 4% in the morning hours, 1% in the midday hours, another 1% in the afternoon and 2% in the night hours. Resting activity in the morning was 1% and 3% in the afternoon. Walking activity was 5% in the morning hours, 2% in the midday hours, 5% in afternoon and 4% in the night hours. Wallowing activity was 3% in the morning hours, 2% in the noon hours and 3% in the afternoon hours (Table 4.15) (Fig. 4.19).

Table 4.15 Rhino Calves' (R7, R14 &R11) Temporal Activity in Monsoon (In %)

Activity	18:00-6:00	6:00-10:00	10:00-14:00	14:00-18:00
Grazing	16	14	7	26
Browsing	2	4	1	1
Resting	0	1	0	3
Walking	4	5	2	5
Wallowing	0	3	2	3

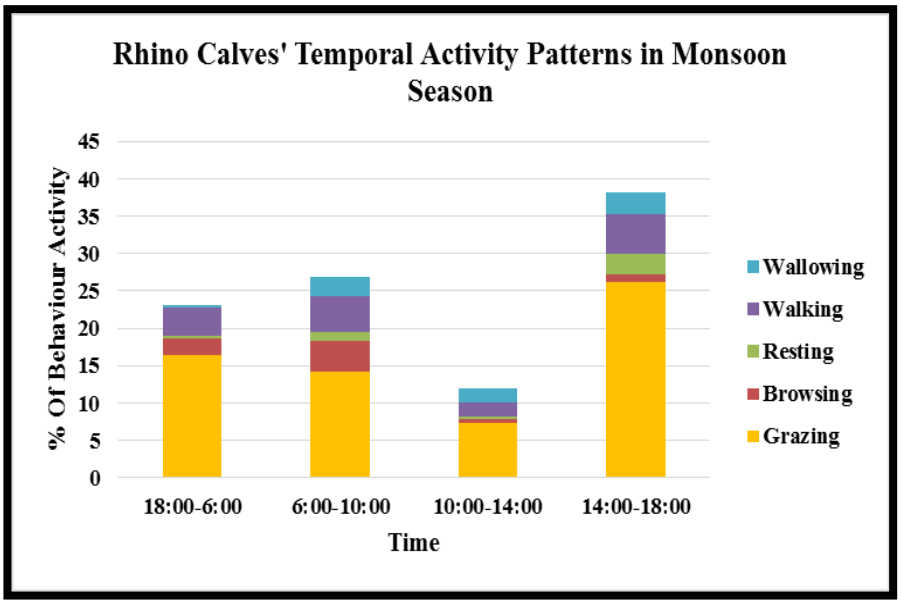

Fig. 4.19 Rhino Calves' (R7, R14 &R11) Temporal Activity Patterns during Monsoon Season

The mean behaviour proportion of the adult males (R1, R2 and R5) was relatively variable than adult females (R3, R6, R13 and R8) and calves (R7, R14 and R11). Adult males' average behaviour proportion was maximum in the night hours with 8±0.1 but it was 5±0.2 among adult females and 5±0.4 with rhino calves.

In contrast to adult males, adult females and calves' mean behaviour proportions were maximum during the evening hour (8±0.1). The mean behaviour of adult males

was 4±0.2 in the afternoon hours. Mean proportion of behaviour was found almost equal in the morning and mid-day hours among three age groups of rhinos (Fig. 4.20). Overall temporal pattern of behaviour activity among all rhinoceros was found to be insignificant (χ^2=2.8857, the *P* value was .82304)

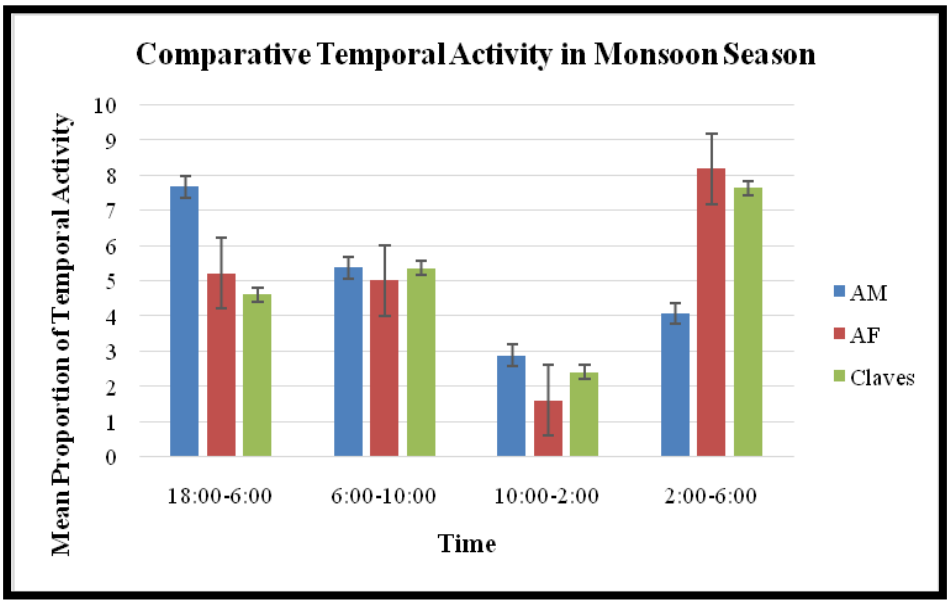

Fig. 4.20 Comparative Temporal Activity of Rhinos during Monsoon Period

4.1.2.3 Retreating monsoon

This is a short duration of the season (October and November). During this period, rhinos were tracked 642 times and observed 491 time (76.47%). Adult males (R1, R2 and R5) were observed 186 times (37.88%), adult females (R3, R6, R13 and R8) 171 times (34.82%) and rhino calves (R7, R14 and R11) were observed for 134 times (27.29%).

Throughout this period, 57% and 69% grazing activity was observed with adult male R1 and R2 respectively. But maximum grazing (69%) was observed with another

adult male R5. Browsing proportion was observed maximum with R2 (22%) and minimum with R1 (17%) among males. No browsing activity was observed with adult male R5. Resting proportion was 3% with R1 and 4% with R5. No resting activity was observed with R2. Walking activity was maximum with R5 (19%) and minimum with R1 (6%) among males. Walking activity was 11% with R2. Wallowing activity was 17% with R1 and 8% with R5. No wallowing activity was observed with R2 (Table 4.16.) (Fig. 4.21). Behaviour variation among males was found to be significant (χ^2=43.0731, *P* value 0.00001 result was significant at $p<.05$).

Table 4.16 Adult Males' (R1, R2 &R5) Behaviour during Retreating Monsoon Season

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Resting (%)	Walking (%)	Wallowing (%)
R1	38	151	57	17	3	6	17
R2	5	9	67	22	0	11	0
R5	7	26	69	0	4	19	8

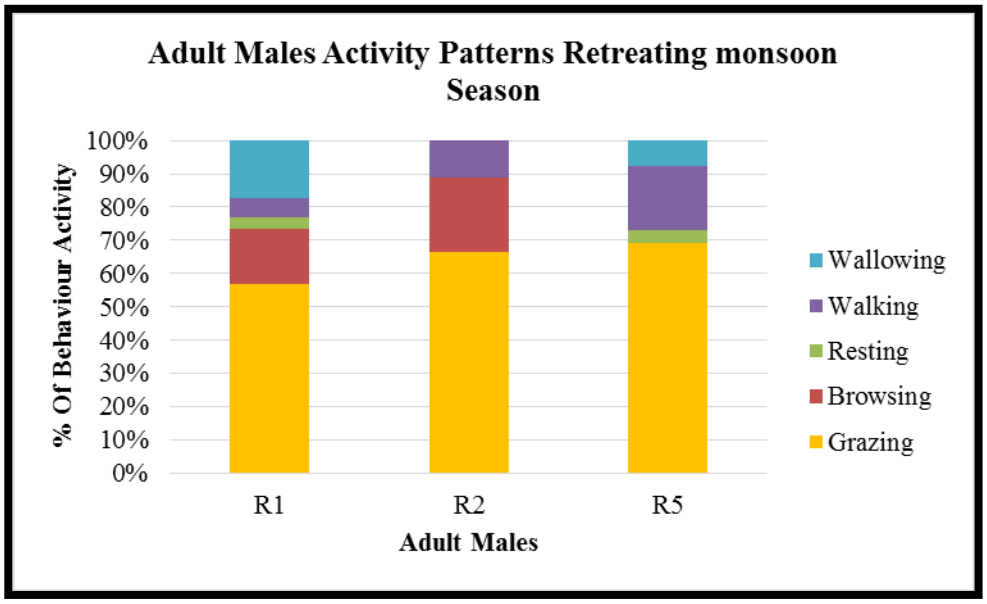

Fig. 4.21 Adult Males' (R1, R2 & R5) Activity in Retreating Monsoon Season

Adult females' (R3, R6, R13 and R8) proportion of grazing activity was comparatively more in the retreating monsoon. Grazing proportion was maximum observed with R6 (83%) among females. R13 had 81%, R3 had 63% and solitary female R8 had 43% of grazing observed during this season. No Browsing was observed in this season with adult females. Resting activity proportion was only observed with R13 (5%). Walking activity was 48% with solitary adult female R8 which was highest among adult females. Walking activity was observed 12% with R13, 13% with R3 and 5% with R6. The proportion of wallowing activity was 23% with R3, 12% with R6, 9% with R8 and only 3% were observed with R13 (Table 4.17) (Fig. 4.22). Behaviour variation among adult females was found to be significant (χ^2=98.679, the *P* value 0.00001 result was significant at $p<.05$).

Table 4.17 Adult Females' (R3, R6, R13 &R8) Behaviour during Retreating Monsoon Season

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Resting (%)	Walking (%)	Wallowing (%)
R13	11	43	81	0	5	12	3
R3	8	30	63	0	0	13	23
R6	19	75	83	0	0	5	12
R8	7	23	43	0	0	48	9

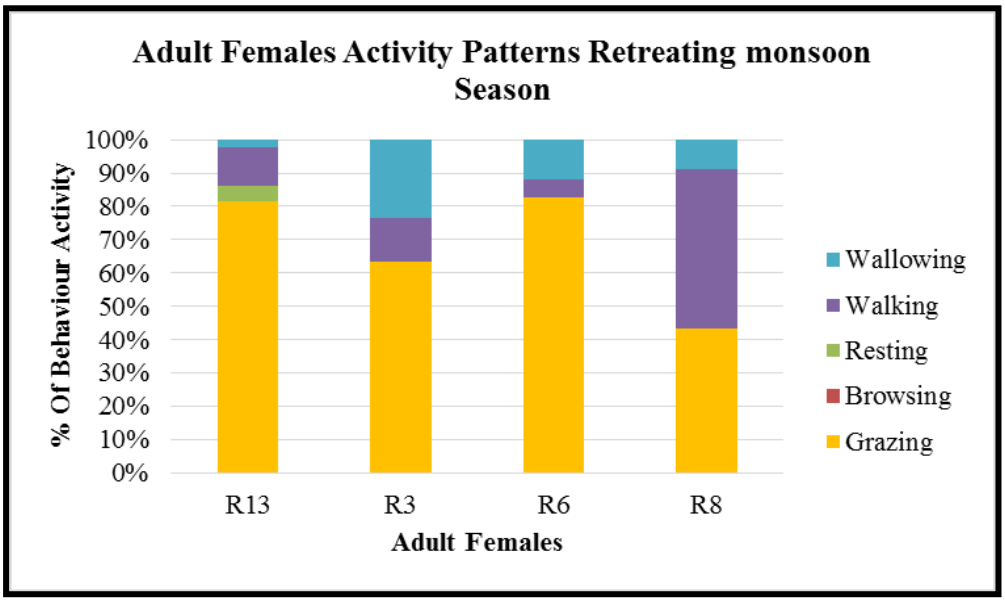

Fig. 4.22 Adult Females' (R3, R6, R13&R8) Activity in Retreating Monsoon Season

The behaviour activity of rhino calves is relatively similar to that of adult females in retreating monsoon. Rhino calves' grazing activity is comparatively more than other seasons and it was also maximum among rhinos. Grazing activity was 86%

with male calf R7 and 85% with another male calf R14. Grazing proportion was 81% with female calf R11. The proportion of browsing activity was observed only with R14 (2%). The resting activity was 5% with female calf R11, 2% with male calf R14 and only 1% with another male calf R7. Walking activity was 14% with R11 which was the highest among the calves. Walking was 7% with R14 and 4% with R7. Wallowing activity was 5% with male calf R14 and 8% with another male calf R7. No wallowing activity was observed with female calf R11 (Table 4.18.) (Fig. 4.23). Behaviour variations among calves were observed to be significant (χ^2=178477, the *P* value .0223 result was significant at $p<.05$).

Table 4.18 Rhino Calves' (R7, R14 &R11) Behaviour during Retreating Monsoon

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Resting (%)	Walking (%)	Wallowing (%)
R11	6	21	81	0	5	14	0
R14	10	41	85	2	2	7	5
R7	18	72	86	0	1	4	8

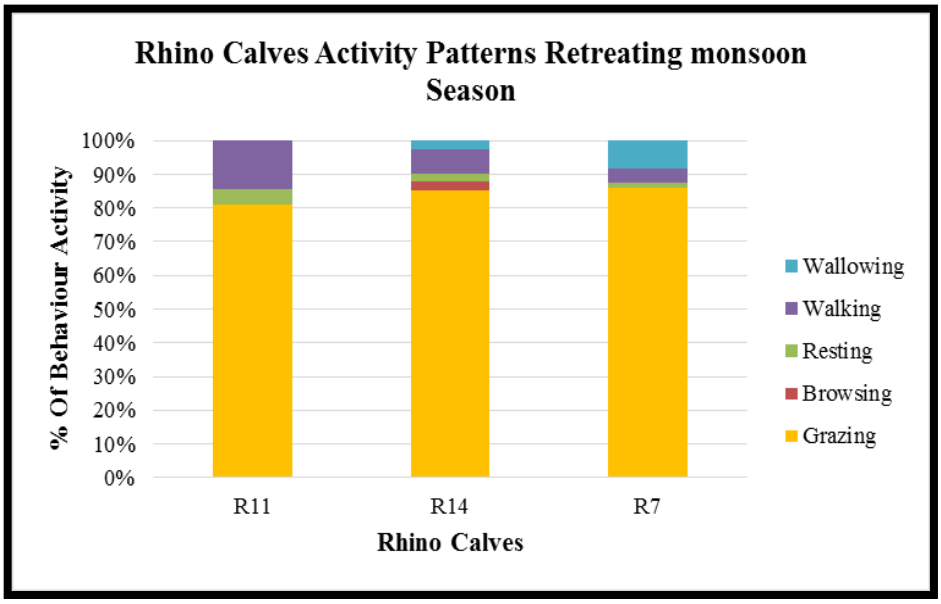

Fig. 4.23 Rhino Calves' (R7, R14 &R11) Activity in Retreating Monsoon Season

During this season, adult males' (R1, R2 and R5) mean grazing proportion was 64±4 while it was 68±2.45 with adult females (R3, R6, R13 and R8). It was maximum with rhino calves (R7, R14 and R11) (84±1.6). Mean browsing proportion was 13±7 with adult males and 1±0.8 with rhino calves. Mean resting proportion activity among males was 2±1 while it was 1±1 with adult females and calves. Mean walking activity was comparatively higher with adult females with 20±10, 12±4 with adult males and 9±3 with rhino calves. Wallowing mean proportion was 8±5 with adult males, 12±4 with adult females and 4±2.4 with calves (Fig. 4.24).

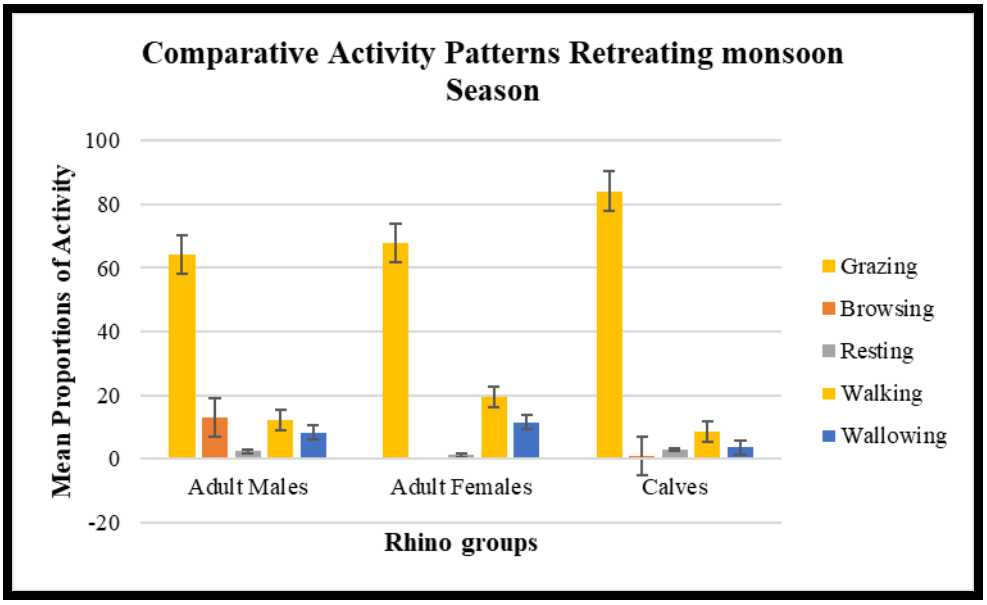

Fig. 4.24 Comparative Activity Patterns of Rhinos during Retreating Monsoon Season

4.1.2.3.1 Temporal Activity Pattern of Rhinos during Retreating monsoon

In the retreating monsoon, temporal grazing proportion was maximum in the morning and afternoon hours. The grazing proportion of adult males (R1, R2 and R5) was 25% in the morning hours, 3% in mid-day hours, 16% in the afternoon hours and 13% in the night hours. Browsing was 3% in the morning hours, 1% in the noon and 4% in the night hours. No browsing was observed during the afternoon. Resting was 1% in the morning as well as during night hours. No resting was observed with adult males in the mid-day hours but 7% resting activity was observed in the afternoon hours. The temporal proportion of walking activity was 3% in the morning hours, 1% in the mid-day hours and 3% in the afternoon hours. No walking was observed in the night hours. Wallowing activity was 3% in the morning hours, 11% in the midday hours and 5% in the afternoon hours (Table 4.19) (Fig. 4.25).

Table 4.19 Adult Males' (R1, R2 and R5) Temporal Activity in Retreating Monsoon (In %)

Activity	18:00-6:00	6:00-10:00	10:00-14:00	14:00-18:00
Grazing	13	25	3	16
Browsing	4	3	1	0
Resting	1	1	0	7
Walking	0	3	1	3
Wallowing	0	3	11	5

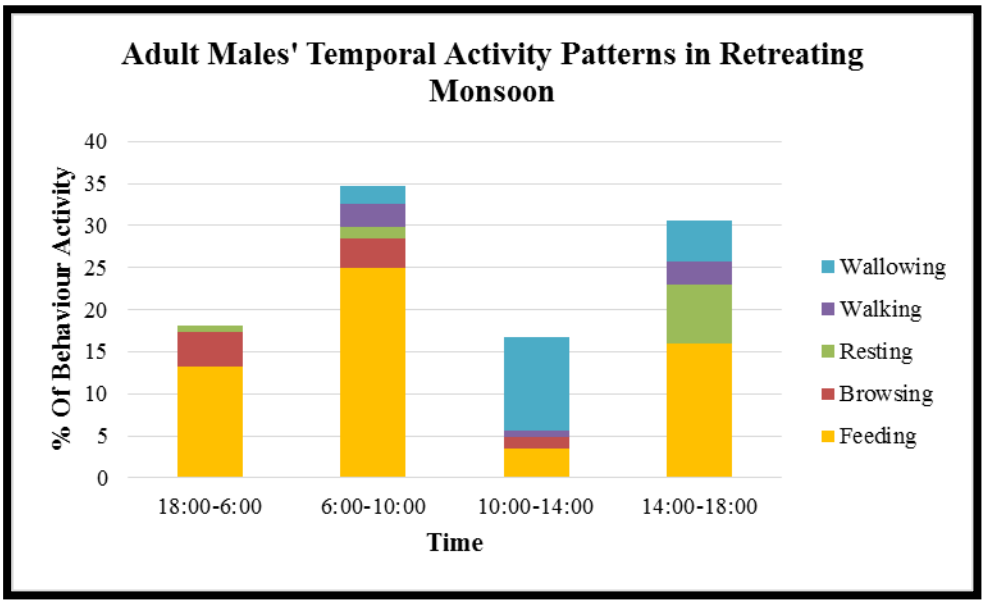

Fig. 4.25 Adult Males' (R1, R2 &R5) Temporal Patterns of Activity in the Retreating Monsoon Season

The temporal proportion of grazing was maximum among adult females (R3, R6, R13 and R8) in the afternoon hours (36%). Grazing activity was 25% in the morning hours, 5% in the mid-day hours and 11% during night. No browsing was observed with adult females. The temporal proportion of resting activity was 1% each in the morning, mid-day and afternoon hours. Walking activity was 1% during mid-day

and night hours. Walking was 5% in the morning hours and 3% in the afternoon hours with adult females. Wallowing activity was found highest in the afternoon hours (7%). In the morning hours, wallowing activity was 1% and 2% in the midday hours. No wallowing was observed during the night hours (Table 4.20) (Fig. 4.26).

Table 4.20 Adult Females' (R3, R6, R13 & R8) Temporal Activity in Retreating Monsoon (In %)

Activity	18:00-6:00	6:00-10:00	10:00-14:00	14:00-18:00
Grazing	11	25	5	36
Browsing	0	0	0	0
Resting	0	1	1	1
Walking	1	5	1	3
Wallowing	0	1	2	7

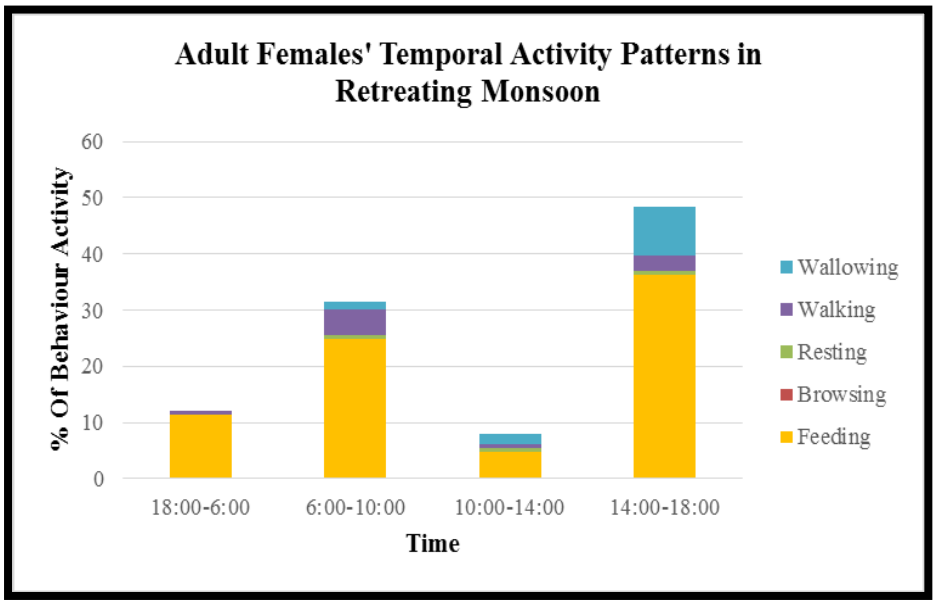

Fig. 4.26 Adult Females' (R3, R6, R13&R8) Temporal Activity Patterns in Retreating Monsoon Season

Temporal pattern of activity of rhino calves (R7, R14 and R11) in retreating monsoon season was almost similar to adult females (R3, R6, R13 and R8). Grazing activity was maximum in the afternoon hours (37%). It was 29% in the morning hours, 5% in the mid-day hours and 12% in the night hours. The temporal proportion of browsing was 1% each in the mid-day and afternoon hours. No browsing was observed in the morning and night hours. Resting activity was 1% in the morning hours and 2% in the afternoon hours. Walking activity was 1% each in the noon and night hours. In the morning, walking activity was 3% while in the afternoon walking was 2%. The proportion of wallowing activity was 2% each in the mid-day and afternoon hours. In the morning hours, only 1% wallowing was observed but no wallowing in the night hours (Table 4.21) (Fig. 4.27).

Table 4.21 Rhino Calves' (R7, R14 &R11) Temporal Activity in Retreating Monsoon (In %)

Activity	18:00-6:00	6:00-10:00	10:00-14:00	14:00-18:00
Grazing	12	29	5	37
Browsing	0	0	1	1
Resting	0	1	0	2
Walking	1	3	1	2
Wallowing	0	1	2	2

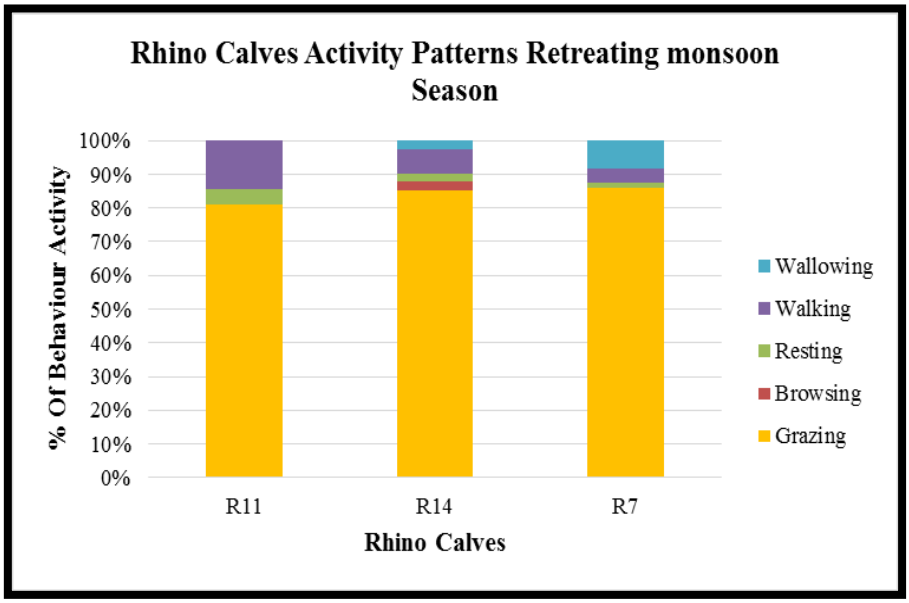

Fig. 4.27 Temporal Activity Pattern of Rhino Calves' (R7, R14 & R11) in Retreating Monsoon Season

In the retreating monsoon, adult males' (R1, R2 and R5) mean proportion of activity was 6.9±0.2 and 6.1±0.1 during the morning and afternoon hours respectively. In the night and mid-day hours, adult males' mean behaviour activity was relatively less with 3.6±0.1 and 4.5±0.2 respectively.

Adult females' (R3, R6, R13 and R8) mean temporal proportion of activity was observed maximum in the afternoon hours with 9.7±0.1 and minimum in the mid-day hours with 1.6±0.4. Mean proportion of activity was 6.3±0.1 in the morning hours and 2.4±0.2 in the night hours.

Rhino calves' (R7, R14 and R11) temporal mean behaviour was maximum in afternoon hours with 9±0.2 which were almost similar to adult females. During morning hours, mean temporal behaviour pattern was 7±0.1. During mid-day hours, mean

behaviour was 2±1 and in the night hours, it was 3±0.1 (Fig. 4.28). Overall temporal pattern of behaviour activity among all rhinoceros was found to be insignificant (χ^2=2.9802, the *P* value was .811331)

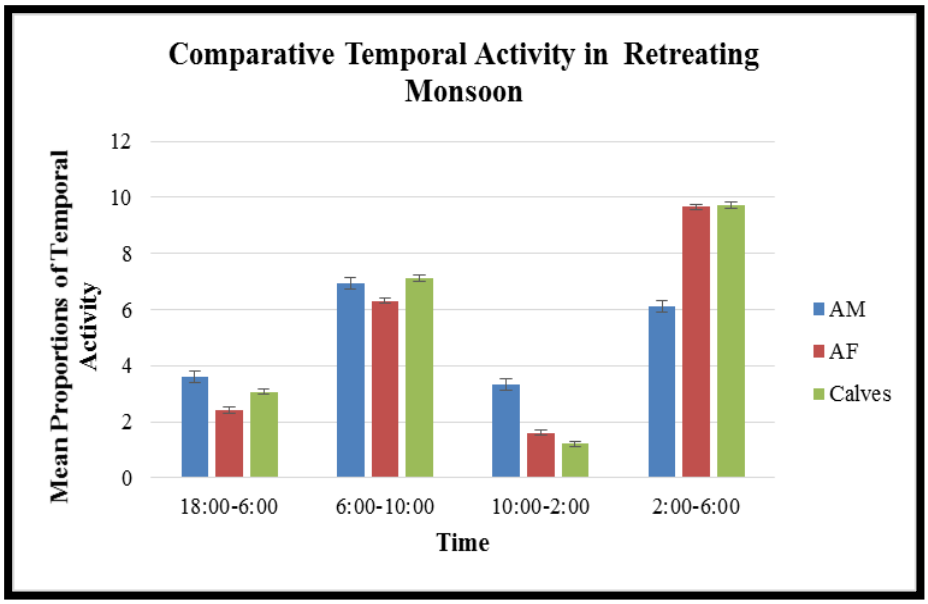

Fig. 4.28 Comparative Temporal Activity Patterns of Rhinos in Retreating Monsoon Season

4.1.2.4 Winter Season

During the winter season, rhinos were tracked 1133 times and were observed 808 times in different locations of MNP. Adult males (R1, R2 &R5) were observed 464 times (57.4%), adult females (R3, R6, R13&R8) 161 times (20%) and rhino calves (R7, R14&R11) were observed 183 times (23%) in this season.

During the winter season, the grazing proportion of activity was 43%, 38% and 32% with adult males R1, R2 and R5 respectively. Adult males' proportion of browsing was 18%, 24%, 25% with R1, R2 and R5 respectively. During winter, browsing was found to be maximum as compared to other seasons among males. The

proportion of resting was 11%, 13%, 7% with R1, R2 and R5. The proportion of wallowing activity was 15%, 13%, 15% with R1, R2 and R5 (Table 4.22) (Fig. 4.29). Behaviour pattern was insignificant among adult males (χ^2=9.844, the *P* value was .27614)

Table 4.22 Adult Males' (R1, R2 and R5) Activity in Winter Season

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Resting (%)	Walking (%)	Wallowing (%)
R1	48	191	43	18	11	13	15
R2	53	213	38	24	13	11	13
R5	15	60	32	25	7	22	15

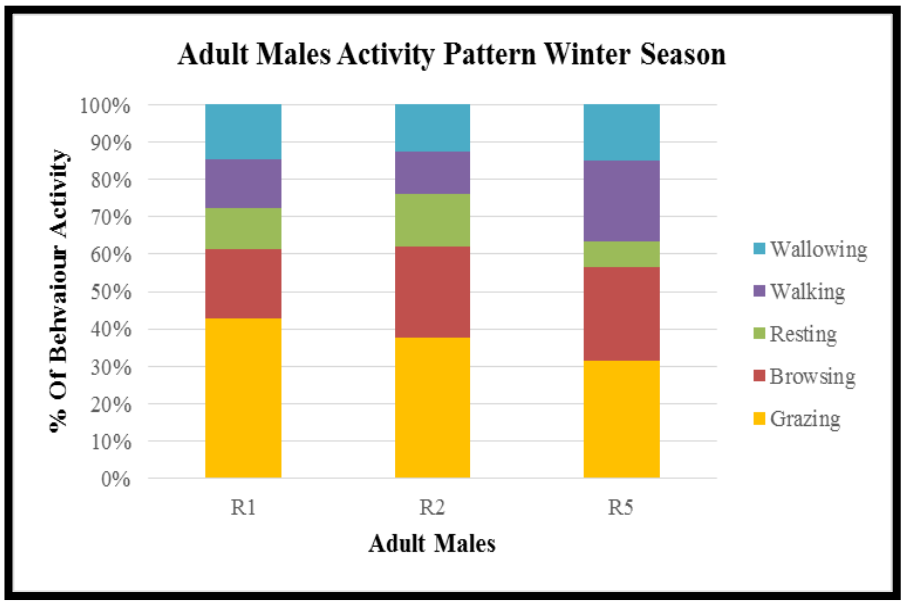

Fig. 4.29 Adult Males' (R1, R2&R5) Activity Pattern in Winter Season

Adult females' (R3, R6, R13 and R8) grazing activity was relatively higher than adult males (R1, R2 and R5). Grazing proportion was 50% with adult female R13, 40% with R3, 60% with R6 and solitary female R8 had 46% of grazing

observed during the winter season. During this season, some females devoted their time to browsing. There were 23% of browsing observed with adult female R3 and 26% with another adult female R8. No browsing was observed with R13 and R6. The proportion of resting activity was 8% each with R13 and R6. Solitary female R8 displayed 5% resting activity but no resting was observed with R3. The proportion of walking activity was maximum with R13 (35%). There was 23%, 17% and 18% walking activity observed with R3, R6, and R8 respectively. The proportion of wallowing activity was 8% each with adult male R13 and R3 in this season. Wallowing proportion was 14% with R6 and 5% with R8 (Table 4.23.) (Fig. 4.30). Overall activity variations among adult females were significant (χ^2=65.9417, the *P* value .00001 result was significant at $p<.05$).

Table 4.23 Adult Females' (R3, R6, R13 and R8) Activity in the Winter Season

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Resting (%)	Walking (%)	Wallowing (%)
R13	8	26	50	0	8	35	8
R3	5	13	46	23	0	23	8
R6	21	83	60	0	8	17	14
R8	10	39	46	26	5	18	5

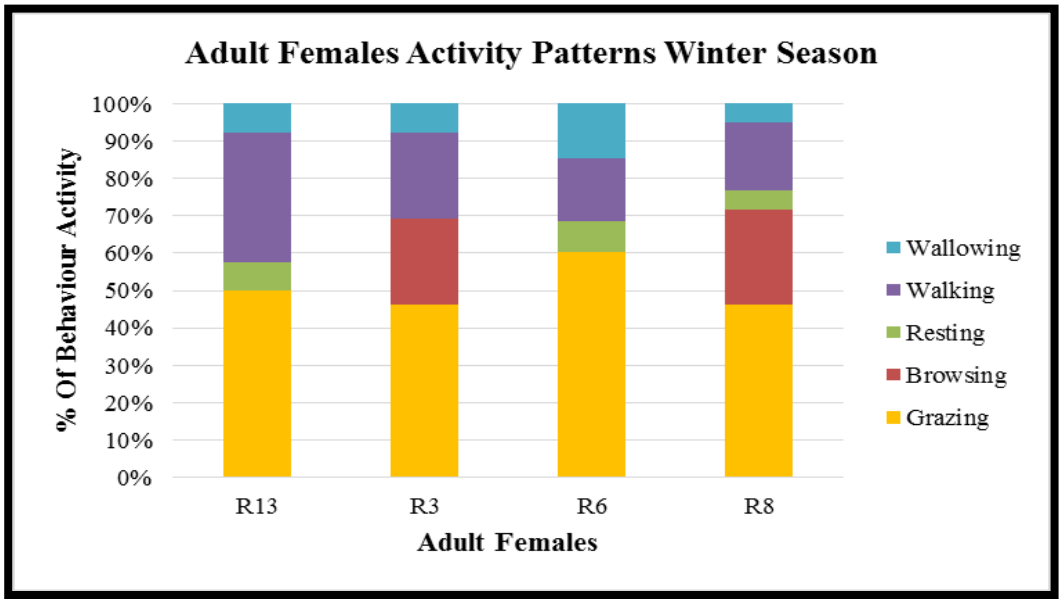

Fig. 4.30 Adult Females' (R3, R6, and R13&R8) Activity Patterns in Winter Season

Rhino calves (R7, R14 and R11) displayed almost similar pattern of behavioural activity as adult females (R3, R6, R13 and R8) with slight variation among them. The proportion of grazing was 52%, 48% and 57% with R11 (female calf), R14 (male calf) and R7 (male calf) respectively. All calves displayed browsing activity during this season. Browsing proportion was 10%, 16%, 5% with R11, R14 and R7. Resting activity was 6% with R11, 8% with R14 and 9% with R7. Walking activity was relatively higher with female calf R11 (25%). Walking was 20% and 15% with male calf R14 and R7 respectively. Wallowing activity was 7%, 8%, 14% with female calf R11, R14 (male calf) and R7 (male calf) respectively (Table 4.24.) (Fig. 4.31). Overall

behaviour variations among calves was found to be insignificant (χ^2=12.7223, the *P* value was .12177).

Table 4.24 Rhino Calves' (R7, R14 &R11) Activity in Winter Season

Rhino Code	Duration of observation (hrs.)	No of observations	Grazing (%)	Browsing (%)	Resting (%)	Walking (%)	Wallowing (%)
R11	18	71	52	10	6	25	7
R14	7	25	48	16	8	20	8
R7	22	87	57	5	9	15	14

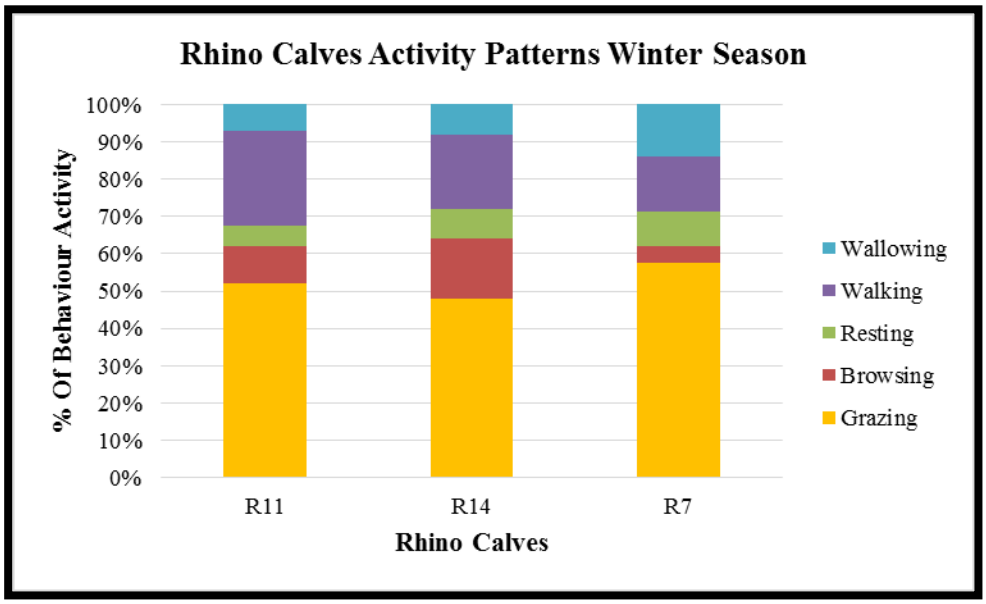

Fig. 4.31 Rhino Claves' (R7, R14 & R11) Activity Pattern in Winter Season

During the winter season, adult males (R1, R2 and R5) mean grazing proportion was 37±3.25, adult females (R3, R6, R13 and R8) 50.6±3.3 and calves (R7,R14 and R11) 53±2.7. Mean browsing proportion of adult males was 22±2.1, adult females 12.2±7.05, and calves 10±3.2. Mean resting proportion of adult males was 10.5±2.1, adult females 5.3±1.9, calves 8±1.04. Adult males mean walking proportion was 15±3, adult females 23.1±4.06 and calves 20±3. Wallowing mean proportion was 14.1±0.7 with males, 8.7±1.9 with females and 10±2.1 with calves (Fig. 4.32).

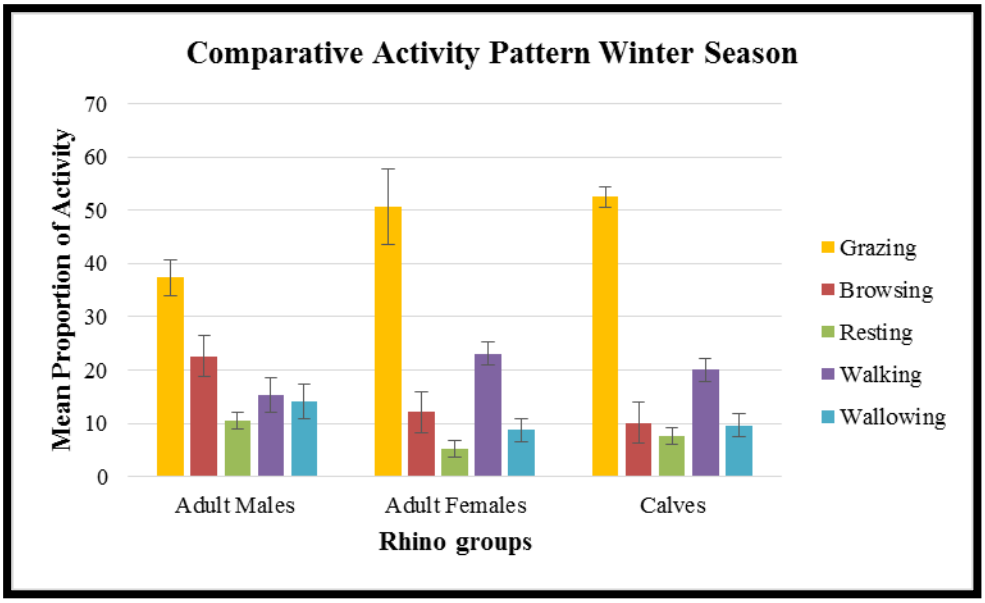

Fig. 4.32 Comparative Activity Patterns of Rhinos in Winter Season

4.1.2.4.1 Temporal Activity Pattern of Rhinos during Winter Season

During the winter season, adult males (R1, R2 and R5) grazing proportion were 11% in the morning hours, 7% in the mid-day hours and 16% in the afternoon. During winter, only 2% grazing proportion observed in night hours. Temporal patterns of browsing were dominant from morning to afternoon hours. In the morning 4%, in the mid-day 7% and in the afternoon 8% browsing was observed. Resting proportion in the

morning hours was 3%, 2% in the mid-day hours and 7% in the afternoon hours. The temporal proportion of walking was 8% in the morning hours, 2% in the mid-day hours and 9% in the afternoon. Only 1% walking activity was observed during night time. Wallowing activity was observed to increase from morning to afternoon. In the morning hours, wallowing was 2%, 3% in the mid-day hours and 8% in the afternoon hours. No wallowing was observed in the night hours (Table 4.25.) (Fig. 4.33).

Table 4.25 Adult Males' (R1, R2 &R5) Temporal Pattern of Activity in Winter Season (In %)

Activity	18:00-6:00	6:00-10:00	10:00-14:00	14:00-18:00
Grazing	2	11	7	16
Browsing	0	4	7	8
Resting	0	3	2	7
Walking	1	8	2	9
Wallowing	0	2	3	8

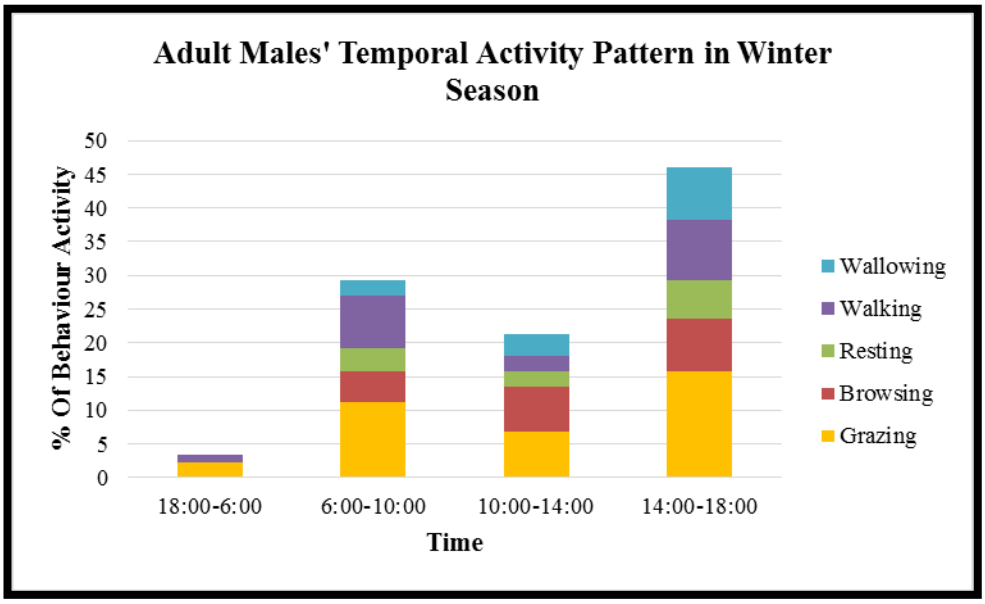

Fig. 4.33 Adult Males' (R1, R2 &R5) Temporal Patterns of Activity in Winter Season

The temporal proportion of grazing activity was observed as dominant activity with adult females (R3, R6, R13 and R8) during morning and afternoon hours in the winter season. In the morning, 25% of grazing was observed, 18% in the afternoons, 6% in midday hours and 4% in the night. The temporal proportion of browsing was 3% and 2% in morning hours and midday hours respectively. There was only 1% browsing observed during the night. Resting activity was 2% in the morning, 6% in the midday and 9% in the afternoon as observed. Walking activity was 4% in the morning, 6% in the midday and 7% was in the afternoon hours. No resting was observed in the night hours. Wallowing activity was 1% in the morning hours, 2% in the noon hours and 7% in the afternoon (Table 4.26.) (Fig. 4.34).

Table 4.26 Adult Females' (R3, R6, R13 and R8) Temporal Pattern of Activity in Winter Season (In %)

Activity	18:00-6:00	6:00-10:00	10:00-14:00	14:00-18:00
Grazing	4	25	6	18
Browsing	1	3	2	2
Resting	0	2	1	4
Walking	2	4	6	9
Wallowing	0	1	2	7

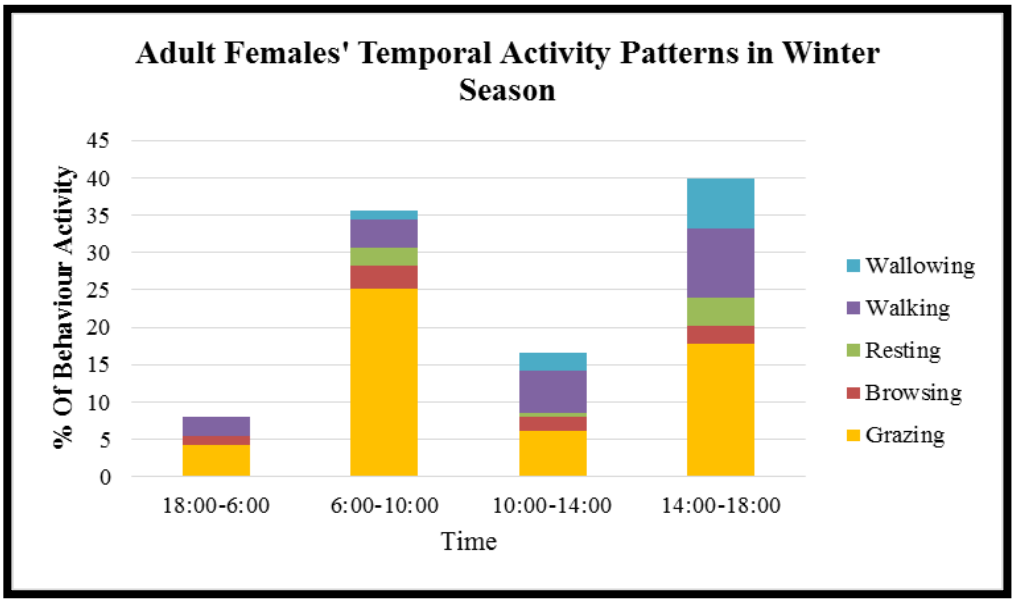

Fig. 4.34 Adult Females' (R3, R6, R13 & R8) Temporal Activity Pattern in Winter Season

Temporal activity pattern of rhino calves (R7, R14 and R11) during the winter season was almost similar to adult females (R3, R6, R13 and R8). Grazing proportion was dominant activity in the morning and afternoon hours. Grazing proportion in the

morning hours was 27% and 12% in the afternoon hours. During mid-day hours, the grazing proportion was 10%, and 5% in the night hours. Browsing proportion was 2% each in the morning and mid-day. It was 3% in the afternoon and in the night only 1% browsing activity was observed with rhino calves. Resting proportion was 2% in the morning, 5% in the afternoon and 1% during the night hours. No resting was observed during mid-day hours. Walking activity was 4% each in the morning and mid-day hours and relatively more (9%) walking were observed in the afternoon hours. There was 2% walking in the night hours. Wallowing activity was 2% each in the morning and midday hours and 7% wallowing activity were observed during afternoon period. No wallowing was observed in the night hours (Table 4.27.) (Fig. 4.35).

Table 4.27 Rhino Calves' (R7, R14 and R11 Temporal Pattern of Activity during Winter Season (In %)

Activity	18:00-6:00	6:00-10:00	10:00-14:00	14:00-18:00
Grazing	5	27	10	12
Browsing	1	2	2	3
Resting	1	2	0	5
Walking	2	4	4	9
Wallowing	0	2	2	7

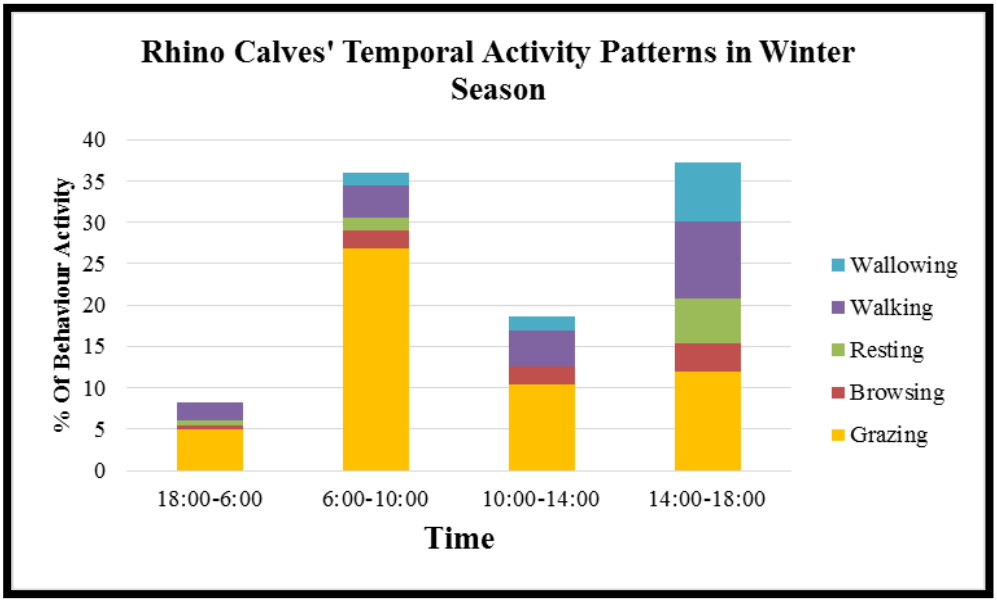

Fig. 4.35 Rhino Calves' (R7, R14 & R11) Temporal Patterns during Winter Season

In the winter season, adult males' (R1, R2 and R5) mean proportion of activity in the morning hours was 6±0.1 and afternoon hours were about 9±.02. In the night and midday hours, adult males' mean behaviour activity was relatively less 4±0.1 and 1±0.1 respectively. Adult females' (R3, R6, R13 and R8) mean proportion of activity was 7±04 in the morning hours and 8±3 in the afternoon. Mean proportion of the activity in midday was 3±02 and 2±1 in the night hours respectively. Rhino calves' (R7, R14 and R11) mean proportion of activity in the morning hours was 7±0.4 and 3±0.2 in the afternoon. In the mid-day hours, calves mean proportion of activity was 4±0.1 and 2±0.1 in the night hours. The temporal pattern of behaviour was observed to be insignificant (χ^2=09.318, the *P* value was .988065) (Fig. 4.36).

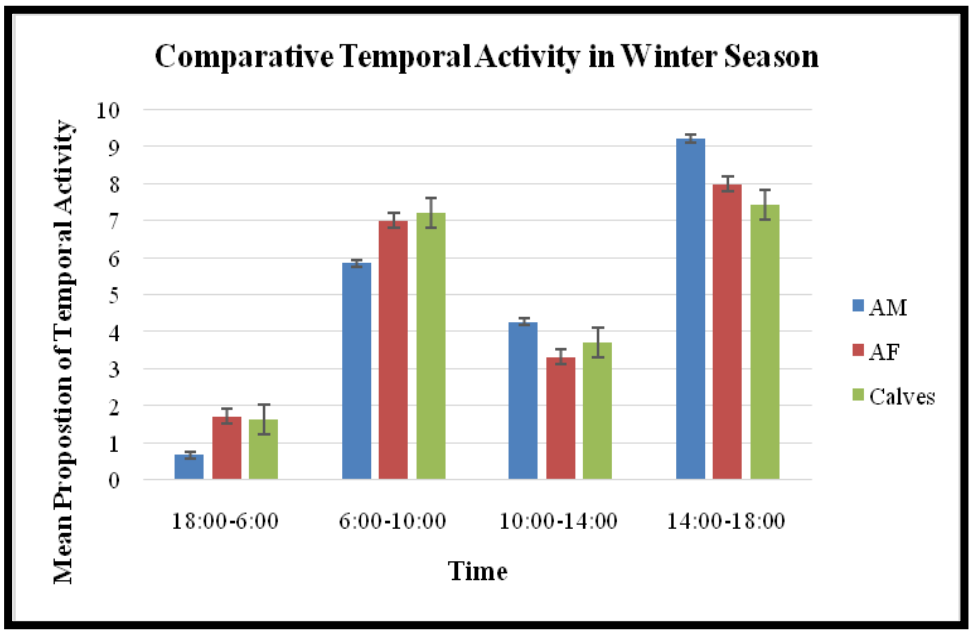

Fig. 4.36 Comparative Temporal Activity Pattern of Rhinos during Winter Season

4.2 Food Plant Preferences and Seasonal Variations

Rhinos ate on 139 plant species in different seasons. Out of 139 species, 23 species were short grass species, 11 species were tall grass species, 23 species were aquatic plants, 11 species shrubs, 30 species herbs, three species creepers, 26 species were trees and 12 species were crops (Table4.28-4.35). As per preference and availability of plants, 49 species were observed to be preferred throughout the year with 1,969 grazing and browsing records (Table 4.36). Almost equal proportions of food plant preferences were observed among all groups (adult male, adult female and calves) of rhinos for 34 plant species in pre-monsoon, monsoon, retreating monsoon seasons out of 220 grazing and browsing records (Table 4.37).

It was during the study, no significant variations were observed in the food habits among adult males (R1, R2 and R5), adult females (R3, R6, R13 and R8) and calves (R7, R14 and R11). But grass species are the major preferable food for all the age groups of translocated rhinos at MNP.

Table 4.28 List of Short Grasses Preferred by Rhinos in MNP

Sl No	**Scientific Name**	**Family**
1	*Axonopus compressus* L	*Poaceae*
2	*Cynodon dactylon* (L.) Pers	*Poaceae*
3	*Cenchrus ciliaris* L.	*Poaceae*
4	*Cyperus compressus* L.	*Cyperaceae*
5	*Cyperus digitatus* Roxb.	*Cyperaceae*
6	*Cyperus rotundus* L.	*Cyperaceae*
7	*Cyperus pilosus* Vahl.	*Cyperaceae*
8	*Cyperus auricomus* Roxb.	*Cyperaceae*
9	*Cyperus iria* L	*Cyperaceae*
10	*Dactyloctenium aegyptium* L.	*Poaceae*
11	*Eleusine indica* (L.) Gaertn.	*Poaceae*
12	*Eragrostis sp.*	*Poaceae*

13	*Fimbristylis aestivalis* (Retz.)	*Cyperaceae*
14	*Hemarthria compressa* (L.f.)R.Br.	*Poaceae*
15	*Imperata cylindrica* L	*Poaceae*
16	*Kyllinga brevifolia* Rottb.	*Cyperaceae*
17	*Leersia hexandra* Sw.	*Poaceae*
18	*Mariscus compactus* (Retz)	*Cyperaceae*
19	*Paspalum conjugatum* Bergius.	*Poaceae*
20	*Paspalum orbiculare* L.	*Poaceae*
21	*Pogonatherum crinitum* (Thunb) Kunth.	*Poaceae*
22	*Scirpus articulates* L	*Cyperaceae*
23	*Seteria glauca* L.	*Poaceae*

Table 4.29 List of Tall Grasses Preferred by Rhinos in MNP

Sl No	Scientific Name	Family
1	*Andropogon sp*	*Poaceae*
2	*Arundo donax* L.	*Poaceae*
3	*Carex sp.*	*Cyperaceae*
4	*Erianthus sp.*	*Poaceae*
5	*Narenga porphyracoma* (Hance) Bor	*Poaceae*

6	*Pollinia cilliata* Trin.	*Poaceae*
7	*Phragmites karka*(Retz)Trin ex Steud	*Poaceae*
8	*Saccharum spontaneum,* L.	*Poaceae*
9	*Saccharum elephantinus* Robx.	*Poaceae*
10	*Themeda villosa* Poiret.	*Poaceae*
11	*Vetiveria zizanioides* (L.) Nash	*Poaceae*

Table 4.30 List of Herbs Preferred by Rhinos in MNP

Sl No	**Scientific Name**	**Family**
1	*Ageratum conyzoides* L.	*Asteracese*
2	*Alternanthera sessilis* L.	*Amaranthaceae*
3	*Amaranthus spinosus* L.	*Amaranthaceae*
4	*Amaranthus viridis* L.	*Amaranthaceae*
5	*Amphineuron opulentum* (Kaulf.) Holttum.	*Thelypteridaceae*
6	*Astraceae sp.*	*Asteracese*
7	*Brassica camprestris* L.	*Brassicaceae*
8	*Casia tora* L	*Caesalpiniaceae*

9	*Centella asiatica* L.	*Apiaceae*
10	*Chenopodium album* L.	*Chenopodiaceae*
11	*Commelina longifolia* Lam	*Commelinaceae*
12	*Commelina benghalensis* L.	*Commelinaceae*
13	*Commelina sps.*	*Commelinaceae*
14	*Drymaria diandra* L.	*Caryophyllaceae*
15	*Diplazium esculentum* Retz.	*Athyriaceae*
16	*Eclipta alba* L	*Asteracese*
17	*Eclipta prostate* L	*Asteracese*
18	*Euphorbia hirta* L	*Euphorbiaceae*
19	*Floscopa scandens* L	*Commelinaceae*
20	*Fragaria indica* Andr.	*Rosaceae*
21	*Grangea maderaspatana* L. Poir.	*Asteracese*
22	*Houttuynia cordata*Thunb.	*Sauruaceae*
23	*Hydrocotyle rotundifolia* Lam.	*Apiaceae*

24	*Leucas linifolia* Roth.	*Lamiaceae*
25	*Oxalis corniculata* L.	*Oxalidaceae*
26	*Premna herbaceae* Roxb.	*Verbenaceae*
27	*Polygonum chinense* L.	*Polygonaceae*
28	*Pouzolzia sp.*	*Urticaceae*
29	*Pteridium aquilinum* L. Kuhn	*Pteridaceae*
30	*Spilanthes paniculata* Wall. ex D.C.	*Asteracese*

Table 4.31 List of Aquatic Plants Preferred by Rhinos in MNP

Sl No	**Scientific Name**	**Family**
1	*Azolla pinnata* R.Br.	*Azollaceaee*
2	*Blyxa aubertii* Rich.	*Hydrocharitaceae*
3	*Boerhavia diffusa* L nom.com	*Nyctaginaceae*
4	*Blumea laciniata* (Roxb.) DC	*Asteraceae*
5	*Cuphea balsamona* Browne	*Lythraceae*
6	*Enhydra fluctuans* Lour	*Asteraceae*

7	*Eichhornia crassipes* (Mort) Solms.	*Pontederiaceae*
8	*Eleocharis fistulosa* (Roxb)Schult.	*Cyperaceae*
9	*Hydrilla verticillata* (L.f) Royale.	*Hydrocharitaceae*
10	*Hydrocotyle sibthropioides* L.	*Apiaceae*
11	*Ipomoea reptans* Frossk.	*Convolvulaceae*
12	*Jussiaea repens* Ktze.	*Onagraceae*
13	*Lemna pancicostate* L.	*Lemnaceae*
14	*Monochoria vaginalis* (Burm.f) C.Presl. Ex. Kunth.	*Pontederiaceae*
15	*Najas graminea* Del.	*Najadaceae*
16	*Nymphaea nouchali* Burm.	*Nymphaeaceae*
17	*Pistia stratiotes* L.	*Araceae*
18	*Potamogeton crispus* L.	*Potamogetonaceae*
19	*Polygonum barbatum* L.	*Polygonaceae*
20	*Polygonum hydropiper* L.	*Polygonaceae*
21	*Sagittara sagitifolia* L.	*Alismataceae*
22	*Trapa bispinosa* Roxb.	*Trapaceae*

23	*Vallisneria spiralis* L.	*Hydrocharitaceae*

Table 4.32 List of Creepers Preferred by Rhinos in MNP

Sl No	Scientific Name	Family
1	*Mikania scandens* B.L.Rob	*Asteraceae*
2	*Paederia foetida* L.	*Rubiaceae*
3	*Paederia hirsute* L.	*Rubiaceae*

Table 4.33 List of Shrubs Preferred by Rhinos in MNP

Sl No	Scientific Name	Family
1	*Alpinia allughas* (Gaertn.)B.N.	*Zingiberaceae*
2	*Blastus cochinchinensis* (Benth.) Triana	*Malastomaceae*
3	*Clerodendron infortunatum* L.	*Verbenaceae*
4	*Flemingia bracteata* (L) W.T.	*Papilionaceae*

	Aiton	
5	*Ganaphalium indicum* L.	*Asteraceae*
6	*Leea indica* (Burm.f) Merry.	*Leeaceae*
7	*Lannea grandis* Engler.	*Anacardiaceae*
8	*Malastoma malabatricum* L	*Malastomaceae*
9	*Malastoma sp.*	*Malastomaceae*
10	*Solanum torvam* Sw.	*Solanaceae*
11	*Xanthium indicum* L	*Asteraceae*

Table 4.34 List of Tree Species Preferred by Rhinos in MNP

Sl No	Scientific Name	Family
1	*Albizzia procera* Benth	*Mimosaceae*
2	*Alstonia scholaris* L.R.Br.	*Apocynaceae*
3	*Anthocephalus cadamba* (Roxb.) Bosser	*Rubiaceae*
4	*Bauhinia variegate* (L.)Benth	*Caesalpiniaeeae*
5	*Bischofia javanica* Blume	*Euphorbiaceae*
6	*Bombax ceiba* L	*Bombacaceae*
7	*Butea monosperma* (Lam) Taub	*Fabaceae*
8	*Careya arborea* Roxb.	*Lacythedaceae*
9	*Cassia fistula* L.	*Caesalpiniaeeae*
10	*Dillenia indica* L.	*Dilaneaceae*
11	*Dillenia pentagyna* Roxb.	*Dilaneaceae*
12	*Emblica officinalis* L	*Euphorbiaceae*
13	*Eugenia jambolana* Lam	*Myrtaceae*
14	*Ficus glomerata* Roxb	*Moraceae*
15	*Ficus religiosa* L.	*Moraceae*

16	*Gmelina arborea*Roxb.	*Verbenaceae*
17	*Lagerstremia parviflora* L.	*Lythraceae*
18	*Morus sps*	*Moraceae*
19	*Macaramga denticulata*(Blume) Muller Ar	*Euphorbiaceae*
20	*Spondias magnifera* L	*Anacardiaceae*
21	*Sterculia villosa* L.	*Sterculiaceae*
22	*Sida equate* L.	*Malvaceae*
23	*Terminalia bellirica (*Gaertn.) Roxb.	*Combretaceae*
24	*Terminalia chebula* Retz.	*Combretaceae*
25	*Trewia nudiflora* L.	*Euphorbiaceae*
26	*Zizyphu sjujuba* Mill.	*Rhamnaceae*

Table 4.35 List of Agricultural Crops Preferred by Rhinos in MNP

Sl No	Scientific Name	Family
1	*Brassica oleracea* L.	*Brassicaceae*
2	*Capsicum annuum* L.	*Solanaceae*
3	*Cicer arietinum* L	*Fabaceae*
4	*Cucurbita maxima* Duchesne	*Cucurbitaceae*
5	*Cucumis sativas* L.	*Cucurbitaceae*
6	*Hibiscus subdarifa* L	*Malvaceae*
7	*Luffa acutangula* (L.) Roxb	*Cucurbitaceae*
8	*Oryza sativa* L	*Poaceae*
9	*Pisum sativam* L.	*Papilionaceae*
10	*Phaseolus aureus* (L.) R. Wilezek	*Papilionaceae*
11	*Solanum tuberosum* L.	*Solanaceae*
12	*Triticum aestivum* L.	*Poaceae*

Apart from these plant species, some plant preferences were very particular in respect of season. In the pre-monsoon, 8 particular species were recorded with 22 grazing observation among all groups of rhinos. During monsoon season, 6 plant species were exclusively recorded with 24 grazing observation noted among adult males (R1, R2 and R5) only. In retreating monsoon season, 4 plant species were recorded in 34 grazing records. During winter, 13 particular plant species were recorded with 46 grazing observation among all groups of rhinos.

Just after the release, some rhinos strayed outside the park and raided crops in agriculture fields. There were 12 agriculture crop species preferences recorded with 70 grazing records during the settling phase of rhinos. Adult male R1 and R2 raided agriculture crops during the settling phase after release at MNP for the maximum number of times. But paddy was observed to be preferred inside encroached areas of Bhuyanpara range of MNP.

During this period, only a single observation was recorded for *Brassica camprestris, Casia tora, Diplaziu esculentum, Hydrocotyle rotundifolia, Spilanthes paniculata, Hydrocotyle sibthropioides, Mikania scandens. Amphineuron opulentum, Flemingia bracteata, Spilanthes paniculata, Xanthium indicum, Bauhinia variegate, Emblica officinalis, Careya arborea.*

4.2.1 Seasonal Preference of Plants

4.2.1.1 Preferred Plant Species Round the Year

As mentioned earlier, 49 types of different plants species were preferred by rhinos all round the years. Among the 49-plant species, 45% (n=22) species are grasses, 16 % (n=8) species are herbs, 12 % (n=6) species are aquatic plants, 4% (n=2) species are creepers and 22 % (n=11) species belong to tree species were observed to be eaten all round the year irrespective of the seasons. Preferences of grasses were found more than other plants. As per observation *Arundo donax* (19%), *Cynodon dactylon* (17%), *Imperata cylindrica* (13%) *Saccharum spontaneum* (9%), *Saccharum elephantinus* (9%) grasses were preferred more than the other aquatic plants and herbs (Table 4.36).

Astracea sp., Centralla asiatica, Eclipta alba, Eclipta prostate, Floscopa scandens, Houttuynia cordata, Oxalis corniculata, Pteridium aquilinum are the common herbs prefered. *Enhydra fluctuans, Jussiaea repens, Pistia strafiotes, Boerhavia diffusa, Lemna panicostate,* and *Polygonum barbatum* are the common aquatic plants preferred by rhinos all-round the year. Common creeper in Manas NP, *Paederia foetida* was observed to be preferred for 1% than other plants species.

All the rhinos were seen to browse some tree twigs, leaves and fruits in this period but browsing was observed to be highest among adult males (R1, R2 and R5) and calves (R7, R14 and R11). During monsoon season, low browsing observed among all the translocated rhinos. Preferably rhino's browse dwarf plants like *Bombax ceiba, Butea monosperma, Careaya arborea, Cassia fistula, Macaramga denticulate, Gmelina arborea* and *Dillenia pentagyna* (Table 4.36).

Table 4.36 Plants Species Preferred All Round the Year

Sl No	Name of the Plant	% of Observation
1	*Axonomus compressus* (L.) Pers	3.8
2	*Arundo donax* L	18.7
3	*Andropogon sp.*	8.2
4	*Cenchrus ciliaris* L	5.2
5	*Cynodon dactylon* (L) Pers	17.3

6	*Cyperus rotundus* L.	0.6
7	*Cyperus compressus*L.	1.2
8	*Cyperus sp.* L.	0.3
9	*Eleusine indica* (L.) Gaertn.	0.4
10	*Eragrostis sp.*	0.7
11	*Hemarthria compressa*(L.f) R Br	0.5
12	*Imperata cylindrica*	13.5
13	*Kyllinga brevifolia* Rottb.	2.4
14	*Narenga porphyracoma* (Hance) Bor	0.7
15	*Paspalum conjugatum* Bergius	0.5
16	*Paspalum orbiculare* L.	0.4
17	*Pogonatherum crinitum* (Thunb.) Kunth.	1.9
18	*Saccharum spontaneum*,L.	8.9
19	*Saccharum elephantinus*,L.	8.5
20	*Scirpus articulates* L	0.2
21	*Seteria glauca* L.	0.5

22	*Themeda villosa* (Poiret)	1.0
23	*Astraceae sp.*	0.3
24	*Centella asiatica* L.	0.2
25	*Eclipta alba* L	0.3
26	*Eclipta prostate* L	0.4
27	*Floscopa scandens* L	0.2
28	*Houttuynia cordata* Thunb.	0.2
29	*Oxalis corniculata* L.	0.3
30	*Pteridium aquilinum* L. Kuhn	0.3
31	*Jussiaea repens* L	0.2
32	*Pistia strafiotes* L	0.2
33	*Boerhavia diffusa* L	0.1
34	*Lemna pancicostate* L	0.1
35	*Polygonum barbatum* L	0.1
36	*Enhydra fluctuans* Lour	0.1
37	*Paederia foetida* L.	0.2
38	*Paederia hirsute* L.	0.1

39	*Bombax ceiba* L	0.3
40	*Butea monosperma* (Lam) Taub	0.2
41	*Careya arborea* Roxb.	0.2
42	*Cassia fistula* L.	0.2
43	*Macaramga denticulate* (Blume) Muller Ar	0.4
44	*Gmelina arborea* Roxb.	0.1
45	*Dillenia pentagyna* Roxb.	0.2
46	*Morus sp.*	0.1
47	*Dillenia indica* L.	0.0
48	*Papilionaceae sp.*	0.2
49	*Spondias magnifera* L	0.1

4.2.1.2 Plant Species Preferred in Pre-monsoon, Monsoon and Retreating Monsoon

During pre-monsoon, monsoon and retreating monsoons rhinos were observed on equal preferences to 34 species of plants. Throughout this period, rhinos preferred 41% (n=14) grasses, 44% (n=15) aquatic plants, 9% (n=3) herbs and 6% (n=2) shrubs respectively. Among the grasses, *Vetiveria zizanioides* (10.5%), *Cyperus auricomus* (5.5%), *Cyperus pilosus* (5.0%), *Cyperus disgitatus* (3.6%) were preferred

for a highest number of times. Tall grasses like *Eraianthus sp.* (4.5%), *Phragmites karka* (4.1%) preferences were observed to be low among all groups of rhinos.

Among the aquatic plants, *Azolla pinnata* (3.6%), *Cuphea balsamona* (2.7%), *Eichhornia crassipes* (2.7%), *Eleocharis fistulosa* (5.9%) *Monochoria vaginalis* (6.4%) and *Vallisneria spiralis* (10%) were preferred among all aged groups of rhinos.

Among the shrubs, rhinos preferred *Malastomamala batricum, Alpinia allughas* during this period. *Chenopodium album, Commelina bengalensis, Leucas liniflolia* were herbs mostly preferred by rhinos during these seasons (Table 4.37).

Table 4.37 Plant Species Preferred in Pre-monsoon, Monsoon and Retreating monsoon

Sl No.	Name of the Plants	% of Observation
1	*Cyperus digitatus* Roxb.	3.6
2	*Cyperus iria* L	2.3
3	*Cyperus auricomus* Roxb.	5.5
4	*Cyperus pilosus* Vahl.	5.0
5	*Carex sp.*	3.6
6	*Dactyloctenium aegyptium* L	2.3
7	*Erianthus sp.*	4.5

8	*Fimbristylis aestivalis* (Retz.)	1.8
9	*Leersia hexandra* Sw.	2.3
10	*Mariscus compactus* (Retz)	1.8
11	*Oryza sativa* L.	4.5
12	*Pollinia cilliata* Trin	0.9
13	*Phragmites karka (Retz)* Trin ex Steud	4.1
14	*Vetiveria zizanioides* (L.) Nash	10.5
15	*Azolla pinnata* R.Br.	3.6
16	*Blyxa aubertii* Rich.	2.3
17	*Blumea laciniata* (Roxb.) DC	1.4
18	*Cuphea balsamona* Browne	2.7
19	*Eichhorni acrassipes* (Mort) Solms.	2.7
20	*Eleocharis fistulosa* (Roxb)Schult.	5.9
21	*Hydrilla verticillata* (L.f) Royale.	0.9
22	*Ipomoea reptans* Frossk.	0.9

23	*Monochoria vaginalis* (Burm.f) C.Presl. Ex. Kunth.	6.4
24	*Najas graminea* Del.	1.8
25	*Nymphaea nouchali* Burm.	1.4
26	*Pistia strafiotes* L.	1.4
27	*Sagittara sagitifolia* L.	0.5
28	*Trapa bispinosa* Roxb.	0.9
29	*Vallisneria spiralis* L.	10.0
30	*Chenopodium album* L.	0.9
31	*Commelina benghalensis* L.	1.4
32	*Leucas linifolia* L	0.9
33	*Malastoma malabatricum* L	0.5
34	*Blastus cochinchinensis* (Benth.) Triana	0.9

Apart from these preferable plant species, some species were observed to be unique in particular seasons. In the pre-monsoon season, eight additional plant species preference was observed and *Malastoma sps. Leea indica* was preferred among the shrubs and *Amaranthus spinosus, Amaranthus viridis* were preferred among the herbs.

Adult males (R1, R2 and R5) and calves (R7, R14 and R11) were observed browsing tree twigs of *Alstonia scholaris, Largerstremia parviflora, Lannea grandis* and *Ficus religiosa.*

During monsoon season, four tree species and one herb preference were observed among adult males (R1, R2 and R5) and calves (R7, R14 and R11). These are *Anthocephalus cadamba, Bischofia javanica, Eugenia jambolana, and Trewia nudiflora.* Rhinos mainly preferred leaf and fruits of these tree species. *Ageratum conyzoides* was the only specific herb unique in the monsoon period.

During retreating monsoon, 4 additional species preferences were observed among rhinos. *Albizzia procera and Sida equate* are two tree species which leaves were preferred by all three groups of rhinos. *Commelina longifolia and Clerodendron infortunatum* were the other two herbs observed specifically during this period.

4.2.1.3 Plant Species Preferred during Winter Season

During the winter season, rhinos were observed to prefer species which are available throughout the year. Besides, 13 additional species preferences were observed among rhinos. Rhinos were recorded to prefer such species during 46 times. However, grassland burnings, scarcity of water holes affect rhinos' distribution patterns. Apart from commonly available plants, rhinos preferred some specific herbs like *Drymaria diandra, Euphorbia hirta, Fragaria indica, Polygonum chinense, Grangea maderaspatanal, Premna herbaceae, Pouzolzia spp. Solanum torvam* are the shrub available in the winter season. *Polygonum barbatum* and *Polygonum hydropier* are two aquatic plants preferred during winter. Adult female (R3, R6, R13 and R8) and rhino

calves (R7, R14 and R11) occasionally preferred fruits of two tree species viz. *Terminalia chebula* and *Terminalia bellirica* (Fig.4.37).

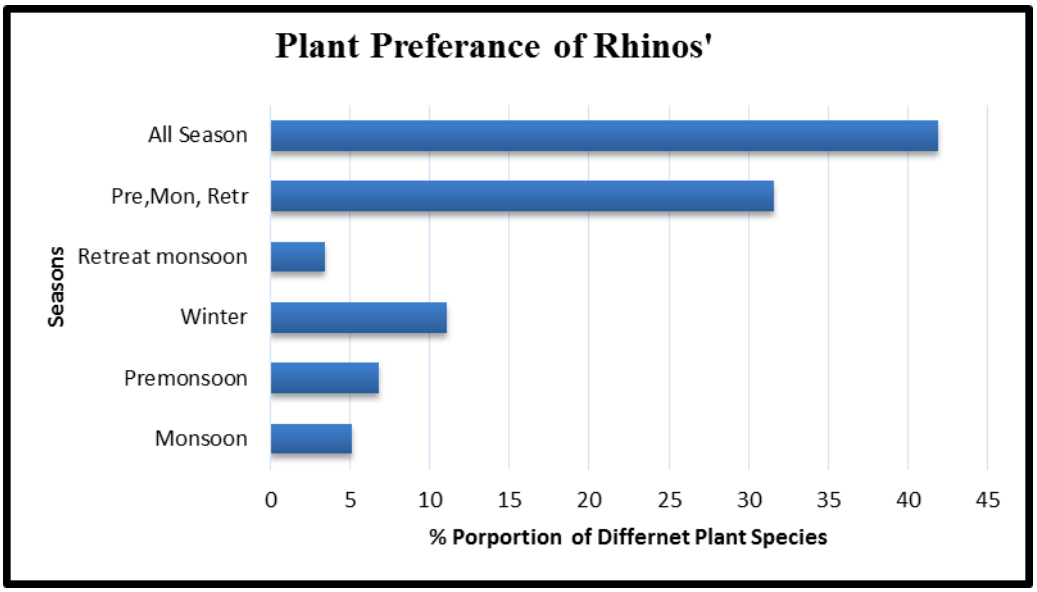

Fig. 4.37 Different Species of Plant Preferred by Rhinos in Different Seasons

4.3 Dispersal Patterns and Spatial Distribution

4.3.1 Dispersal Pattern of Rhinoceros after Release at Manas NP

Just after the release in the new habitat of MNP, first two adult rhinos (R1 and R2) were dispersed about 3.5km distances from the Buraburijhar Rhino release site (Fig 1.5). Later on, all rhinos were released at same release site except R8 (Adult female). R8 was assumed to be pregnant and decided to be released in rhino enclosure situated at

Rhino camp (Fig 1.5). But the adult female moved immediately outside by breaking the enclosure just after the release. Rhinos, which were released subsequently, moved an average of 2.4 km from the release site.

Table 4.38 Pattern of Rhino Dispersal Immediately after Release at MNP

Sl no	Rhino code	Rhino sex	Release Date	Release site	Nearest Site	Distance (Km)
1	R-1	M	12/4/2008	Buraburijhar	Rhino camp	3.5
2	R-2	M	12/4/2008	Buraburijhar	Charpholi	3.5
3	R-3	F	28/12/2011	Buraburijhar	Langpati area	3.21
4	R-5	M	18/1/2011	Buraburijhar	Langpati area	3.21
5	R-6	F	18/1/2011	Buraburijhar	Langpati area	3.21
6	R-7	M(Calf)	18/1/2011	Buraburijhar	Langpati area	3.21
7	R-8	F	18/1/2011	Rhino Camp	Panchmile area	2.31
8	R-11	F(Calf)	20/2/2012	Buraburijhar	Buraburijhar area	0.5
9	R-13	F	20/2/2012	Buraburijhar	Buraburijhar area	0.5
10	R-14	M(Calf)	20/2/2012	Buraburijhar	Dhodongbaha area	1.18
					Average	2.4km

4.3.2 Pattern of Colonization after Release at MNP

As rhinos were translocated batch wise, so for each of the studies, they have divided into four groups accordingly. Two adult male rhinos (R1 &R2) were initially released in Manas NP in the first phase. During 90 days of the observation period, these two rhinos were located 87 % (n=273) time in Bansbari range and 13% (n=41) in Bhuyanpara range. There was no significance observed in their colonization pattern [F (20, 32) =1.01, p=0.46], (Fig.4.38).

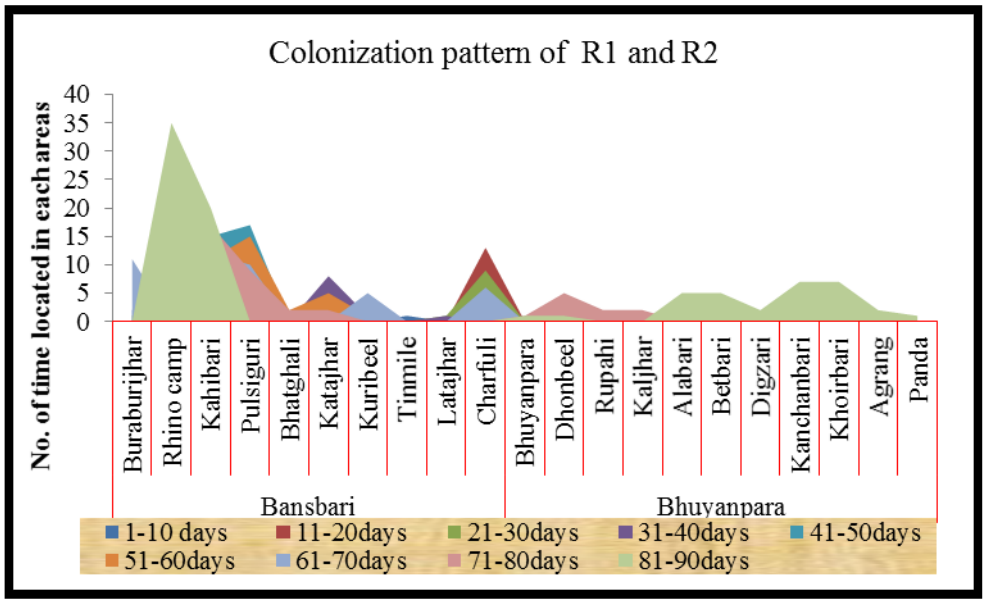

Fig.4.38 Colonization Pattern of R1 and R2 during first 90 Days after Release

Adult female R3 was released along with her female calf R4. There was no radio collar for R4 and so it was located few times only. After the 26 days of release, R4 moved to Panbari Range (Western Range of MNP) which was rather inaccessible for regular tracking. During 90 days of observation, R3 was only located at Bansbari area and there was no significance observed in her colonization pattern [F (8, 44) =7.6, p=2.2]. During 90 days of the observation period, R3 was tracked maximum at Rhino camp area (n=68) and Kuribeel area (n=63) (Fig.4.39).

The R5 (adult male) was released along with a pair of mother and calf (R6 and R7) and another solitary adult female (R8). This group was located 90% (n=557) at Bansbari area and 10% (n=62) at Bhuyanpara range and pattern of colonization was insignificant [F (17, 75) =3.8 p=2.8], (Fig.4.40).

Two pairs of mother and calves (R11 and12, R13 and 14) were released together. During the 90 days of observation period, this group was located 87.90% (n=291) at Bansbari and 12.10% (n=40) at Bhuyanpara range and pattern of colonization was found to be insignificant [F (22, 49) =1.1 p=0.3], (Fig.4.41).

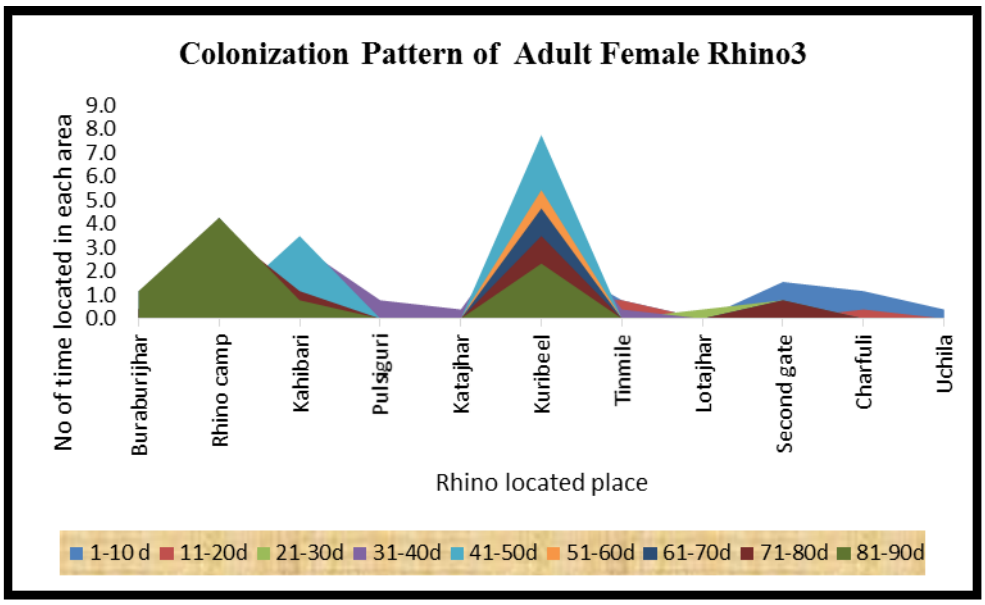

Fig. 4.39 Colonization Pattern of R3duringfirst 90 Days after Release

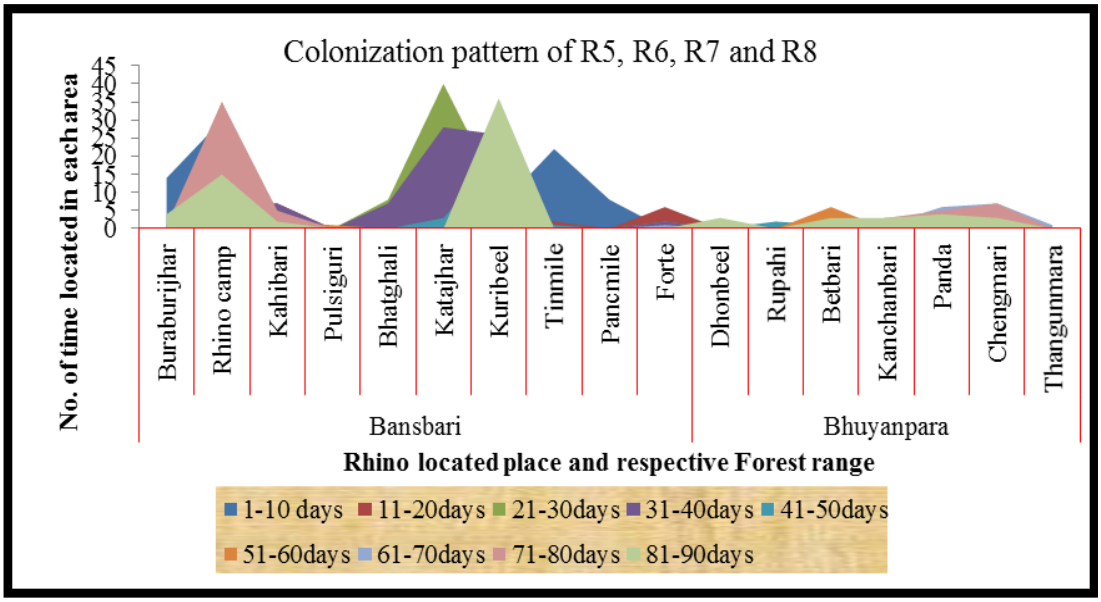

Fig. 4.40 Colonization Pattern of R5, R6, R7 &R8 during the Period of 90 Days after Release

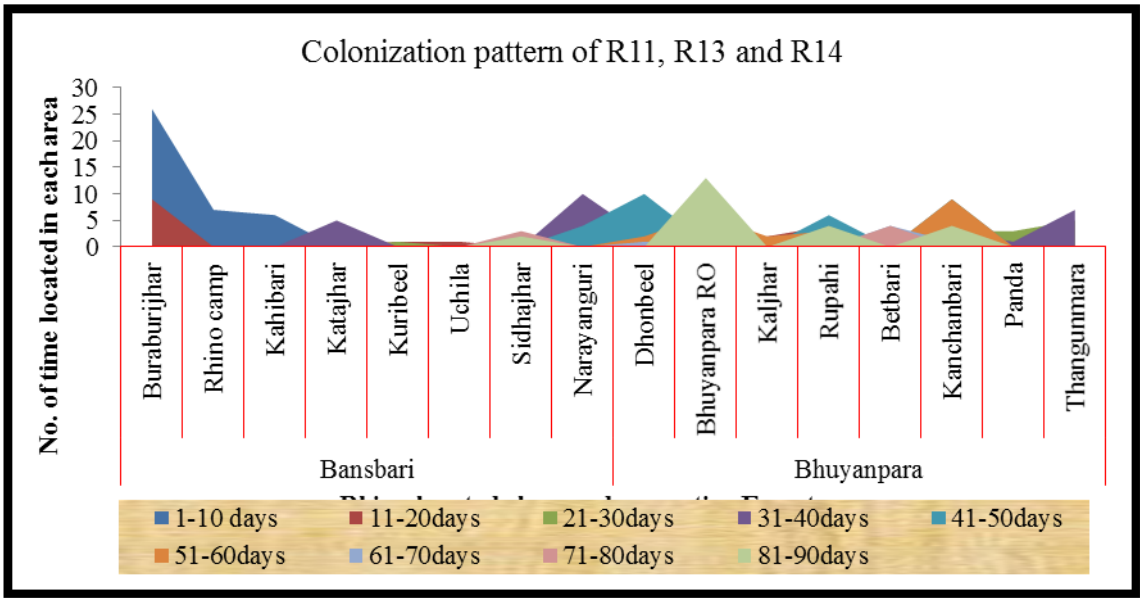

Fig. 4.41Colonization Pattern of R11, R13, R14 during first 90 Days after Release

4.3.3 Home Range of Released Rhinos

Most animals use the same areas repeatedly over time (Darwin, 1861), hence the animal movement is often defined using the home range concepts (Anderson *et al.*, 2005; Borger *et al*., 2006). Home range is the fundamental measures of spaces used by animals (Aebischer *et al*.,1993). It is characterized typically with descriptors of its size, shape, and structures (Kenward, 2001). Translocated rhino's home ranges were analyzed on the basis of radio tracking locations. In total, 4879 rhino radio tracking locations were recorded for 10 individual rhinoceros. Three adult rhinos (R1, R2 & R5) had 1822 locations, four adult females (R3, R6, R8 & R13) had 1842 locations and two male calves (R7 & R14) had 1015 locations whereas the only female calf (R11) had only 200 locations during the study period.

The released rhinoceros home range area curve (Haines *et al.*,2006) were delineated to estimate the home range by using the asymptote protocol (Odum and Kuenzher 1955). The asymptote curve was plotted on an average 10 days interval in *X*-axis against the estimated home range size on *Y*-axis (100% MCP). In the resulting graph, it was observed that asymptote reached different level for both adult male (R1, R2 and R5) and female rhinos (R3, R6, R13 and R8) (Fig 4.42). Adult males (R1, R2 &R5) reached asymptote level at 200 locations while adult females (R3, R6, R8 &R13) reached 60 locations.

From the resulted graph, it was signified that the increased the number of locations does not result in on increasing home range size. This was also indicated the establishment of a home range of rhinoceros.

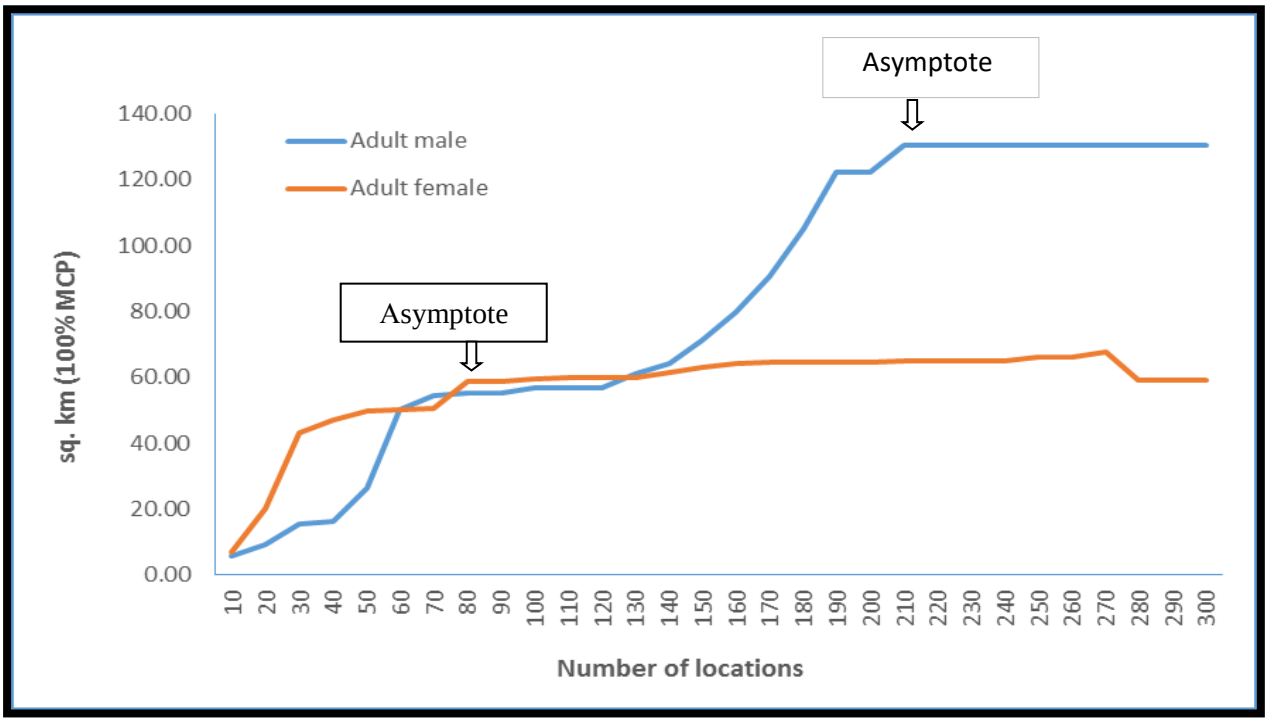

Fig.4.42 100% MCP Home Ranges of Adult Males (R1,R2&R5) and Adult Females (R3, R6, R13 and R8)Cumulative Sequential Samples Plotted vs Number of Cumulative Locations in Home Range Area Curve.

Results also indicated that male rhinos (R1, R2 and R5) were quite explorative and took much time to settle while female rhinos (R3, R6 and, R13) with calves took comparatively less time to settle after release.

As per 100% MCP results, the average home range of adult males (R1, R2 &R5) was 156.6 km^2 and adult female's (R3, R6, R8 &R13) average home range was 90.24km^2. Two male calves' (R7 &R14) average home range was 82.55km^2 and only one female calf (R11) had only 90.66 km^2 home range (Table 4.39).

Table 4.39. Overall Home Ranges of 10 Rhinos as per MCP (100%)

Sl No	Rhino ID	Gender	100% MCP Home Range
1	R1	Adult Male	93.35
2	R2	Adult Male	168.95
3	R3	Adult Female	95.40
4	R5	Adult Male	207.50
5	R6	Adult Female	35.31
6	R7	Male calf	53.75
7	R8	Adult Female	96.13
8	R11	Female calf	90.66
9	R13	Adult Female	134.14
10	R14	Male calf	111.36

The determination of rhinoceros' core area is based on the evaluation of the density of the used surface generated with FKD (Fixed Kernel Density)[1]. FKD home ranges of each rhino and average value for contour area (Table 4.40) was calculated. On an average, FKD isopleths graphs for all 10 rhinos showed inflexion at 55% (Fig 4.43) and these isopleths' value was used as the estimate of the core area home ranges for all the rhinos[2].

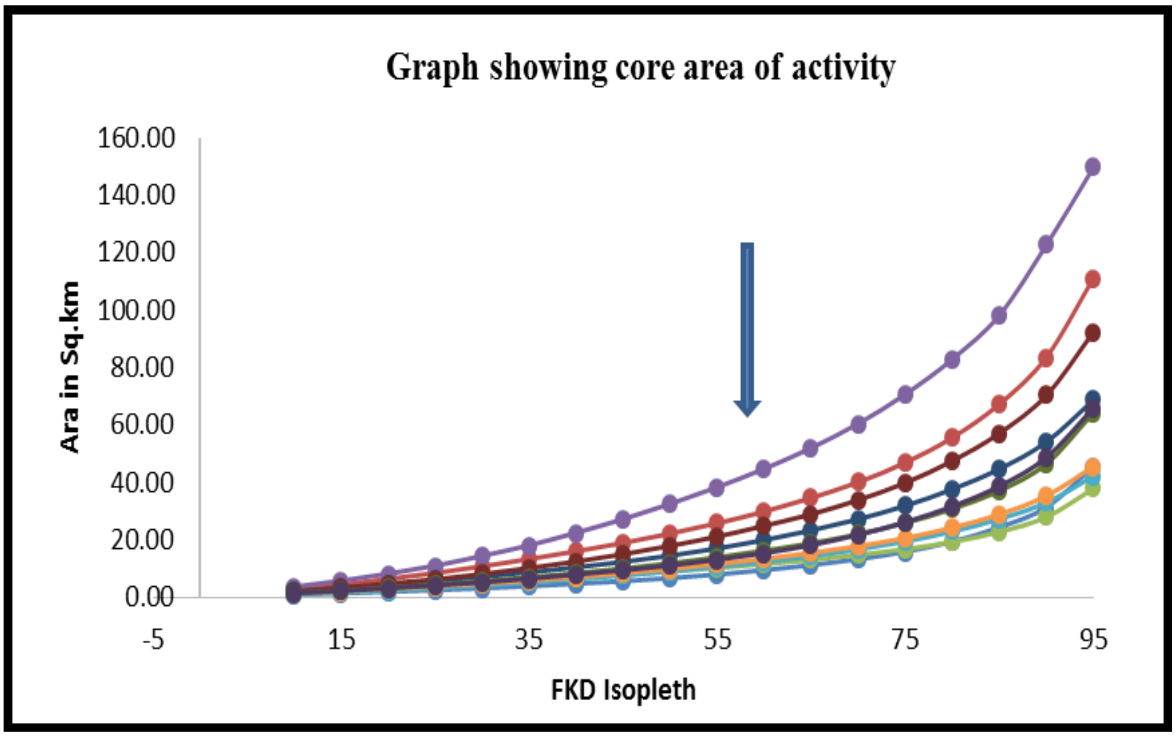

Fig.4.43 FKD (95%) Isopleths Versus Area of the Home range for Defining the Core Area of the Home range at a Point of inflexion (†) for All 10 Released Rhinos.

[1] Details of FKD method is explained in the Chapter III.

[2] Details of Isopleth is explained in Chapter III

Table 4.40 All Rhinos' Home Range in Core Area as per FKD (95%)

Rhino ID	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10
R1	45.26	31.16	24.20	19.23	15.76	13.16	11.13	9.37	7.89	6.62	5.55	4.65	3.84	3.10	2.48	1.88	1.37	0.87
R2	110.90	83.50	67.16	55.55	46.81	40.01	34.54	29.79	25.74	22.17	18.90	16.01	13.32	10.76	8.45	6.38	4.38	2.56
R3	38.06	28.10	22.83	19.36	16.76	14.74	13.02	11.53	10.16	8.95	7.73	6.72	5.66	4.69	3.80	2.86	2.05	1.32
R5	149.70	122.75	98.17	82.86	70.55	60.36	51.86	44.59	38.18	32.34	27.00	22.29	17.87	14.19	10.76	7.98	5.54	3.40
R6	42.13	32.97	27.28	22.95	19.53	16.76	14.48	12.43	10.81	9.14	7.74	6.47	5.29	4.28	3.37	2.53	1.79	1.12
R7	45.50	35.26	28.74	24.12	20.47	17.64	15.27	13.19	11.41	9.71	8.19	6.81	5.61	4.51	3.57	2.65	1.85	1.21
R8	68.65	54.14	44.73	37.67	31.95	27.28	23.36	20.00	17.10	14.57	12.45	10.54	8.79	7.26	5.90	4.51	3.28	2.12
R11	92.31	70.31	57.07	47.44	39.82	33.83	28.90	24.86	21.09	17.91	14.99	12.44	10.15	8.08	6.22	4.75	3.28	1.99
R13	64.07	46.35	37.00	30.67	25.84	21.89	18.77	16.18	13.85	11.81	10.00	8.37	6.90	5.59	4.38	3.29	2.31	1.45
R14	65.64	48.47	38.49	31.43	25.97	21.60	18.00	15.22	12.92	10.90	9.23	7.77	6.33	5.07	3.99	2.99	2.05	1.30
Average	74.29294	58.45627	48.24339	41.02597	35.31422	30.65928	26.75793	23.37778	20.37638	17.64757	15.1632	12.91567	10.79613	8.866026	7.082874	5.437438	3.898834	2.485385

Adult Males (R1, R2 &R5), Females (R3, R6, R13 &R8) and Calves (R7, R14 &R11) Rhinos Overall Core Home Range Areas by MCP (100%)

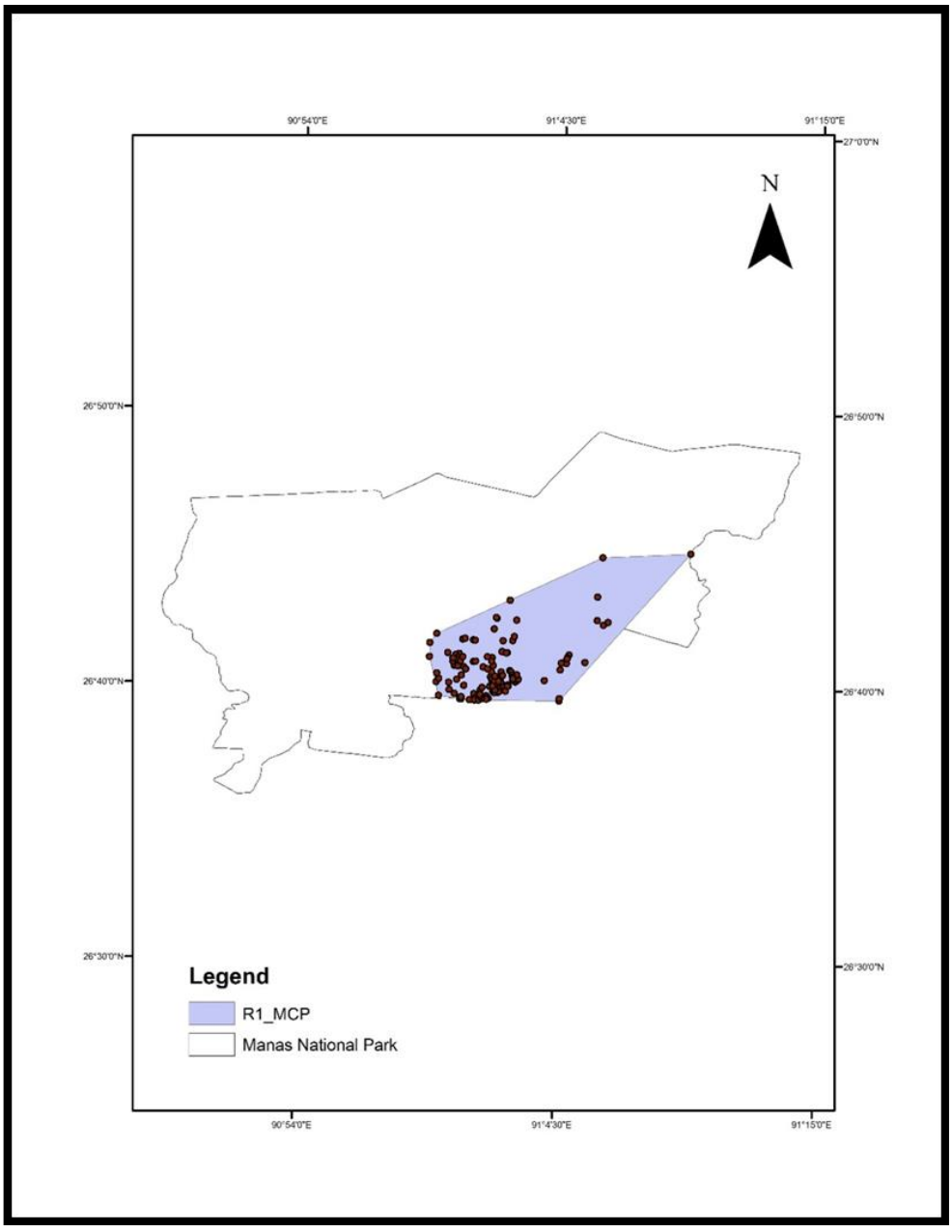

Fig.4.44 Overall Home Range Areas of R1 (Adult male) (100% MCP)

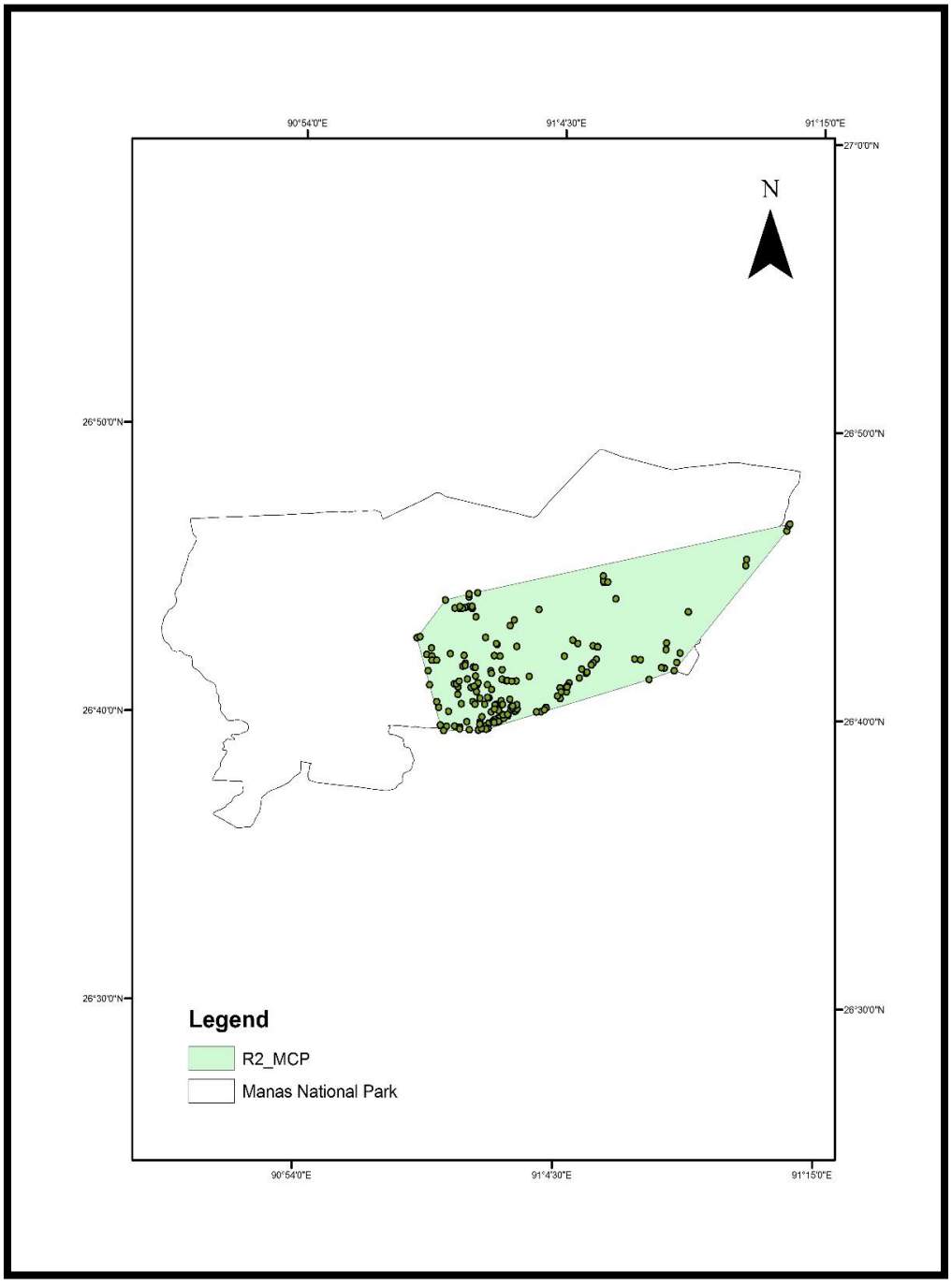

Fig.4.45 Overall Home Range Areas of R2 (Adult Male) (100% MCP)

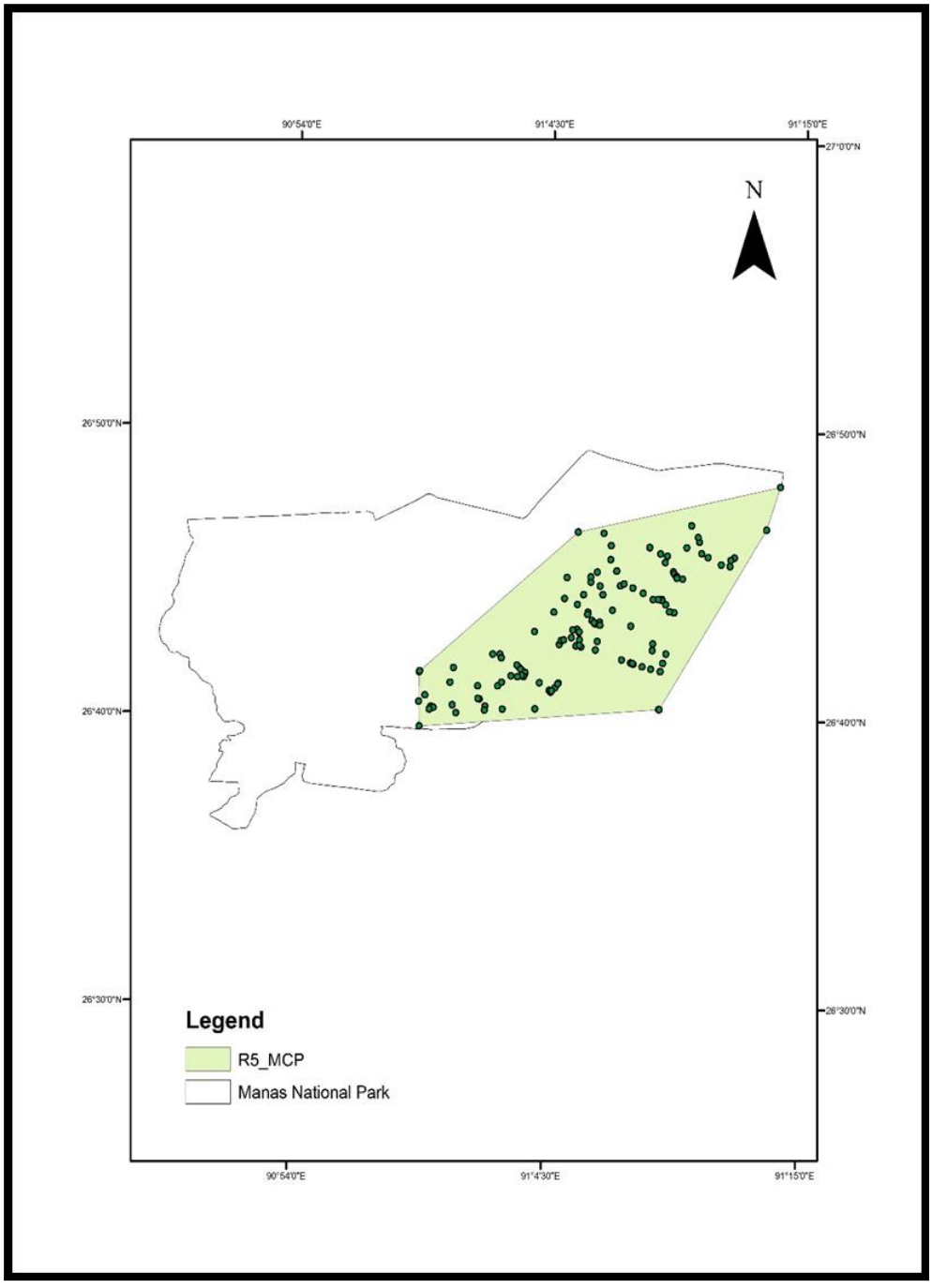

Fig.4.46 Overall Home Range Areas of R5 (Adult Male) (100% MCP)

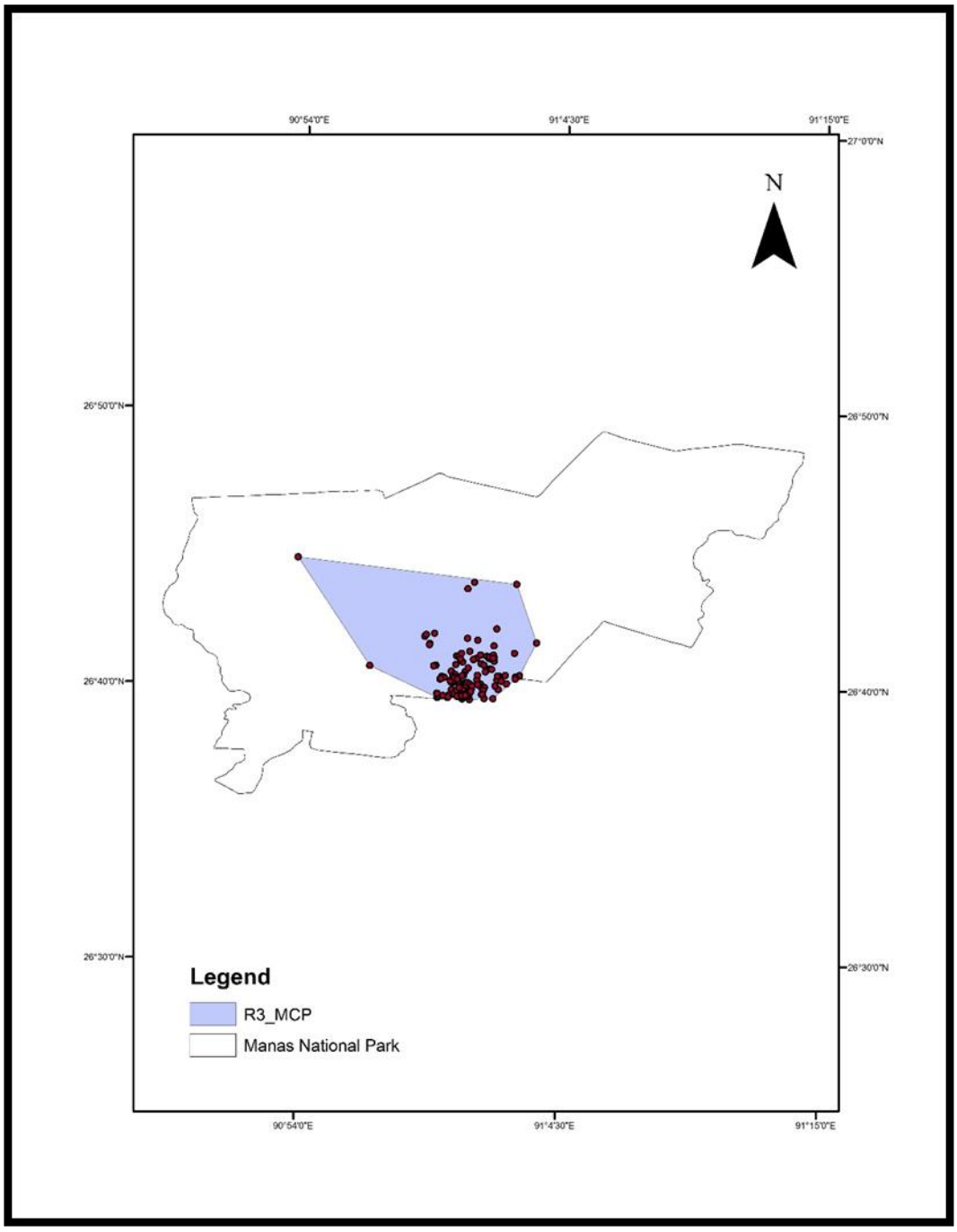

Fig.4.47 Overall Home Range Areas of R3 (Adult Female) (100% MCP)

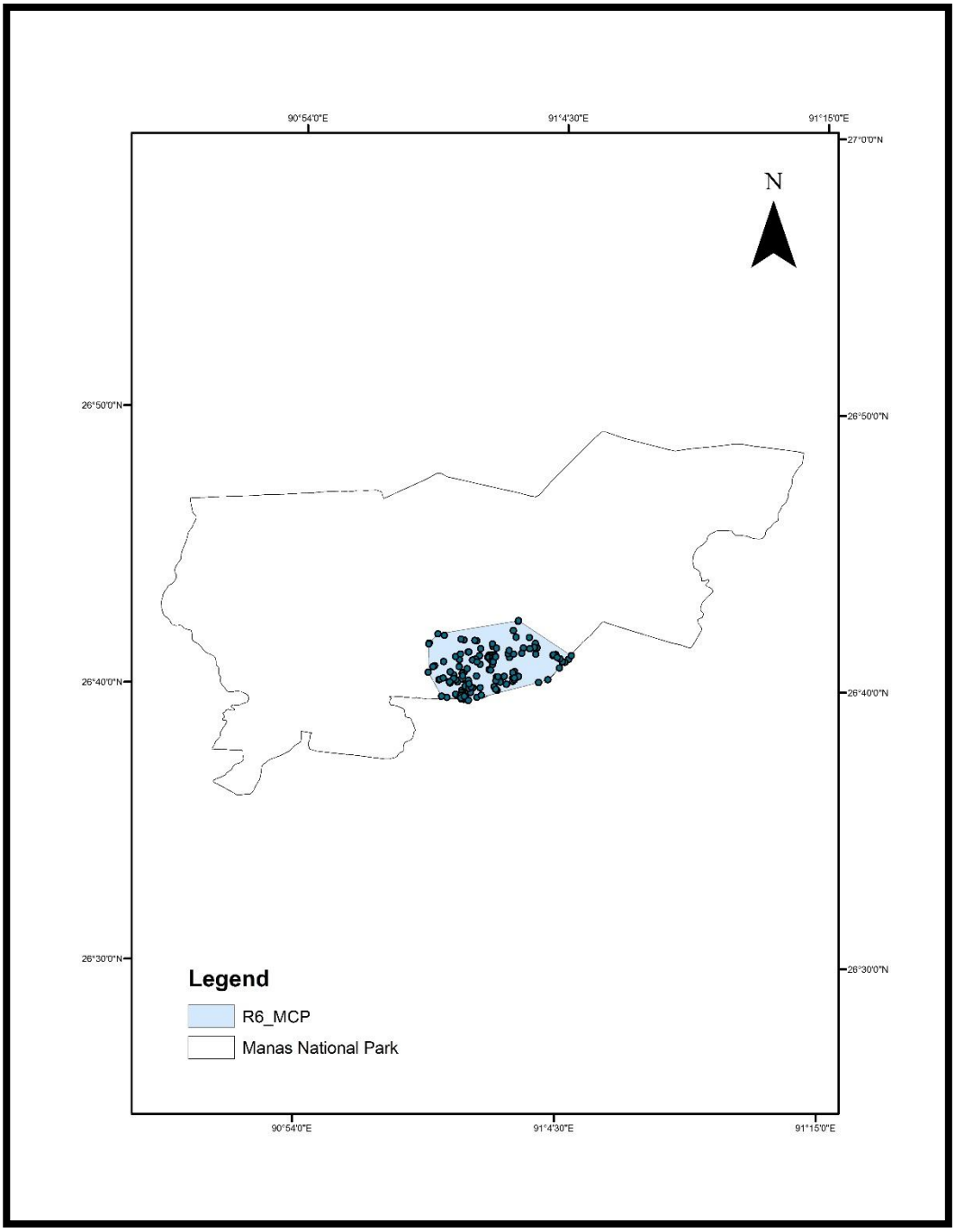

Fig.4.48 Overall Home Range Areas of R6 (Adult Female) (100% MCP)

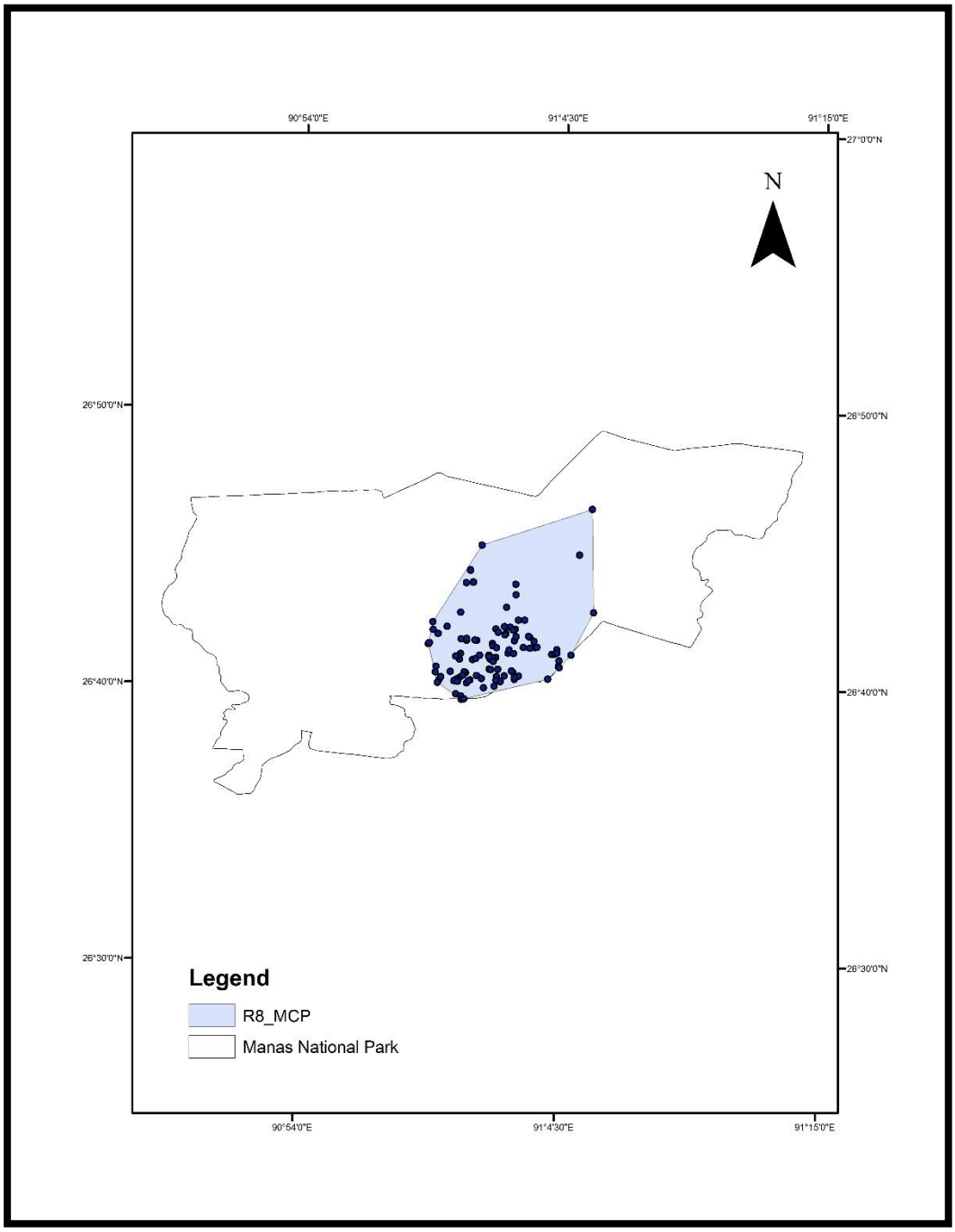

Fig.4.49 Overall Home Range Areas of R8 (Adult Female) (100% MCP)

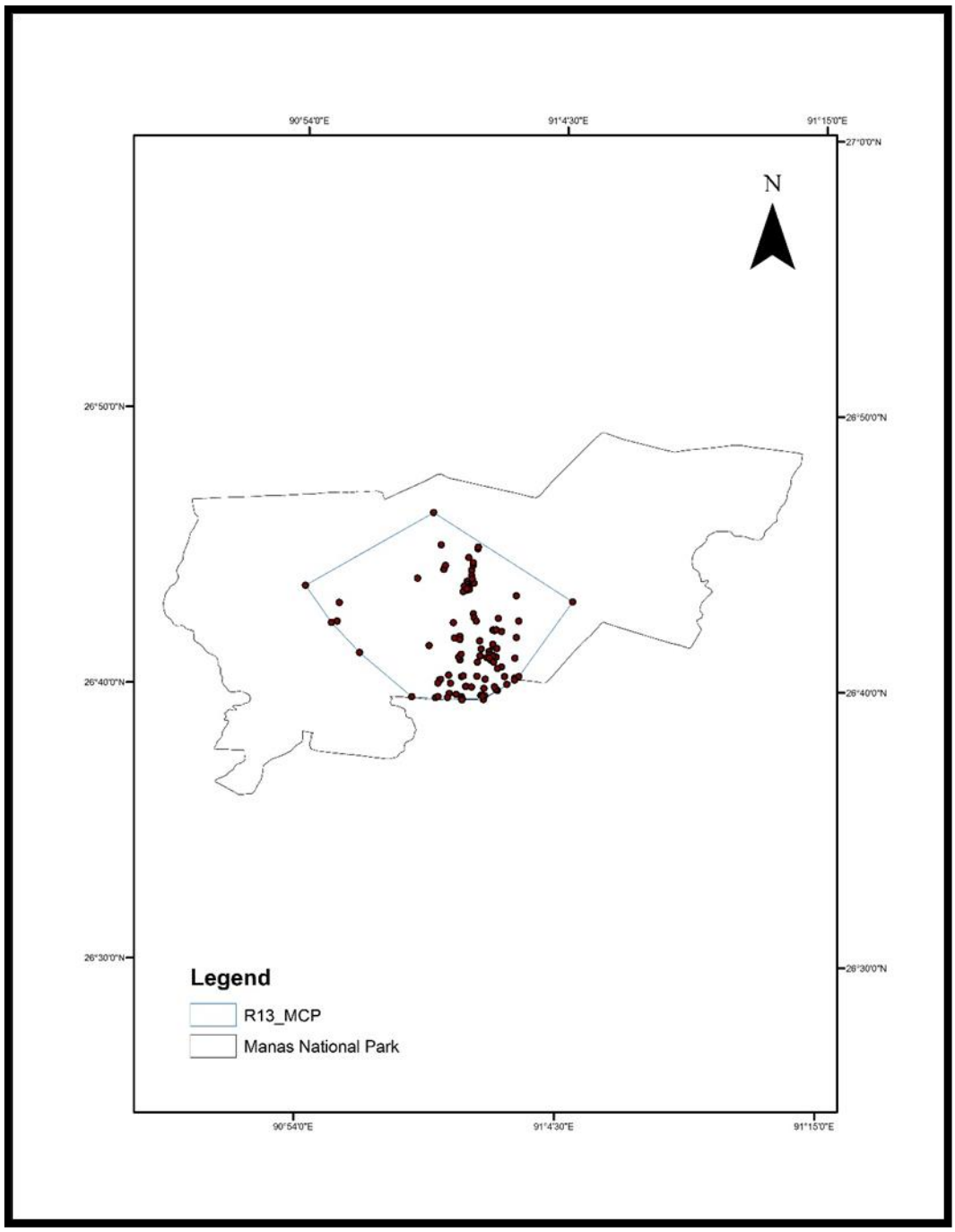

Fig. 4.50 Overall Home Range Areas of R13 (Adult Female) (100% MCP)

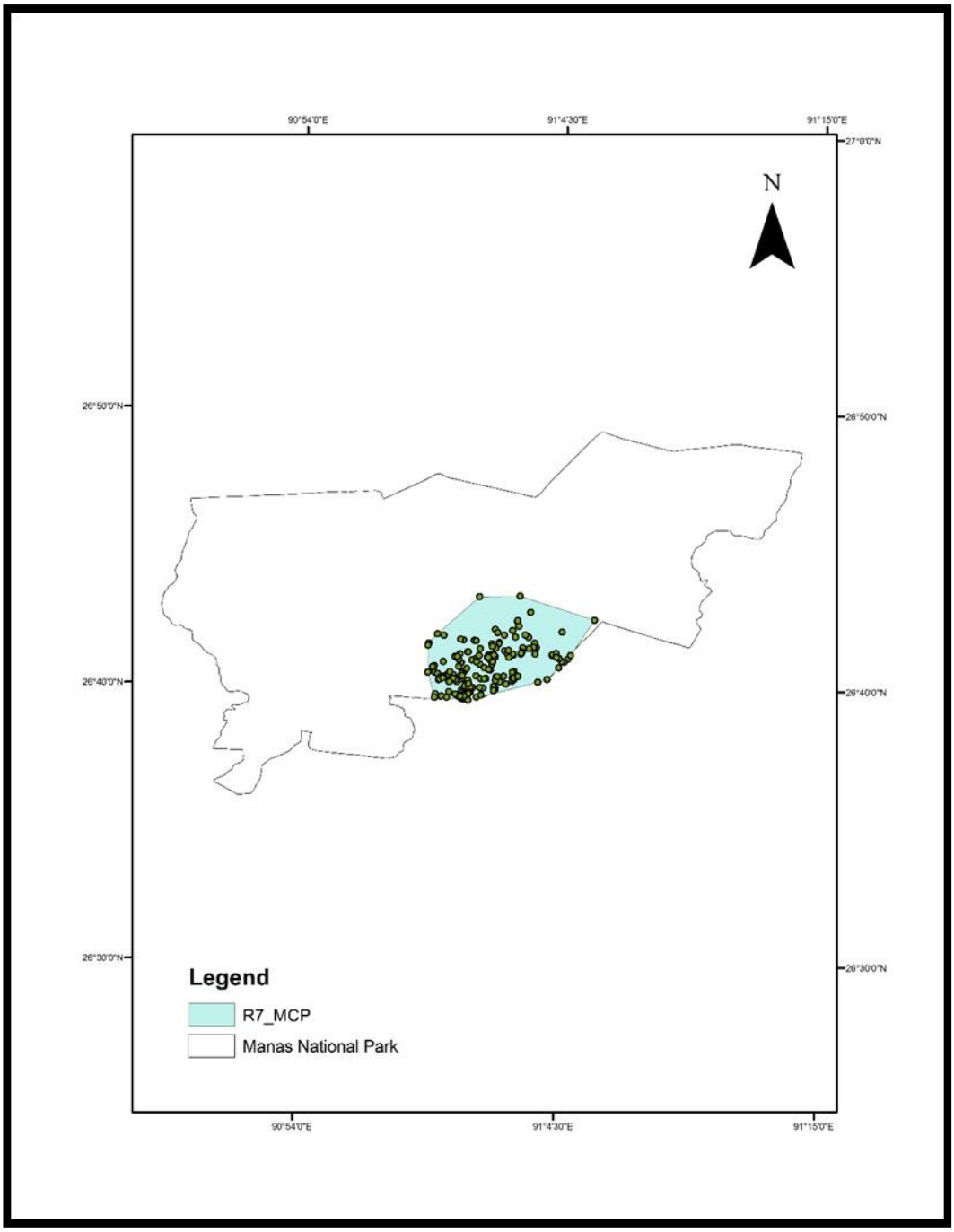

Fig.4.51 Overall Home Range Areas of R7 (Male Calf) (100% MCP)

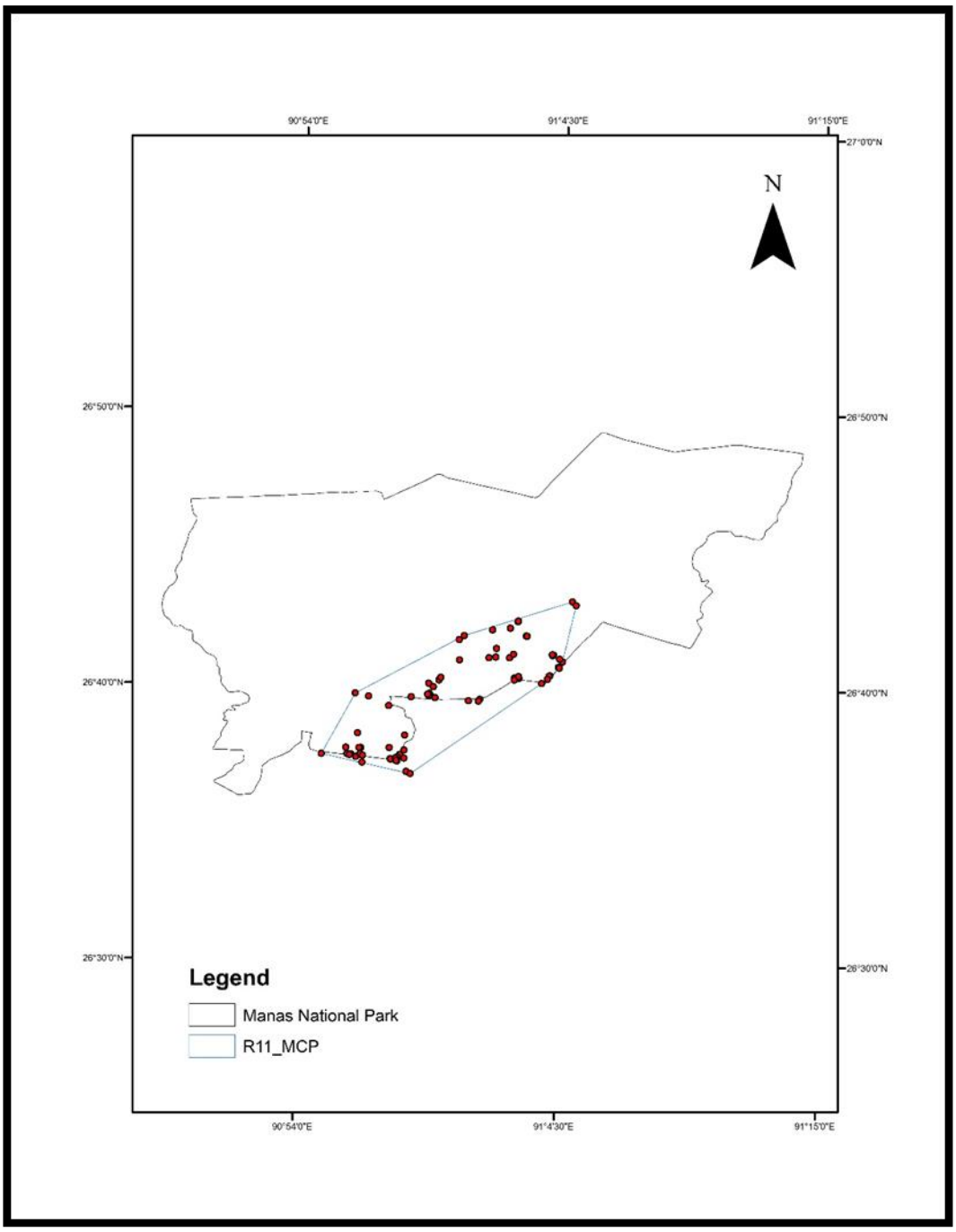

Fig.4.52 Overall Home Range Areas of R11 (Female Calf) (100% MCP)

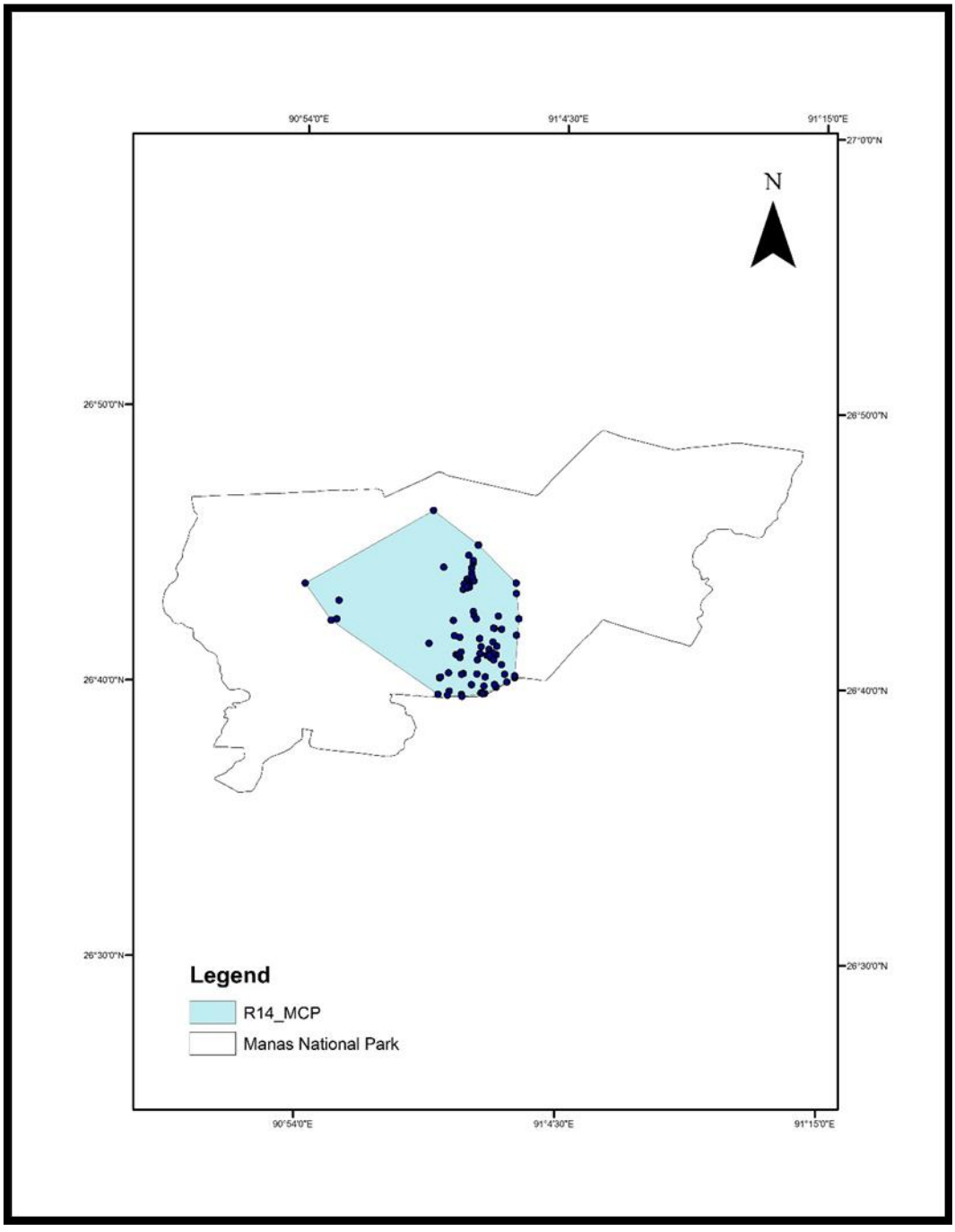

Fig.4.53 Overall Home Range Areas of R14 (Male Calf) (100% MCP)

Adult Male (R1, R2 &R5) and Female Rhinos (R3, R6, R13&R8)

Overall Core Home Range Areas by FKD (95%)

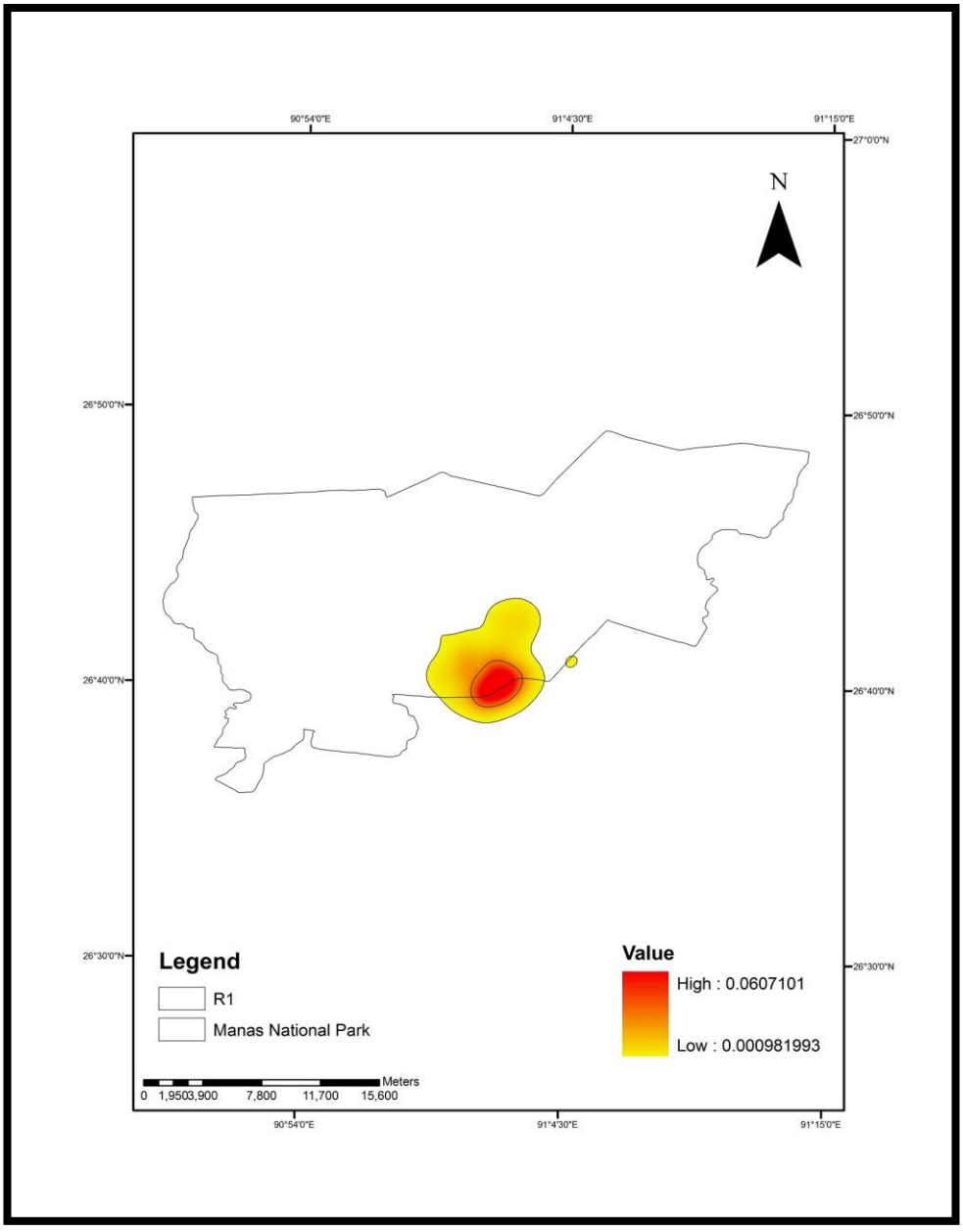

Fig.4.54 Core Home Range of Rhino 1 (Adult Male)

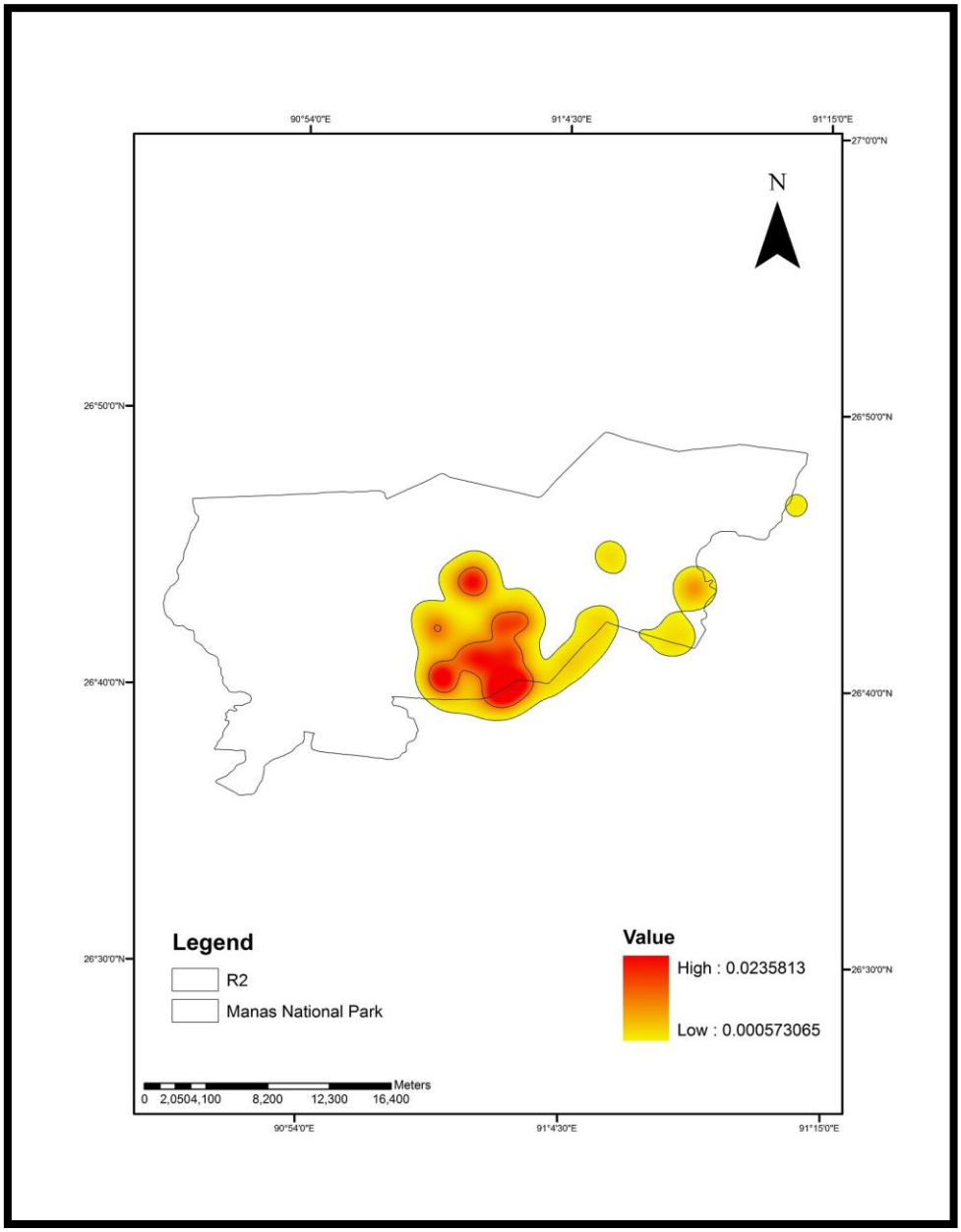

Fig.4.55 Rhino2's (Adult Male) Core Home Range

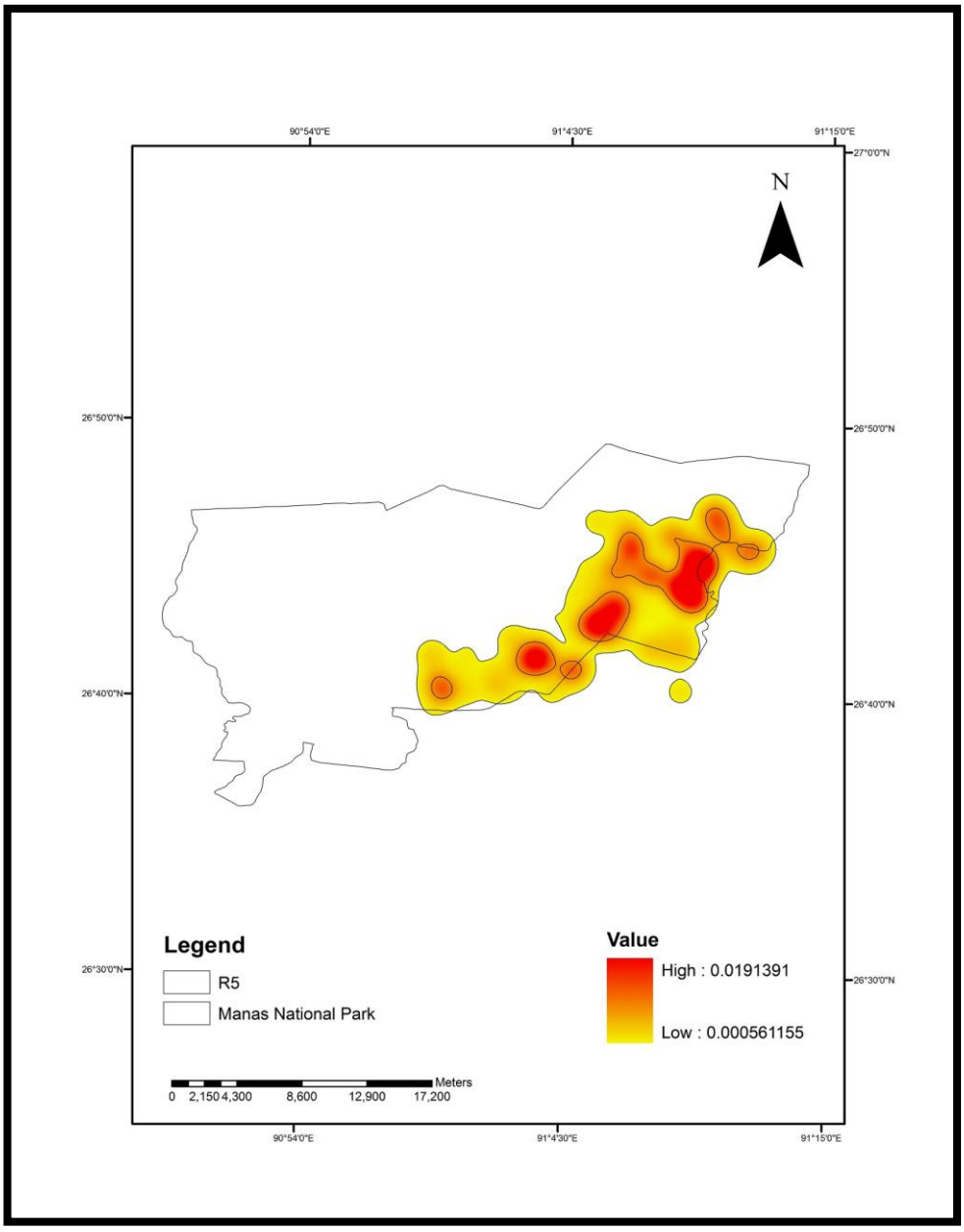

Fig.4.56 Rhino5's (Adult Male) Core Home Range

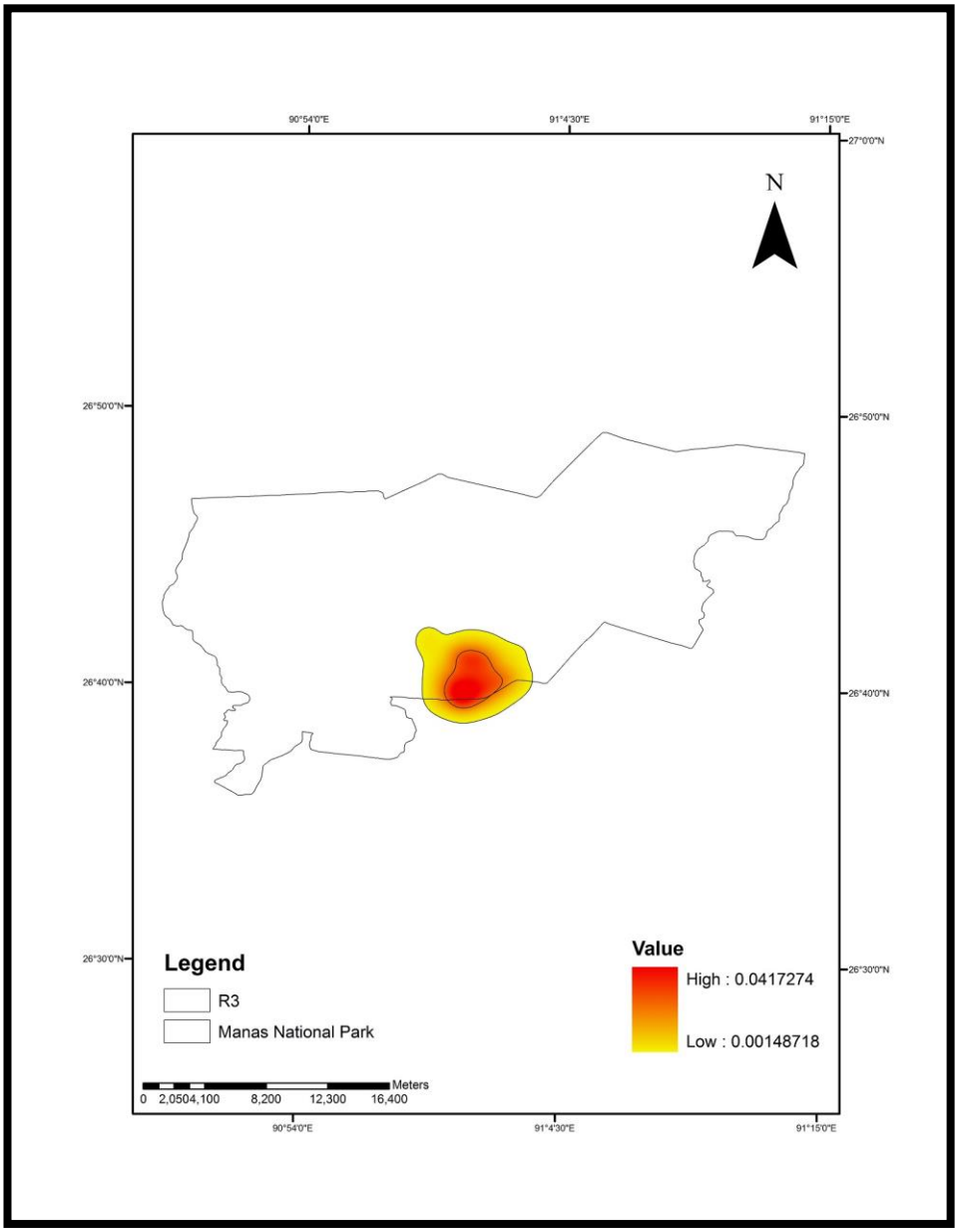

Fig.4.57 Rhino3's (Adult Female) Core Home Range

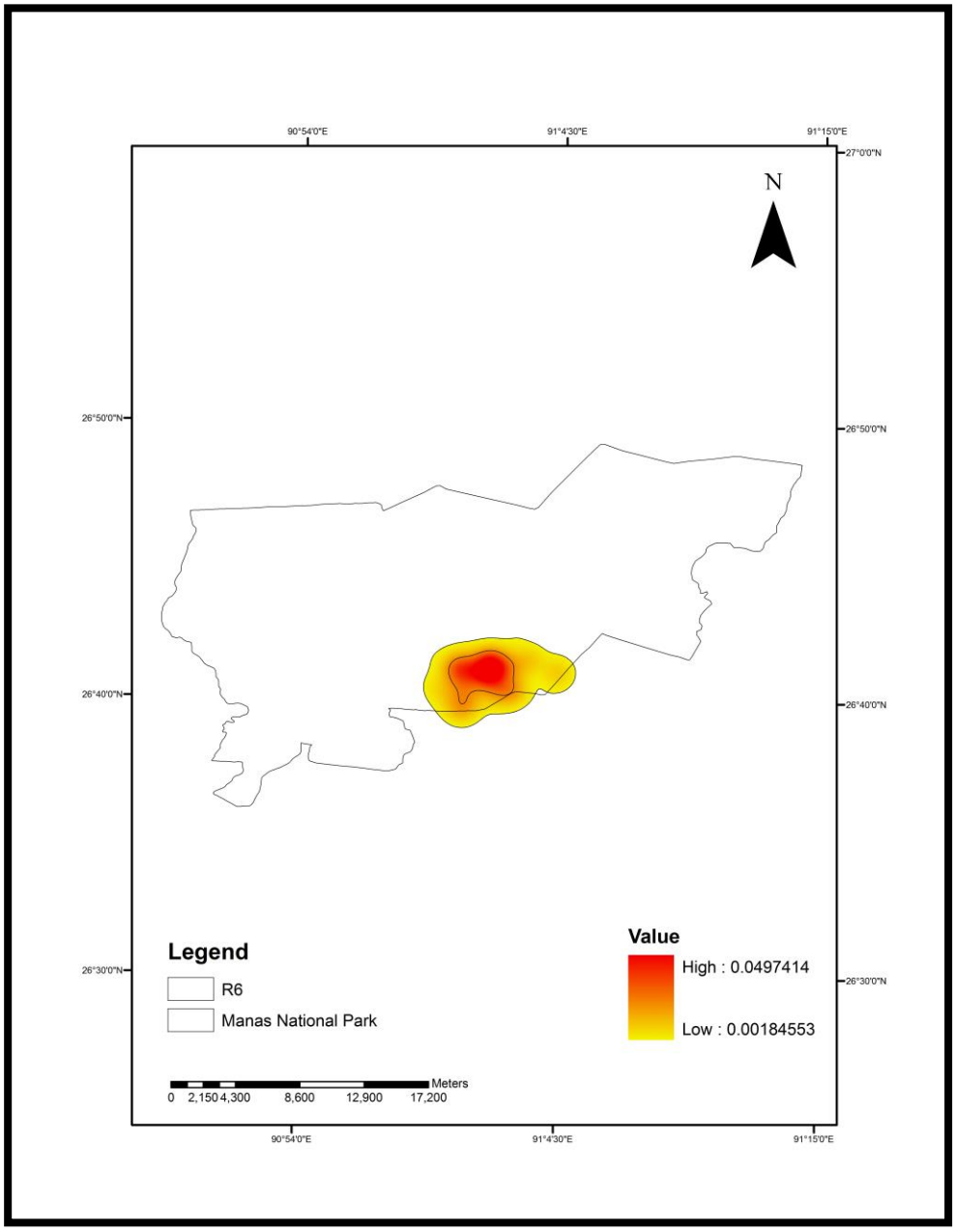

Fig.4.58 R6's (Adult Female) Core Home Range

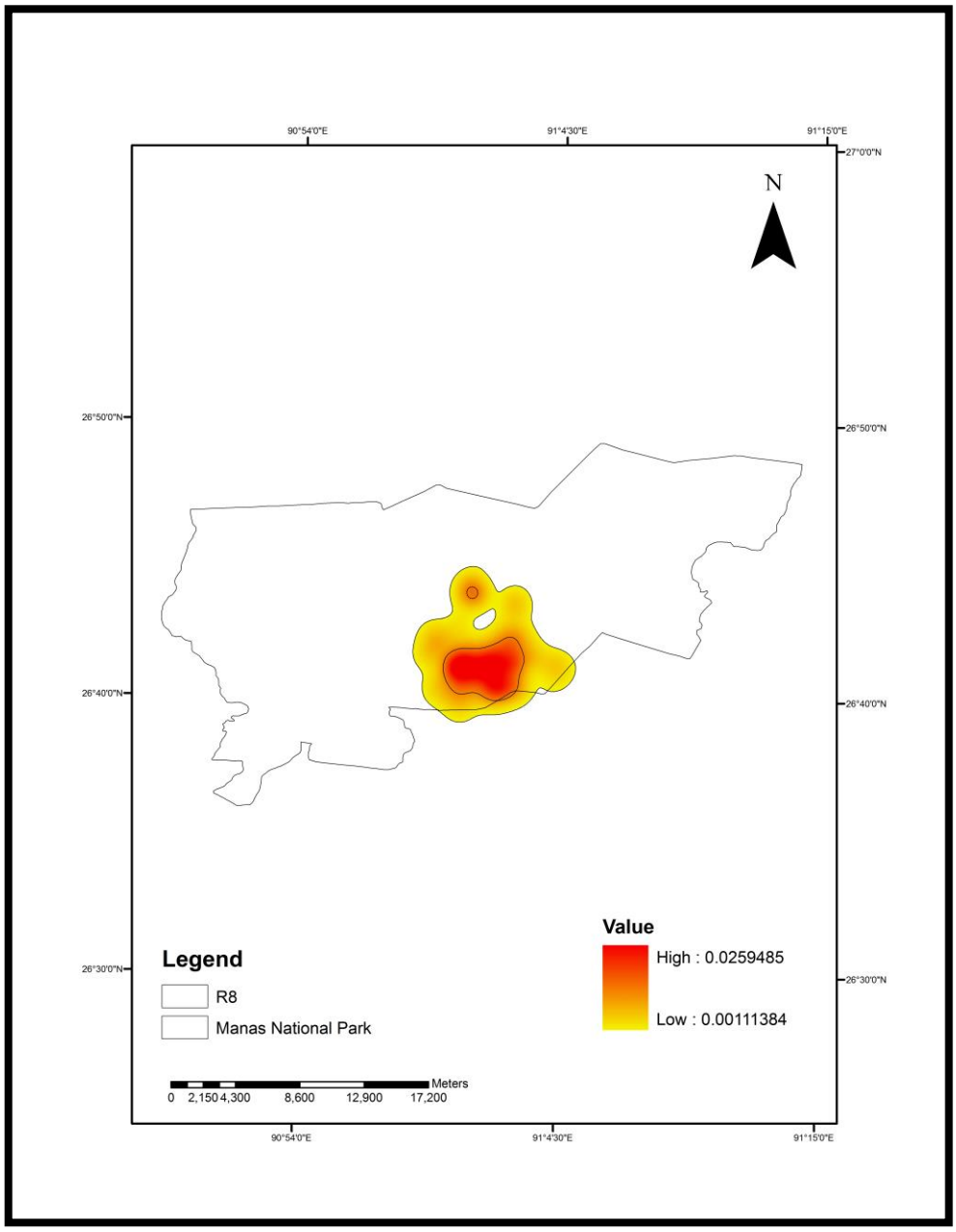

Fig.4.59 R8's (Adult Female) Core Home Range

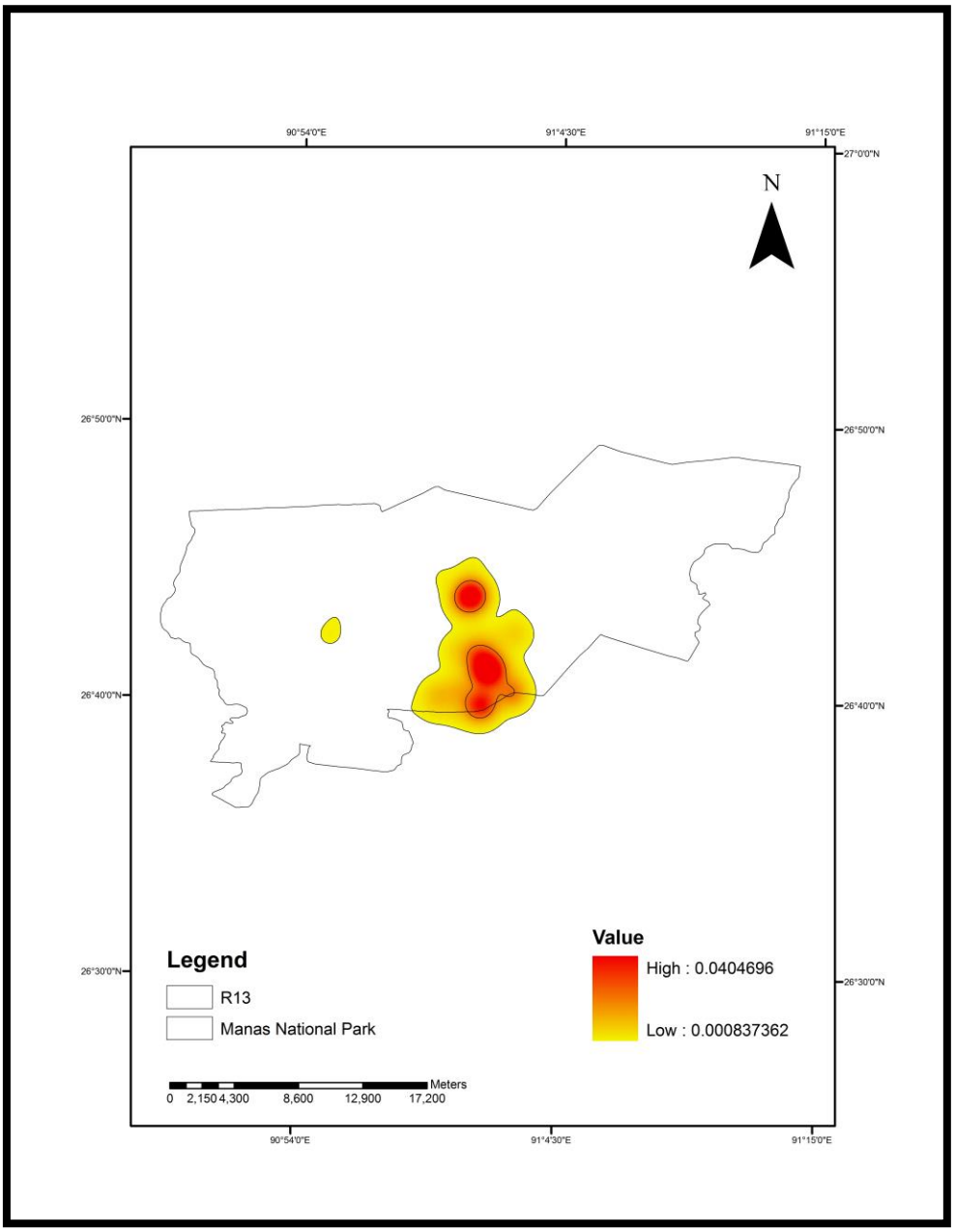

Fig.4.60 Rhino13's (Adult Female) Core Home Range

4.3.3.1 Seasonal Home Ranges of Rhinos

Comparative seasonal data was used to determine the home range for all rhinos with MCP (100%) and FKD (95% and 55%). FKD (95%) was used to avoid partial movement in home range and FKD (55%) was done to see actual core area activity.

As per estimation, adult males (R1, R2 and R5), adult females (R3, R6, R13 and R8) and calves (R7, R14 and R11) did not display particular pattern of home ranges. During pre-monsoon period, the maximum area of home range (73.04 km^2) was displayed by adult rhino R5 while the minimum area was with adult male R1(38.09 km^2).

During monsoon, maximum home range of 145.38 km^2 was displayed by adult male R2 while minimum home range 14.33 km^2 was found with R1 (adult male).

In retreating monsoon, maximum home range of 76.97 km^2 was with adult male R5 and minimum home range of 2.67 km^2 was observed with R2 (adult male).

In winter, the maximum home range of 79.95 km^2 was with R1 and minimum home range of 77.88 km^2 was estimated with R5 (Table 4.41). There was significant variation in seasonal home range change observed among adult male rhinos in MCP (100%) estimation (χ^2=149.6938, the *P* value .00001 result was significant at $p<.05$)

Table 4.41 Adult Male (R1, R2 and R5) Rhinos' Seasonal Home Range Areas

ID	season	MCP (100%) sq. km	FKD (95%) sq. km	FKD (55%) sq. km
R1	monsoon	14.33	23.37	5.28
R1	winter	79.95	57.34	10.19
R1	Pre-monsoon	38.09	40.80	9.38
R1	Retreating Monsoon	11.25	25.14	6.90
R2	Monsoon	145.38	97.39	15.34
R2	Pre-monsoon	49.23	59.09	16.04
R2	Retreating Monsoon	2.67	16.67	4.21
R2	Winter	68.54	68.04	17.11
R5	Monsoon	139.76	119.68	32.71
R5	Pre-monsoon	73.04	78.22	17.06
R5	Retreating Monsoon	76.97	83.90	21.16
R5	Winter	77.88	88.89	22.75

In the Kernel (95%) and Kernel (55%), core area seasonal home range estimations, adult male R5 displayed some exploratory ranging patterns. During pre-monsoon, monsoon, retreating and winter, adult male R5 showed maximum areas of core home ranges.

The seasonal core home range quite varies in other two adult males (R1 and R2). Adult male R1 exhibited minimum core home range in pre-monsoon, monsoon and winter seasons in comparison to R2 and R5. .

The adult male R2 had minimum home range areas in retreating monsoon season in comparison to R1 and R5.

There were significant variations in home range coverage observed in Kernal (95%) (χ^2=49.2013, the *P* value <0.00001 results were significant at $p<.05$)**.** But it was observed insignificant variations in Kernel (55%) estimation (χ^2=10.959 the *p*-value was .08965)

Seasonal Core Home Range Adult Male Rhino1By FKD (95% & 55%)

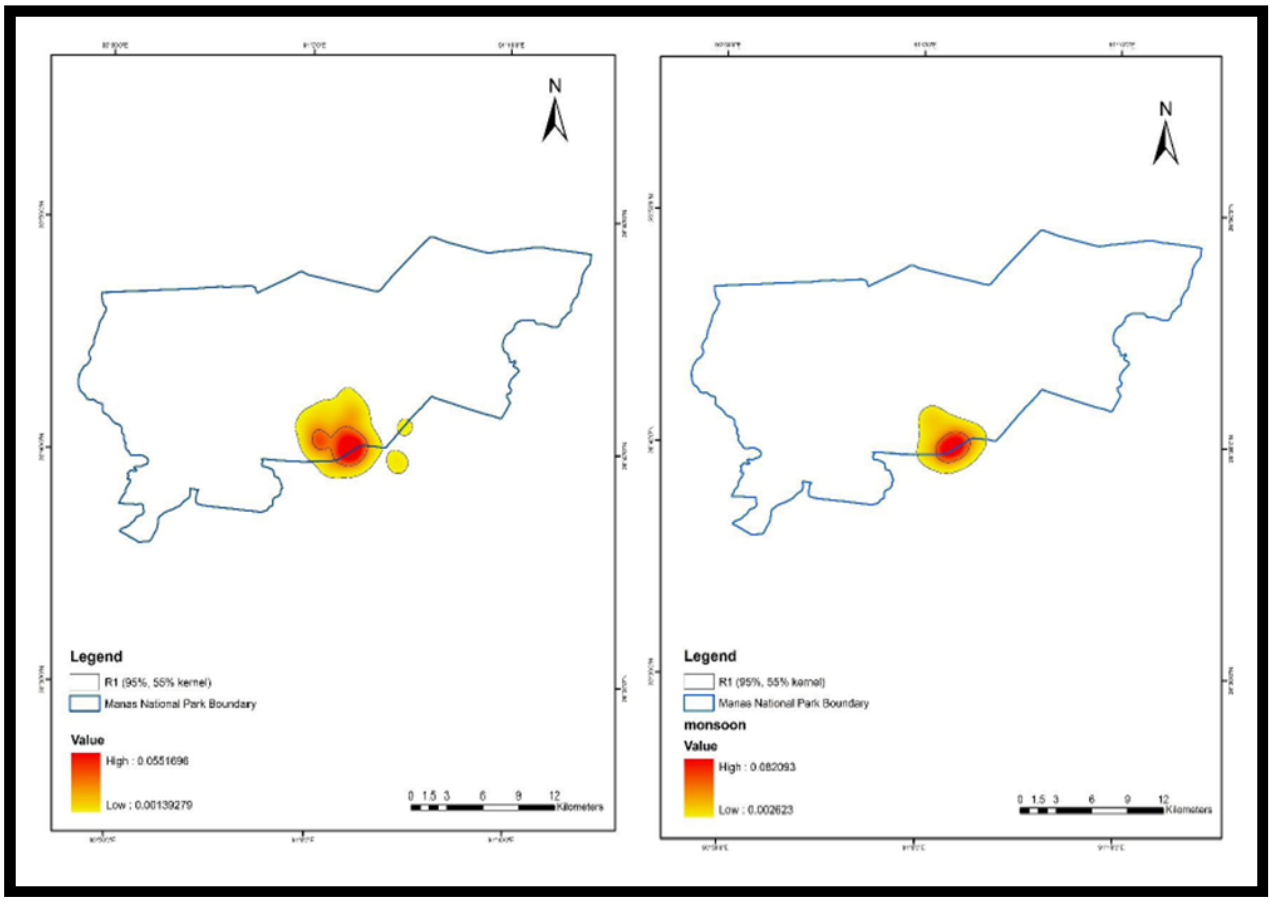

Fig.4.61 Rhino1's Pre-monsoon season Home Range

Fig. 4.62 Rhino1's Monsoon Season Home Range

Seasonal Core Home Range Adult Male Rhino1By FKD (95% & 55%)

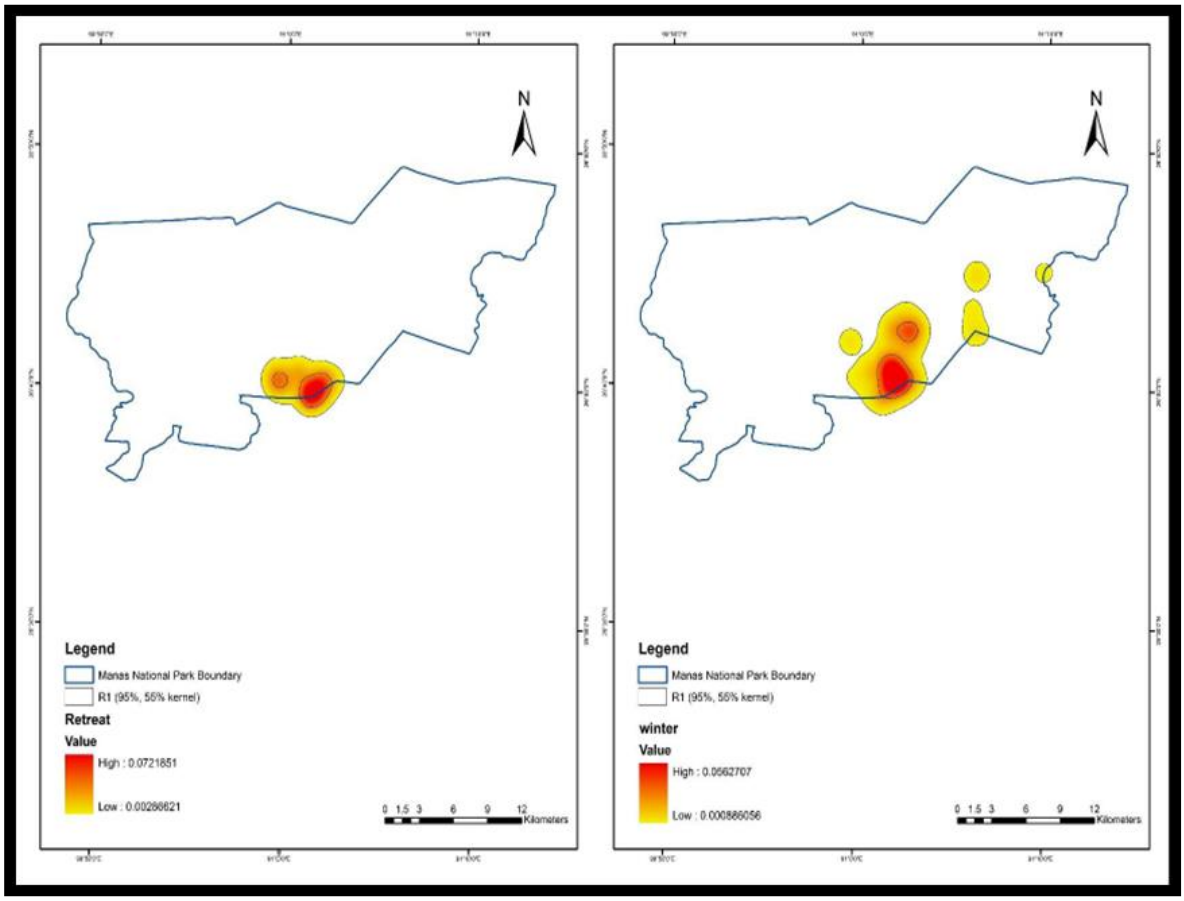

Fig.4.63Rhino1's Retreating Monsoon Season Home Range

Fig. 4.64 Rhino1's Winter Season Home Range

Seasonal Core Home Range of Adult Male Rhino2

By FKD (95% & 55%)

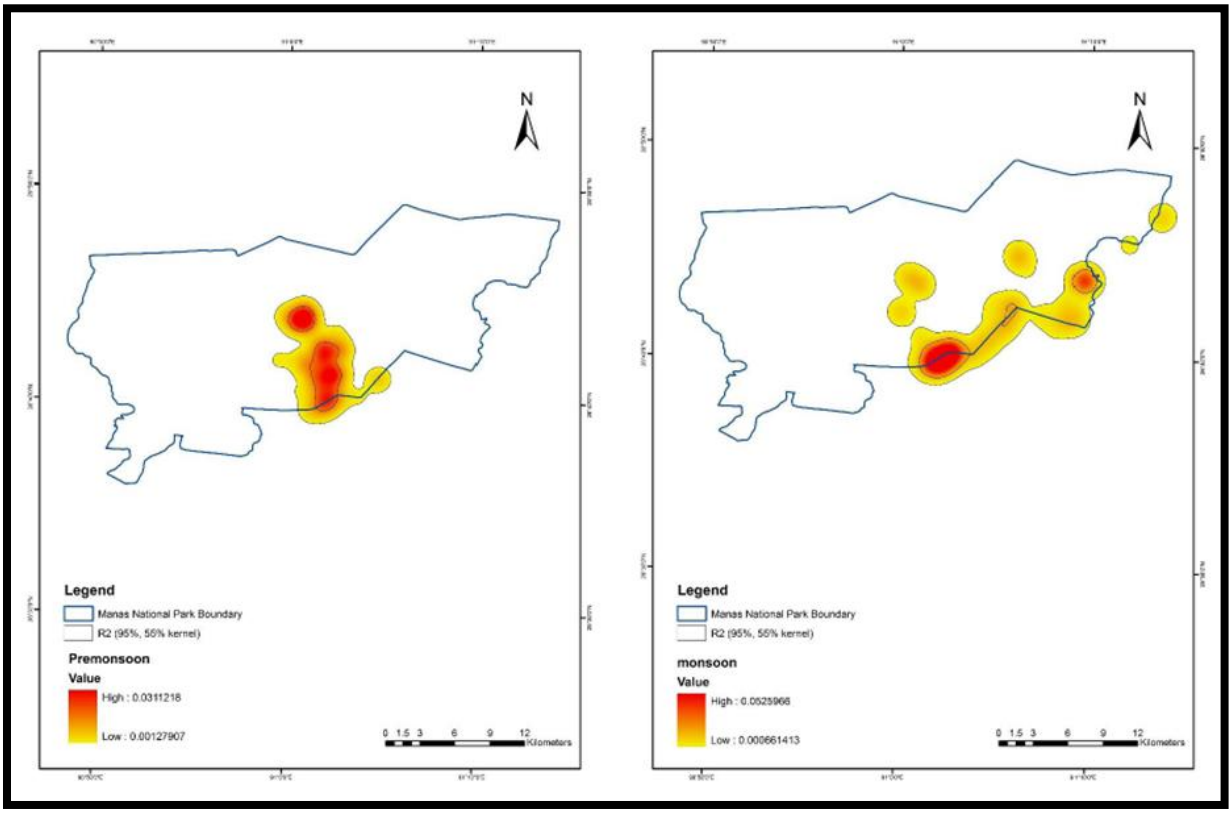

Fig.4.65 Rhino2's Pre-monsoon Season Home Range

Fig. 4.66 Rhino2's Monsoon Season Home Range

Seasonal Core Home Range of Adult Male Rhino2

By FKD (95% & 55%)

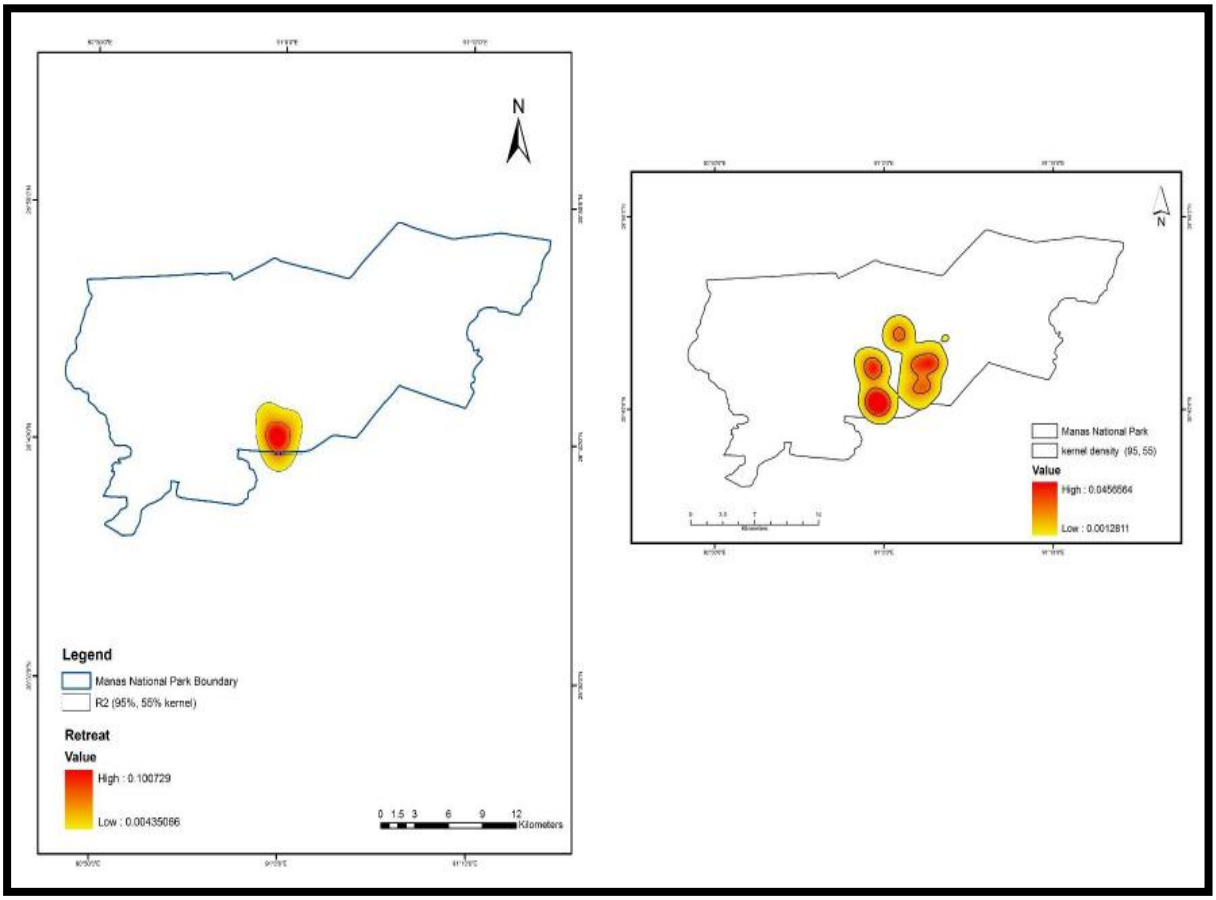

Fig.4.67Rhino2's Retreating monsoon Season Home Range

Fig. 4.68 Rhino2's Winter Season Home Range

Seasonal Core Home Range of Adult Male Rhino5

By FKD (95% & 55%)

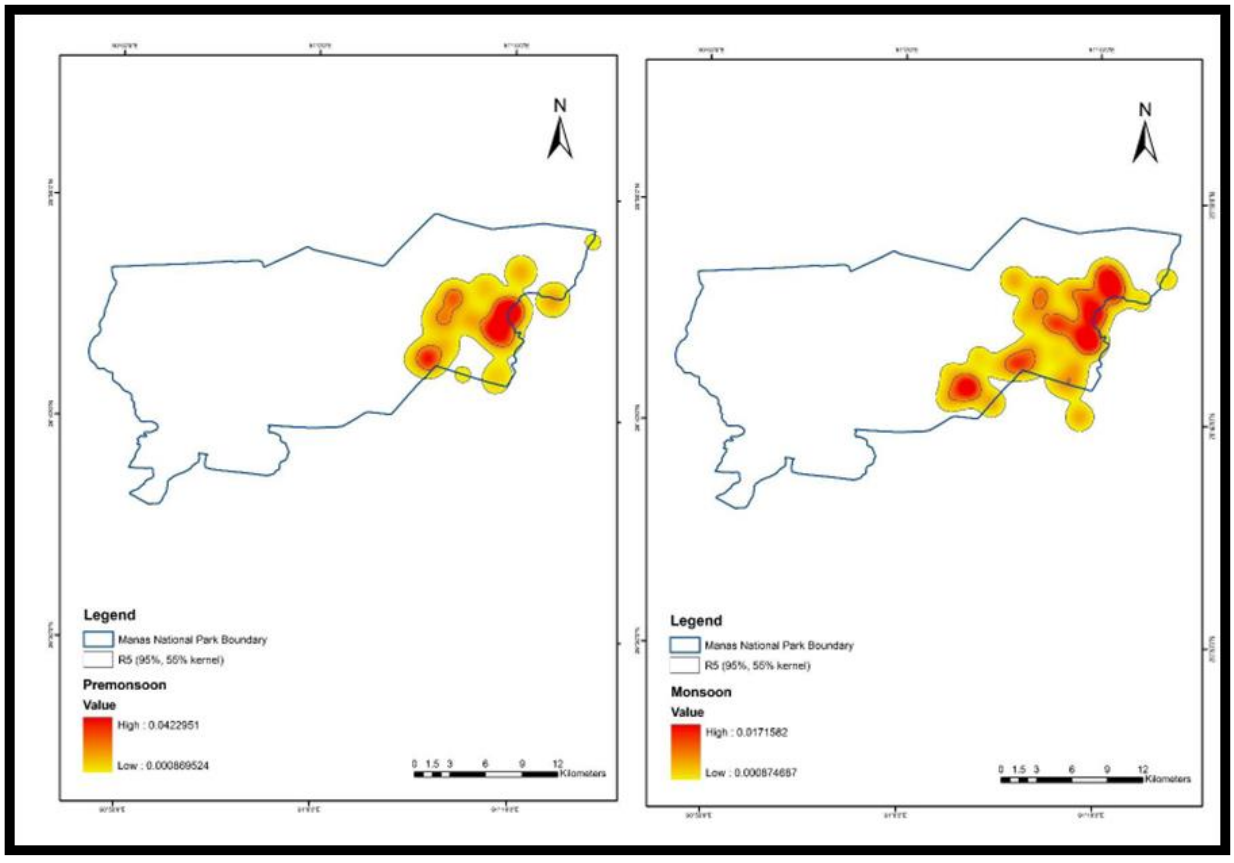

Fig.4.69 Rhino5's Pre-monsoon Season Home Range

Fig.4.70 Rhino5's Monsoon Season Home Range

Seasonal Core Home Range of Adult Male Rhino5

By FKD (95% & 55%)

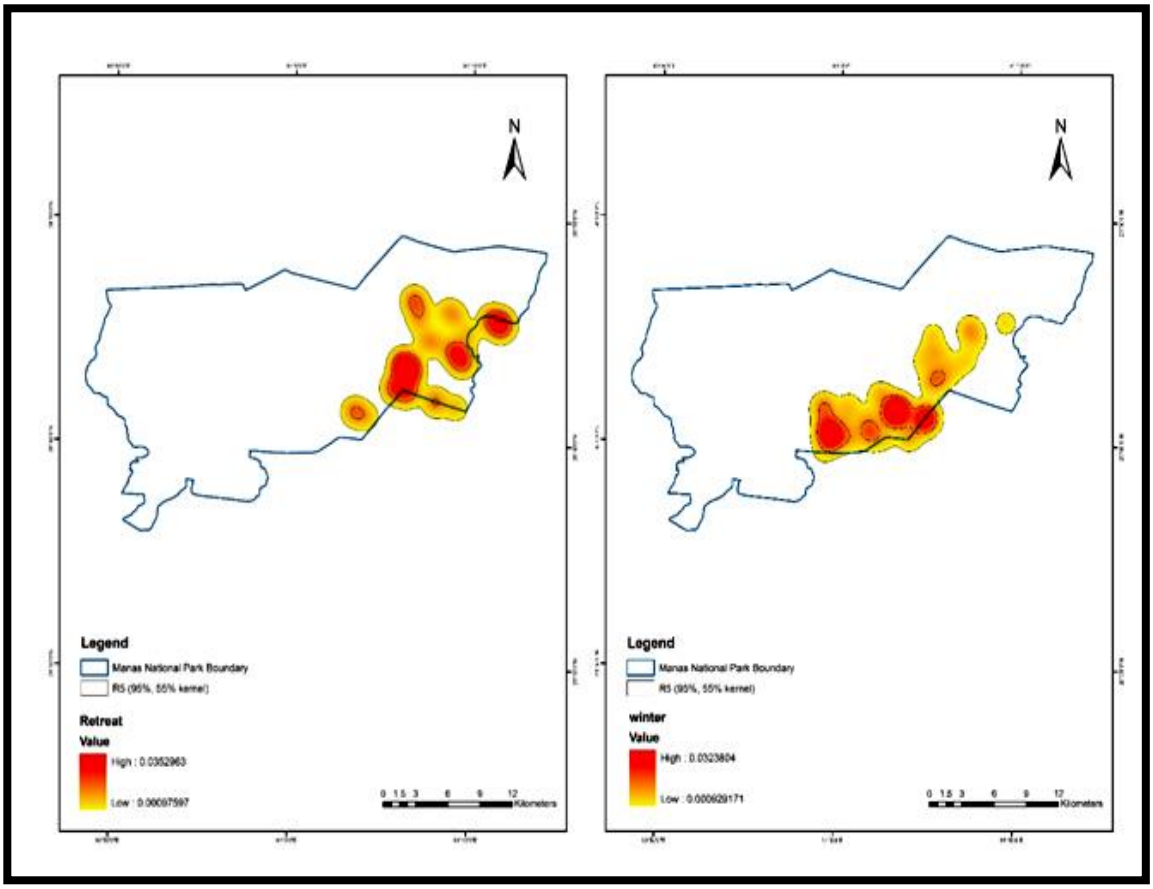

Fig.4.71 Rhino5's Retreating Season Home Range

Fig.4.72 Rhino 5's Winter Season Home Range

Adult female rhinos (R3, R6, R13 and R8) did not display any particular pattern of home range in according to seasons. R3, R6, and R13 had calves and R8 was a solitary adult. Two male calves (R7 and R14) used almost same ranging areas with their mother. Female calf R11 was separated from her mother (R12) 26 days after release at MNP and was using western part (Narayanguri area) of Bansbari range during the study period.

During the pre-monsoon period, the maximum home range of 130.63 km^2 with MCP (100%) was estimated with adult female R13 and minimum home range of 11.3 km^2 was estimated with another adult female R6.

Subsequently, during the monsoon, the maximum home range was 53.91 km^2 with adult female R6 and minimum of 17.2 km^2 with another adult female R3.

In the retreating monsoon season, the maximum home range on MCP (100%) was estimated with solitary adult female R8 (51.96 km^2) and minimum 26.55km^2 with R6 (adult female with calf).

In the winter R8 had maximum home range size (85.89km^2) and minimum home range recorded with R3 (14.39km^2) (Table 4.42). They displayed significant variations in seasonal home range as per MCP (100%), (χ^2=197.6958, the *P* value <0.00001 results was significant at $p<.05$)

Table 4.42 Adult Female Rhinos' (R3, R6, R13 and R8) Seasonal Home Range Areas

ID	Season	MCP (100%) sq. km	FKD (95%) sq. km	FKD (55%) sq. km
R3	Monsoon	17.20	28.68	8.02
R3	Pre-monsoon	12.71	27.67	7.94
R3	Retreating Monsoon	45.82	51.19	10.86
R3	Winter	14.59	21.60	5.03
R6	Monsoon	53.91	30.26	7.60
R6	Pre-monsoon	11.30	24.18	7.54
R6	Retreating-monsoon	26.55	43.63	11.33
R6	Winter	28.78	45.47	14.25
R8	Monsoon	34.42	51.96	17.21
R8	Pre-monsoon	39.72	49.40	11.02
R8	Retreating Monsoon	51.96	51.19	14.31
R8	Winter	85.89	71.77	18.65
R13	Monsoon	30.04	38.62	9.44
R13	Pre- monsoon	130.63	89.72	13.75
R13	Retreat Monsoon	43.73	50.53	12.91
R13	Winter	29.72	37.80	8.62

During the pre-monsoon, the maximum home range of 89.72 km^2 and13.75 km^2 was estimated with adult female R13 on FKD (95%) and FKD (55%) respectively. Solitary adult female R8 had maximum home ranges estimated both in FKD (95%) and FKD (55%) for the monsoon, retreating monsoon and winter seasons.

Adult female R3 had a minimum home range of 28.65km^2 in monsoon season and 21.60km^2in winter season as per on FKD (95%). In pre-monsoon and retreating monsoon, minimum home range estimated 24.18 km^2 and 43.63 km^2 respectively with R6 on FKD (55%). There was a significant home range variation observed among adult females as per Kernel (95%) estimation (χ^2=53.952, the *P*- value <0.00001 results were significant at $p<.05$)

Minimum home range with FKD (55%) estimated in retreating monsoon season was 10.86 km^2 and 5.07 km^2 in winter season with adult rhino R3. There was insignificant, maximum and minimum home range variation observed among adult females as per FKD (55%) estimation (χ^2=7.6267, the *P*- value was .572155 results was insignificant at $p<.05$)

Home ranges of calves (R7, R14 and R11) were more or less dependent on their mothers (R3, R6 and R11) and adult male rhinos (R1, R2, and R5). Male calves R7 and 14 were associated with their mother. Hence home range areas were proportionally similar. Like its mother (R13), R14 had a larger home range of 98.31km^2 in pre-monsoon and R7 (like his mother R6) had minimum pre-monsoon home range of 11.3 km^2 as per MCP (100%) among calves. Similarly, R7 had the larger home range of

58.24 km^2 during monsoon season and R14 had a minimum home range of 20.78 km^2 as per MCP (100%). Again, during winter, the home range of R7 was larger with 45.08 km^2 in respect to his mother (R13) and R14 had a smaller home range of 21.22 km^2 during winter in relation with his mother as per MCP (100%), (Table 4.43). The home range of R11 was not similar with male calves as she solitarily used different locations. There was a significant maximum and minimum home range variation observed among calves as per MCP (100%) estimation (χ^2=111.0822, the *P*- value <0.00001 results was significant at $p<.05$)

Table 4.43 Rhino Calves' (R7, R14 and R11) Seasonal Home Range Areas

ID	Season	MCP (100%) sq. km	FKD (95%) sq. km	FKD (55%) sq. km
R7	Monsoon	55.24	33.92	8.70
R7	Pre-monsoon	11.30	24.11	7.50
R7	Retreating Monsoon	32.33	47.35	12.82
R7	Winter	45.08	47.97	14.41
R11	Monsoon	40.67	56.94	15.84
R11	Pre-monsoon	30.61	42.55	6.97
R11	Retreating Monsoon	11.28	27.74	7.45
R11	Winter	43.23	56.68	12.16
R14	Monsoon	20.78	30.44	5.86

R14	Pre-monsoon	98.31	67.54	9.60
R14	Retreating Monsoon	31.03	43.09	10.76
R14	Winter	21.22	41.27	12.25

In the seasonal core area, home range estimation of calves (R7, R14 and R11) and adult females (R3, R6, R13 and R8) with Kernel (95%) and (55%), slight variations were seen as compared to MCP (100%).Female calf R11 had a larger core area home range with 56.94 km^2 in monsoon season and in winter, it was about 56.68 km^2 as per FKD (95%). In the pre-monsoon and retreating monsoon, R14 (male calf) had larger home range. R7(male calf) had minimum home range among calves during pre-monsoon, monsoon and winter season as per FKD (95%). There was a significant maximum and minimum home range variation observed among calves as per FKD (95%) estimation (χ^2=36.5323, the *P* value <0.00001 results was significant at $p<.05$)

Male calves (R7 and R14) had a larger seasonal core size of home range in pre-monsoon, retreating monsoon and winter season (FKD 55%). In contrast female calf R11 had larger core home range during monsoon season as per FKD (55%) estimation. Minimum core seasonal home range was found with R11(female calf) in pre-monsoon, retreating monsoon and winter season.

There was an insignificant, maximum and minimum core seasonal home range variation observed among calves as per FKD (55%) estimation, (χ^2=8.0934, the *P*-value was .231343 results was insignificant at p<.05). It was also observed that sizes of mother and calves home range as per MCP (100%) was positively related (Linear regression R^2=0.8849) (Fig 4.73).

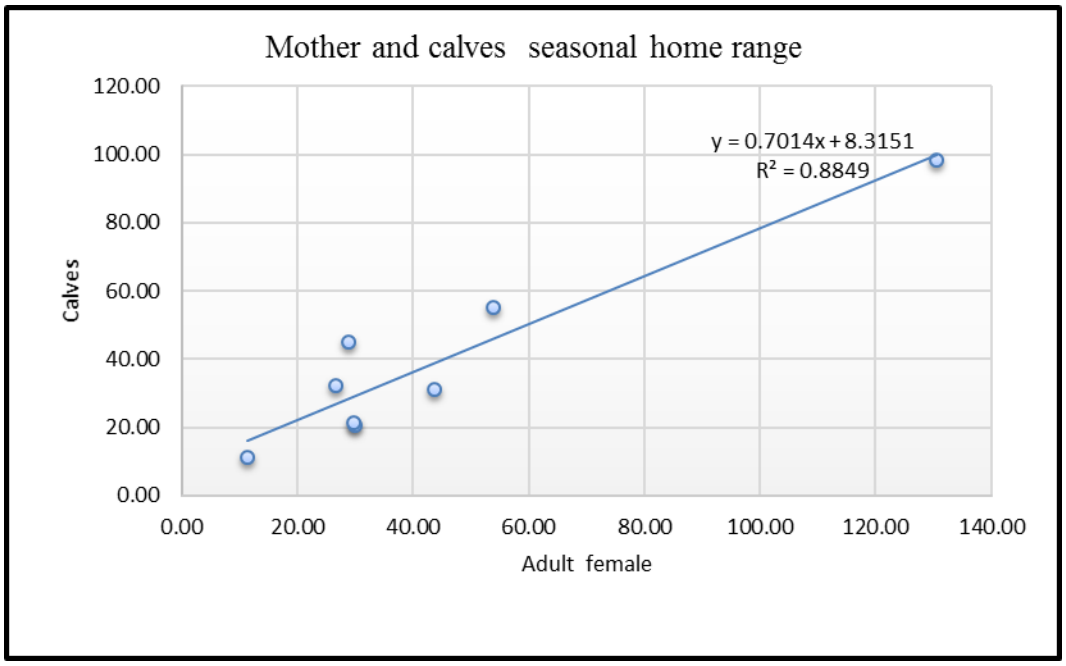

Fig. 4.73 Comparison of Adult Females (R6 &R13) Home Range Areas with their Calves (R7 & R14)

Seasonal Core Home Range of Adult Female Rhino3

By FKD (95% & 55%)

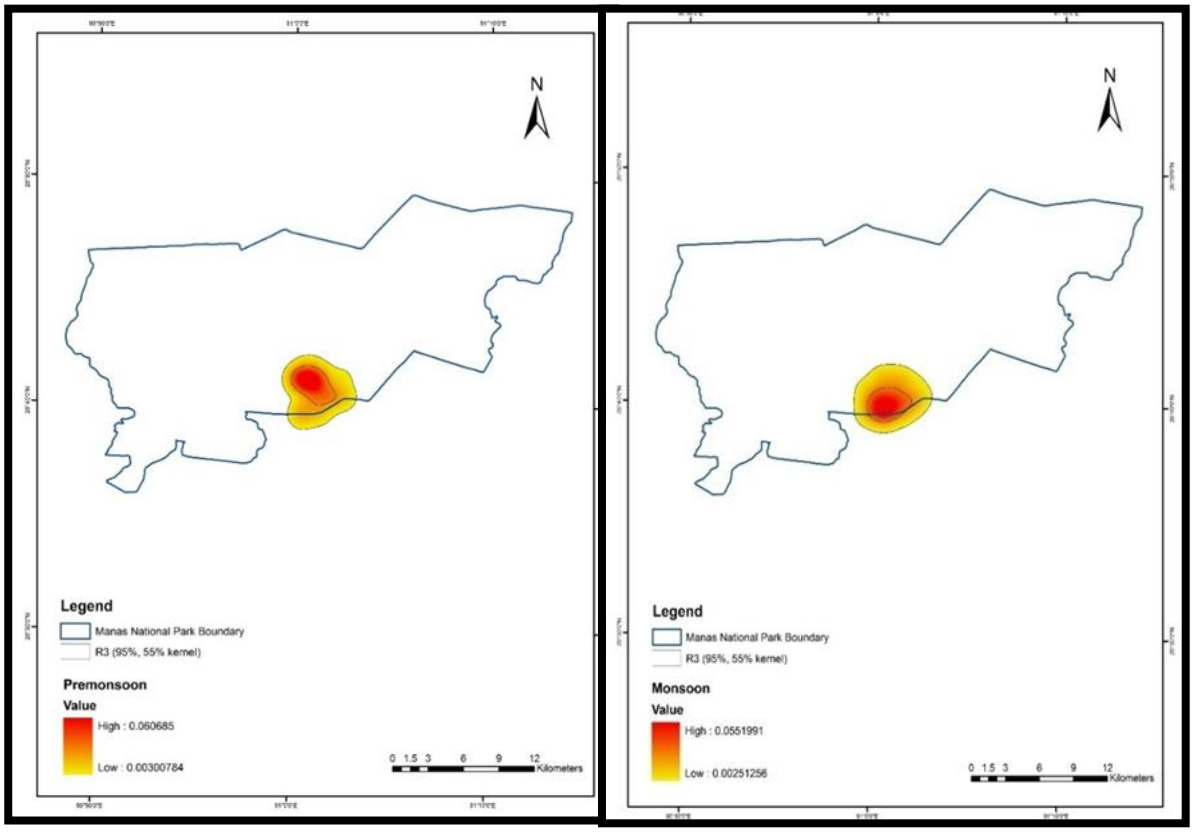

Fig.4.74 Rhino3's Pre- Monsoon Season Home Range

Fig.4.75 Rhino3's Monsoon Season Home Range

Seasonal Core Home Range of Adult Female Rhino3

By FKD (95% & 55%)

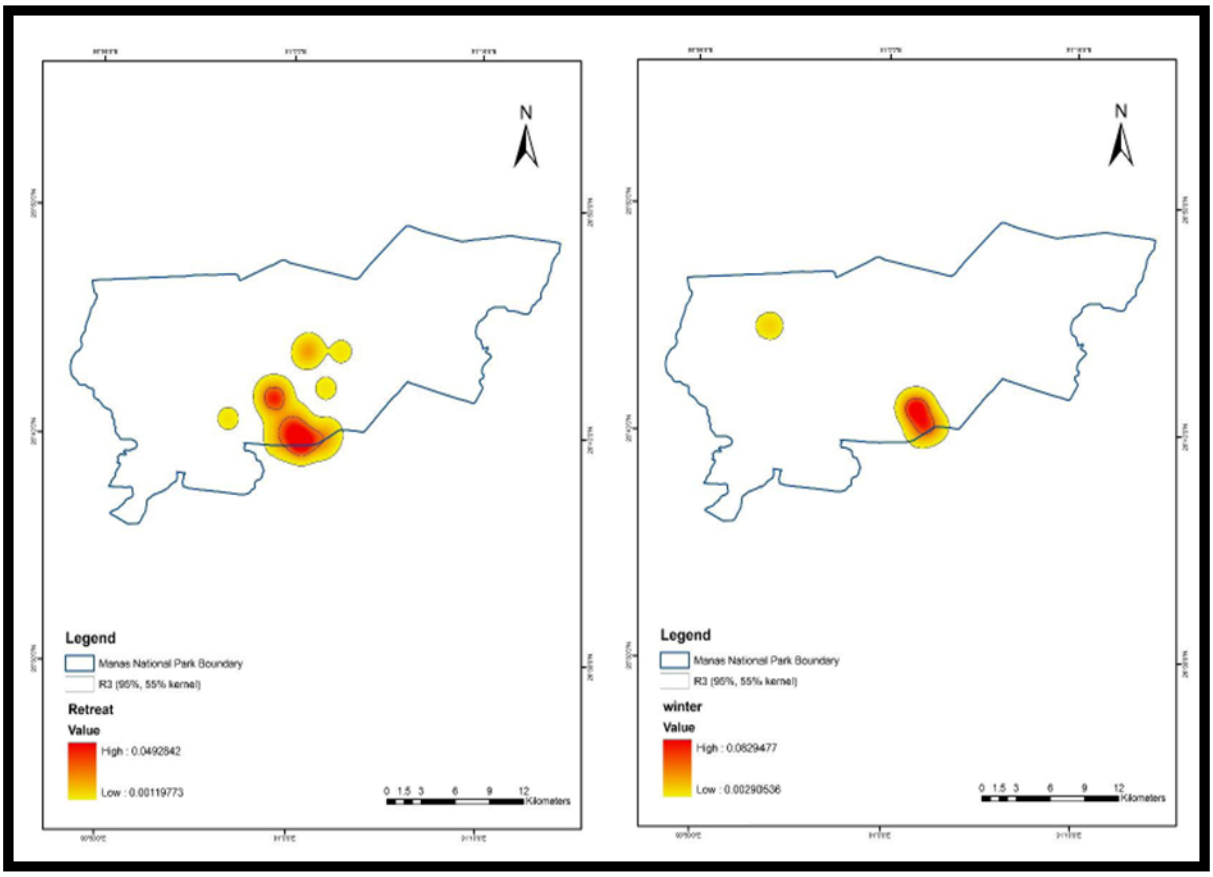

Fig.4.76 Rhino3's Retreating Monsoon Season Home Range

Fig.4.77 Rhino3's Winter Season Home Range

Seasonal Core Home Range of Adult Female Rhino 6

By FKD (95% & 55%)

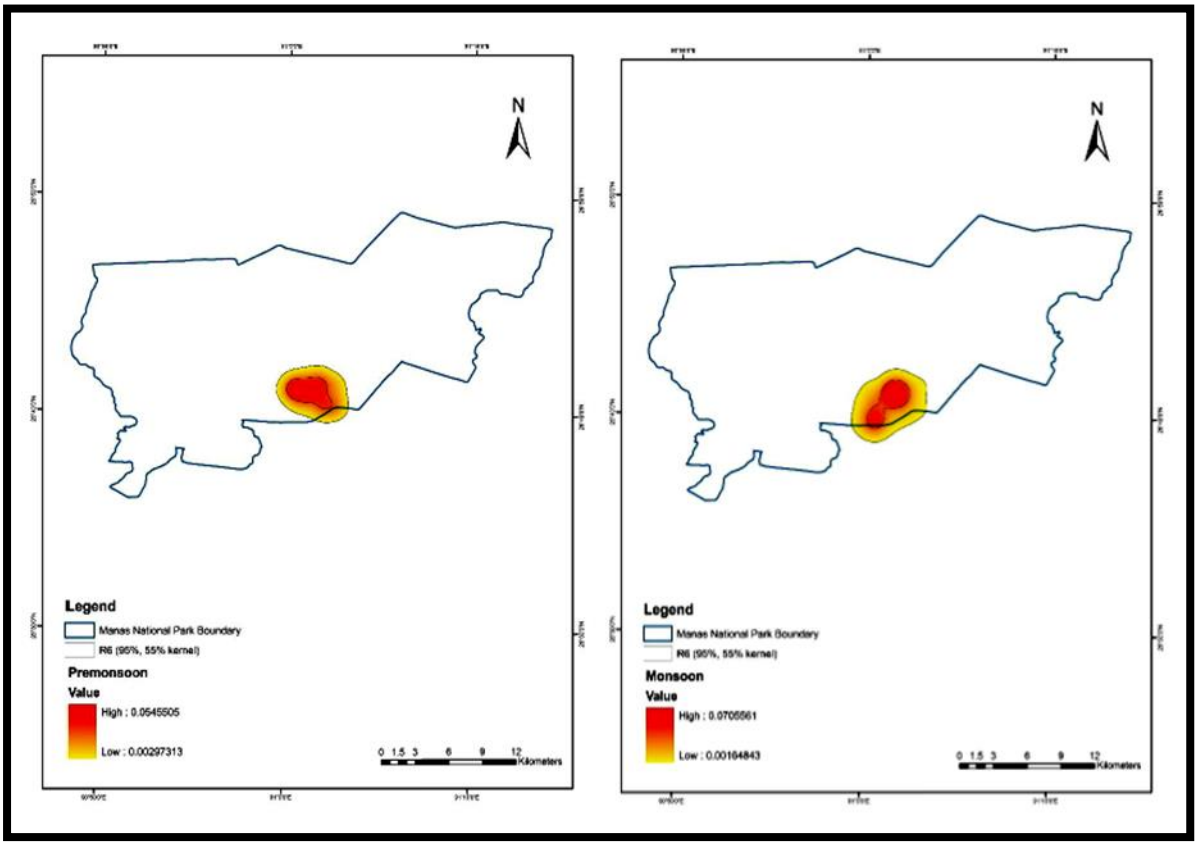

Fig.4.78 Rhino6's Pre-Monsoon Season Home Range

Fig.4.79 Rhino6's Monsoon Season Home Range

Seasonal Core Home Range of Adult Female Rhino 6

By FKD (95% & 55%)

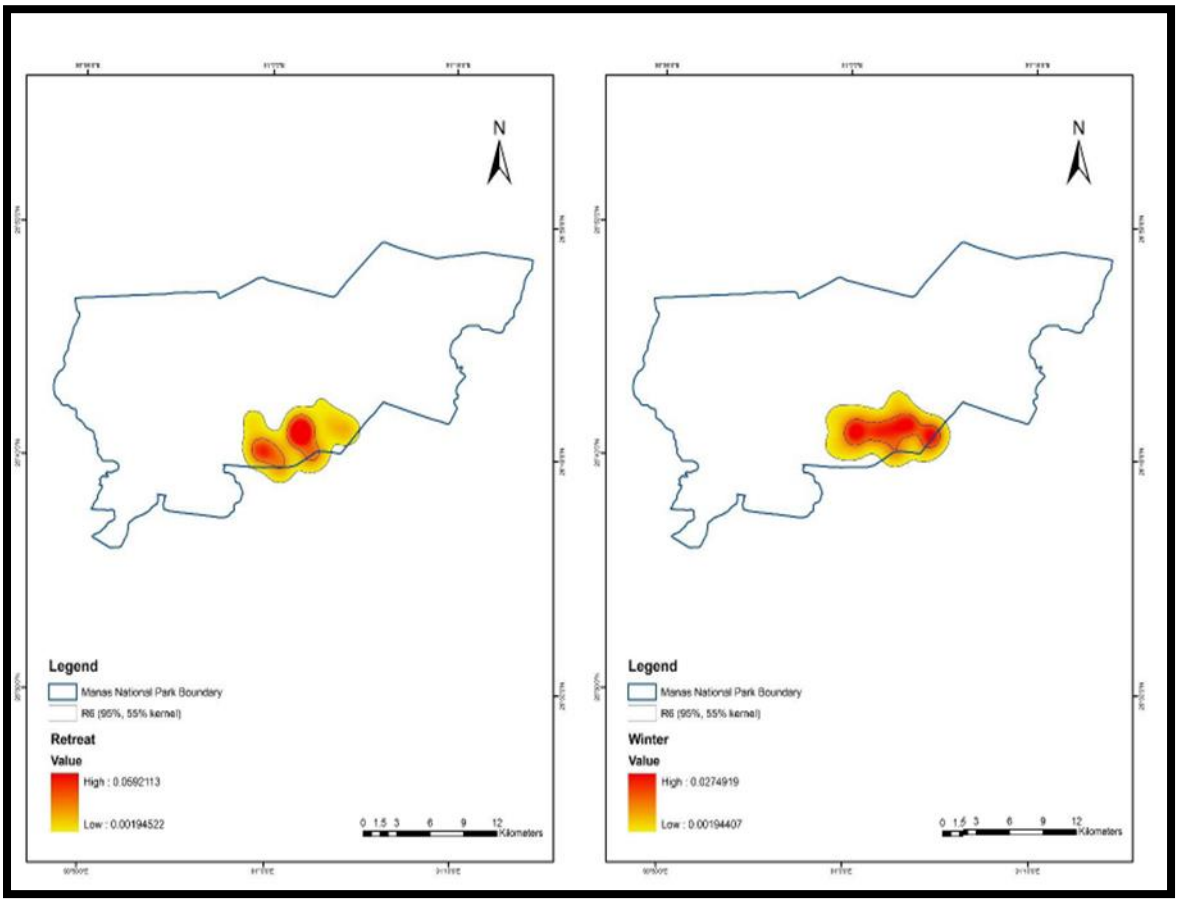

Fig.4.80 Rhino6's Retreating Monsoon Season Home Range

Fig.4.81 Rhino6's Winter Season Home Range

Seasonal Core Home Range of Adult Female Rhino 8

By FKD (95% & 55%)

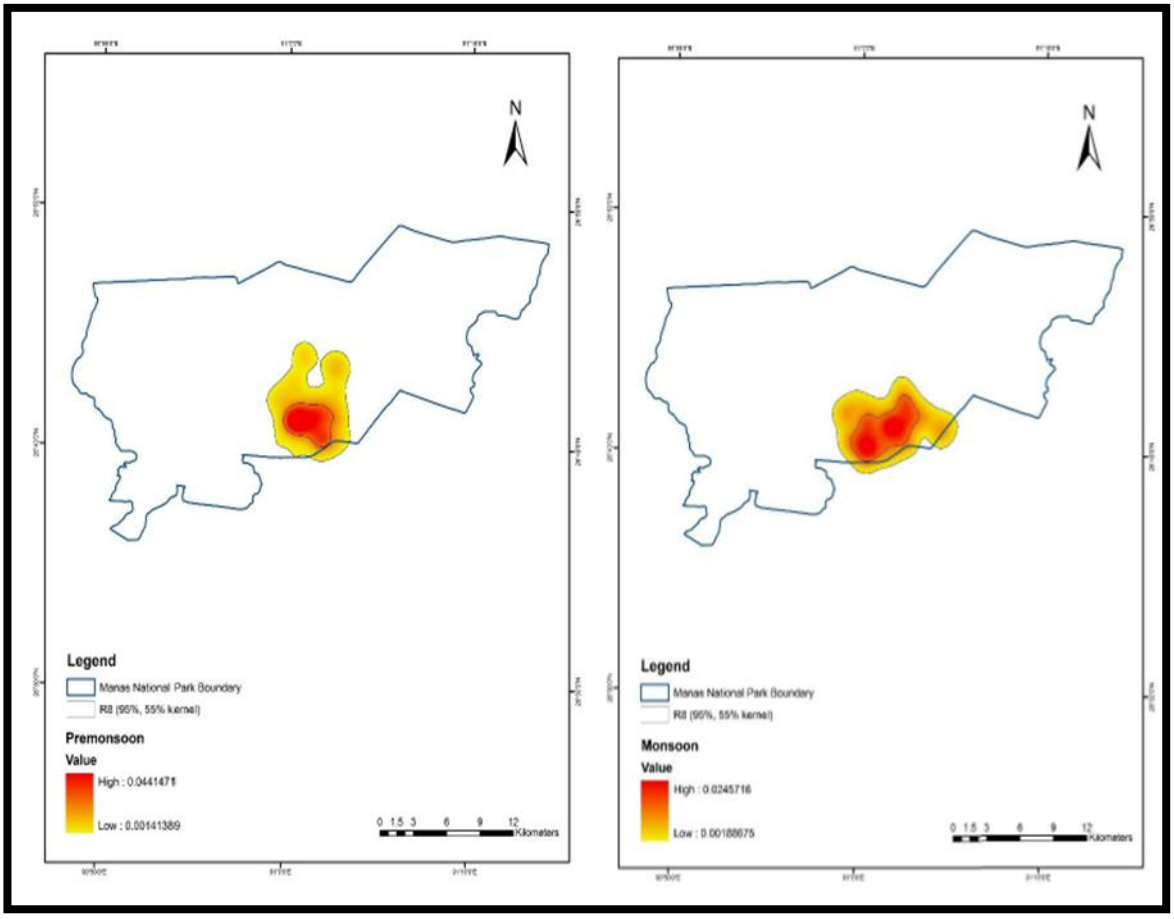

Fig.4.82 Rhino8's Pre-Monsoon Season Home Range

Fig. 4.83 Rhino8'sMonsoon Season Home Range

Seasonal Core Home Range of Adult Female Rhino 8

By FKD (95% & 55%)

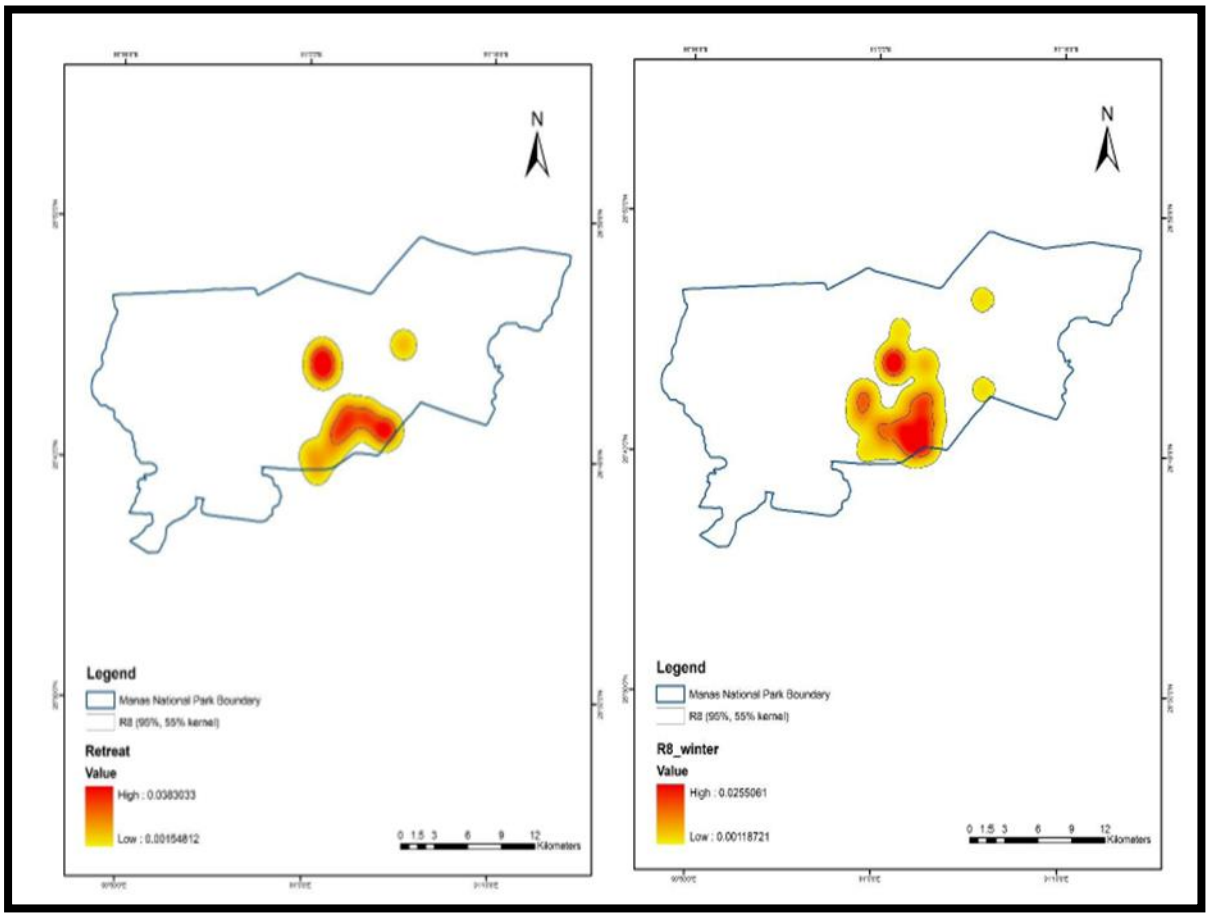

Fig.4.84 Rhino8's Retreating Monsoon Season Home Range

Fig.4.85 Rhino8's Winter Season Home Range

Seasonal Core Home Range of Adult Female Rhino 13

By FKD (95% & 55%)

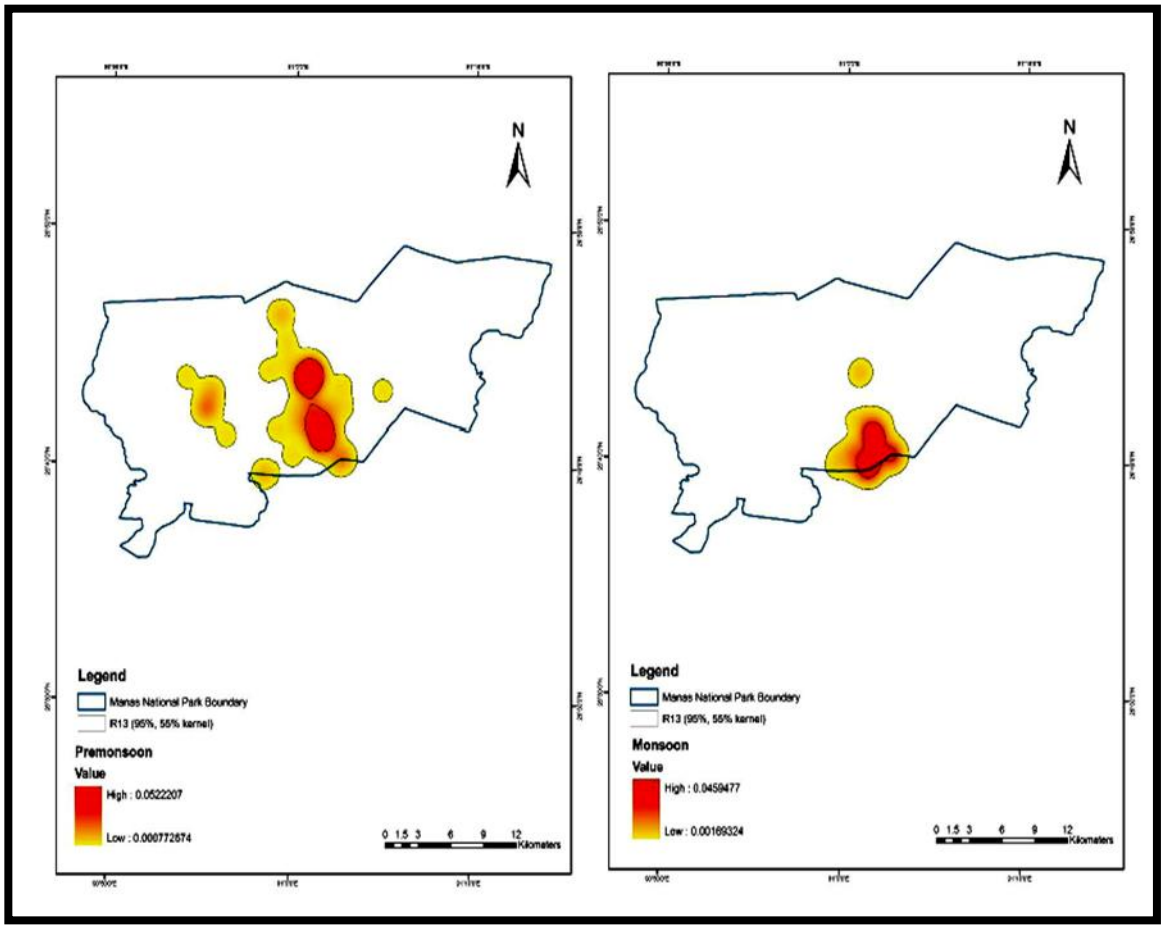

Fig.4.86 Rhino13's Pre-Monsoon Season Home Range

Fig.4.87 Rhino13's Monsoon Season Home Range

Seasonal Core Home Range of Adult Female Rhino 13

By FKD (95% & 55%)

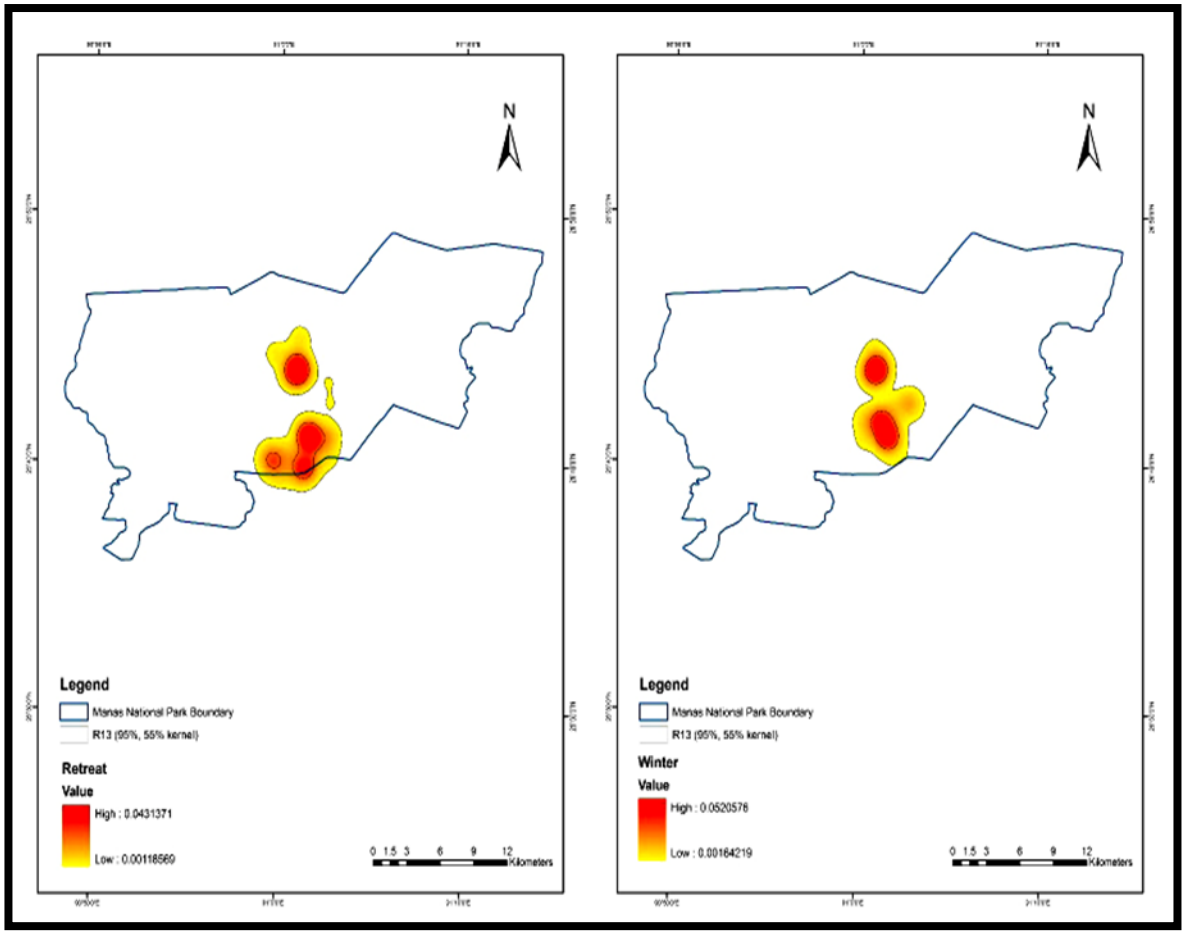

Fig.4.88 Rhino13's Retreating Monsoon Season Home Range

Fig. 4.89 Rhino13's Winter Season Home Range

Seasonal Core Home Range of Male Calf Rhino 7

By FKD (95% & 55%)

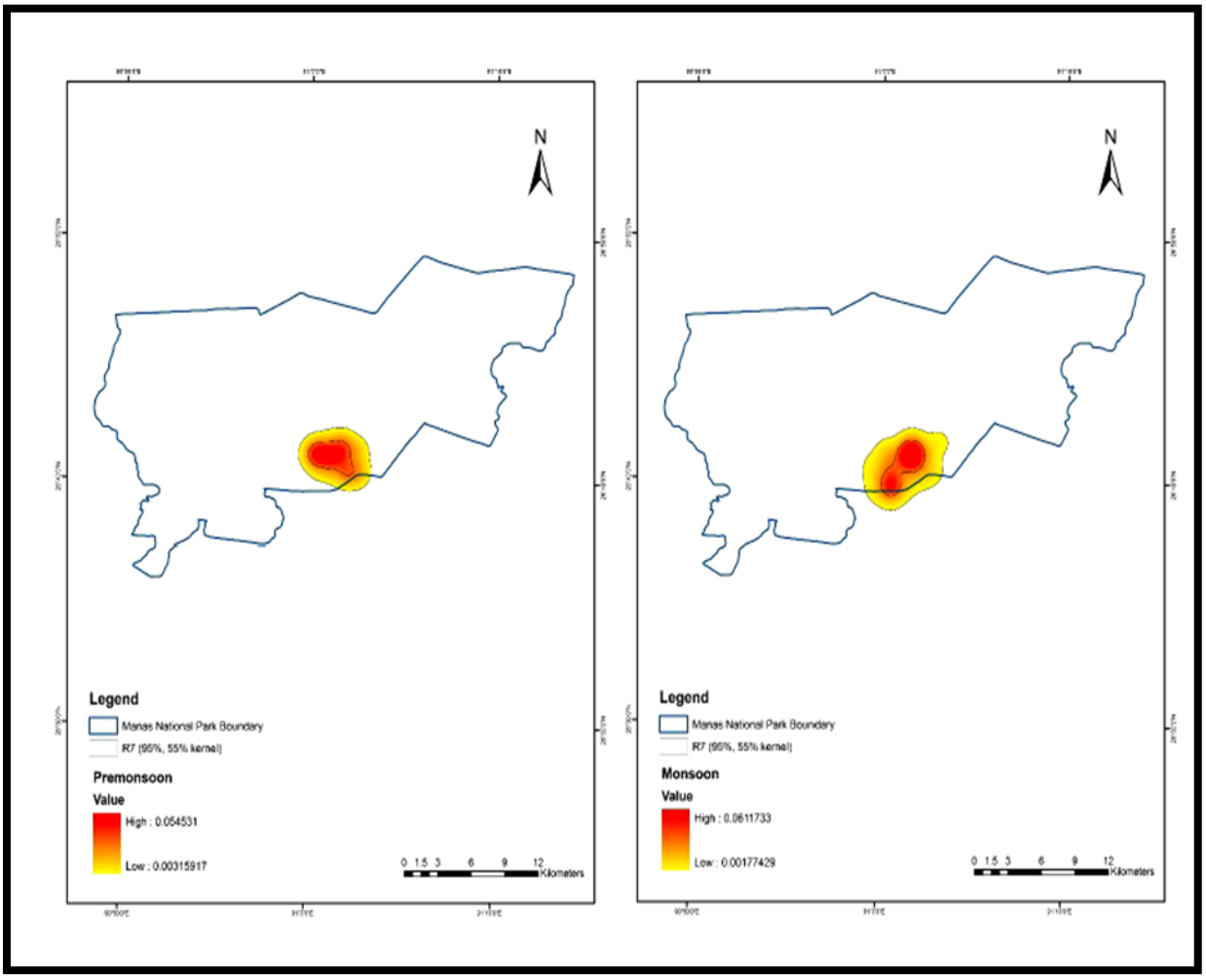

Fig.4.90 Rhino7's Pre-Monsoon Season Home Range

Fig.4.91 Rhino7's Monsoon Season Home Range

Seasonal Core Home Range of Male Calf Rhino 7

By FKD (95% & 55%)

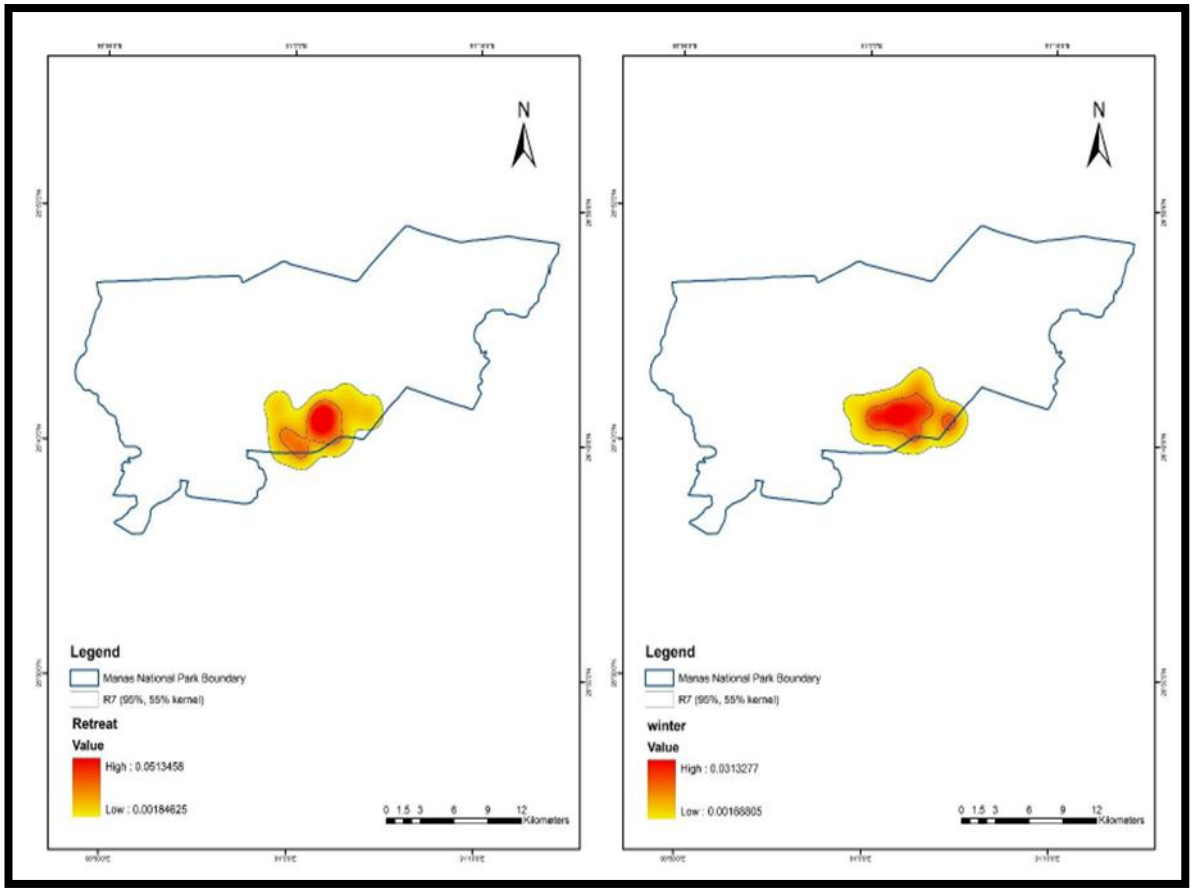

Fig.4.92 Rhino7's Retreating Monsoon Season Home Range

Fig.4.93 Rhino7's Winter Season Home Range

Seasonal Core Home Range of Female Calf Rhino 11

By FKD (95% & 55%)

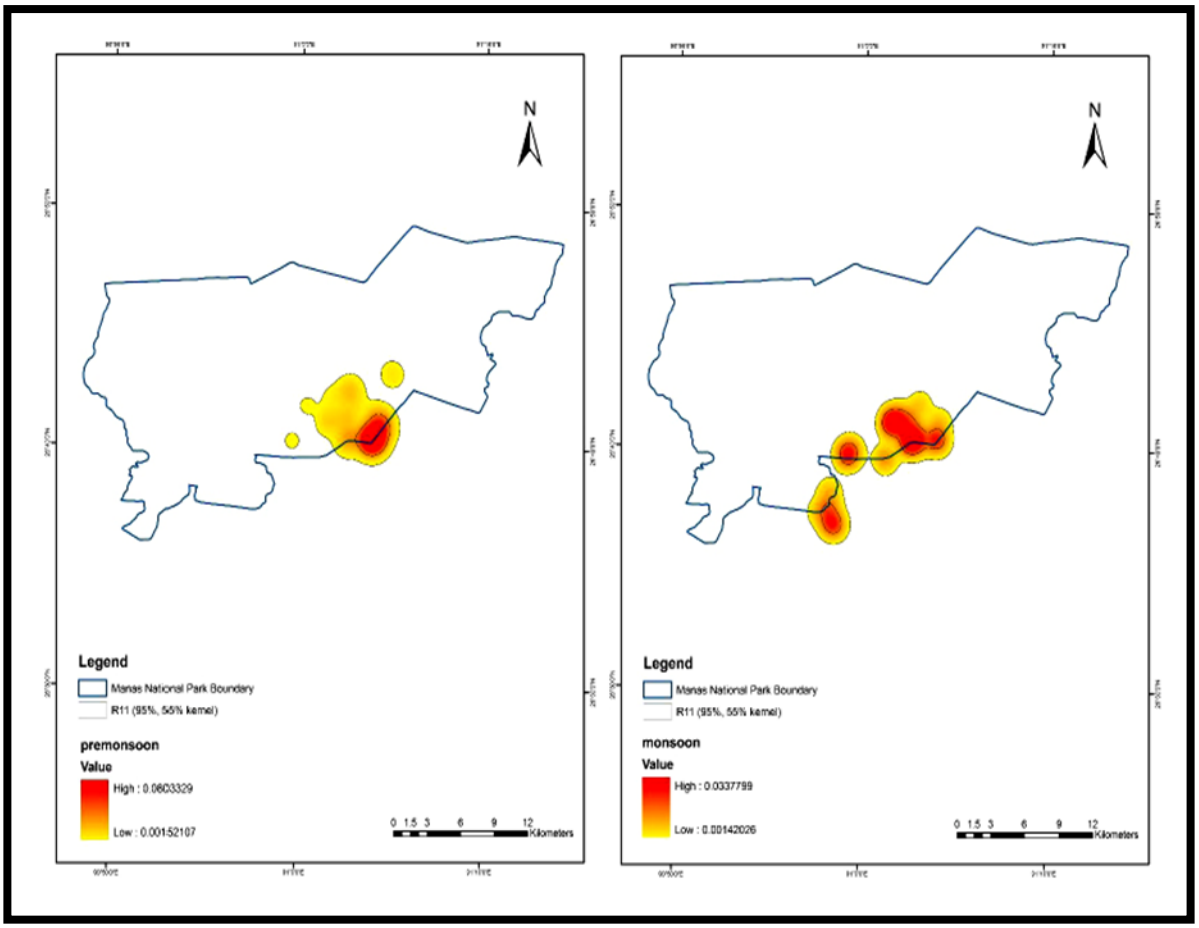

Fig.4.94 Rhino11's Pre-Monsoon Season Home Range

Fig.4.95 Rhino11's Monsoon Season Home Range

Seasonal Core Home Range of Female Calf Rhino 11

By FKD (95% & 55%)

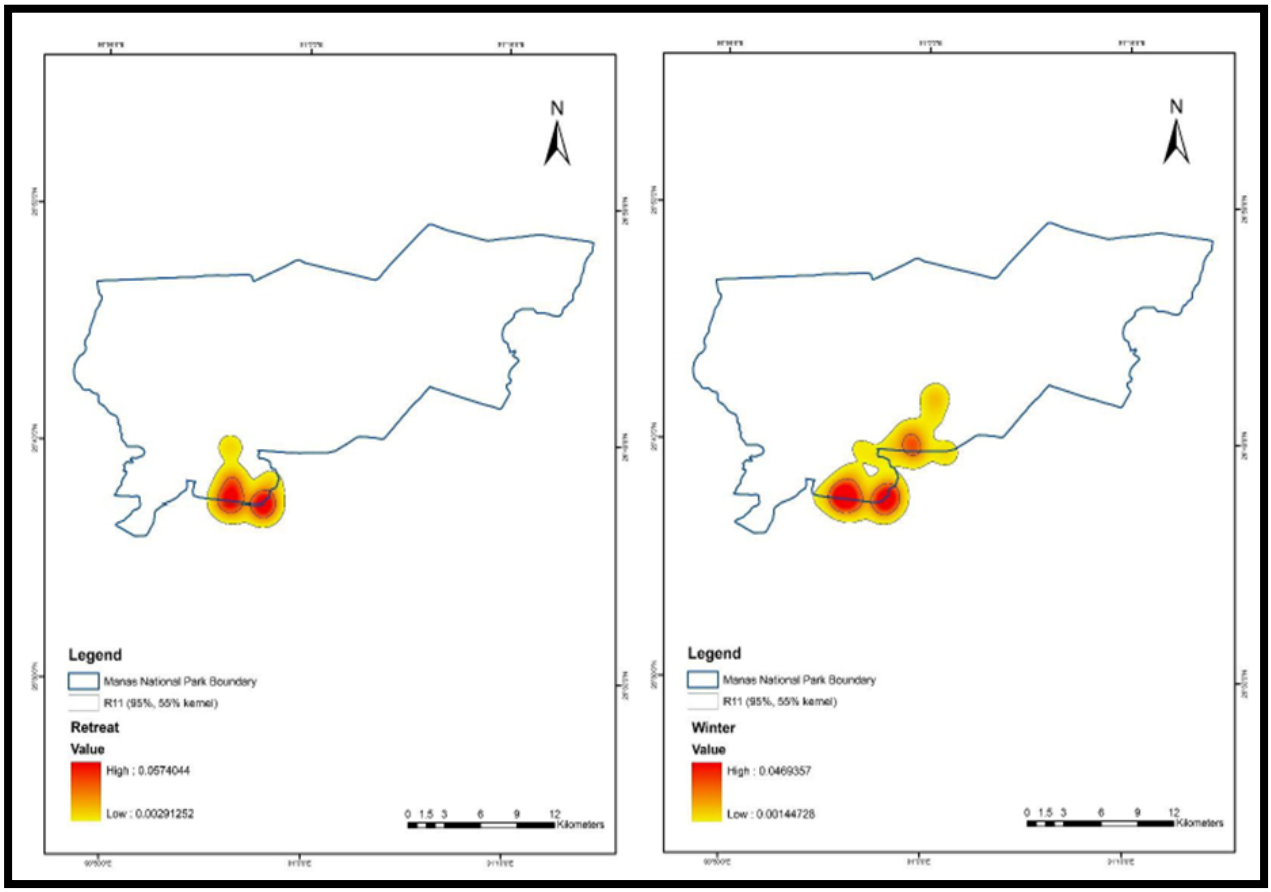

Fig.4.96 Rhino11's Retreating Monsoon Season Home Range

Fig.4.97 Rhino11's Winter Season Home Range

Seasonal Core Home Range of Male Calf Rhino 14

By FKD (95% & 55%)

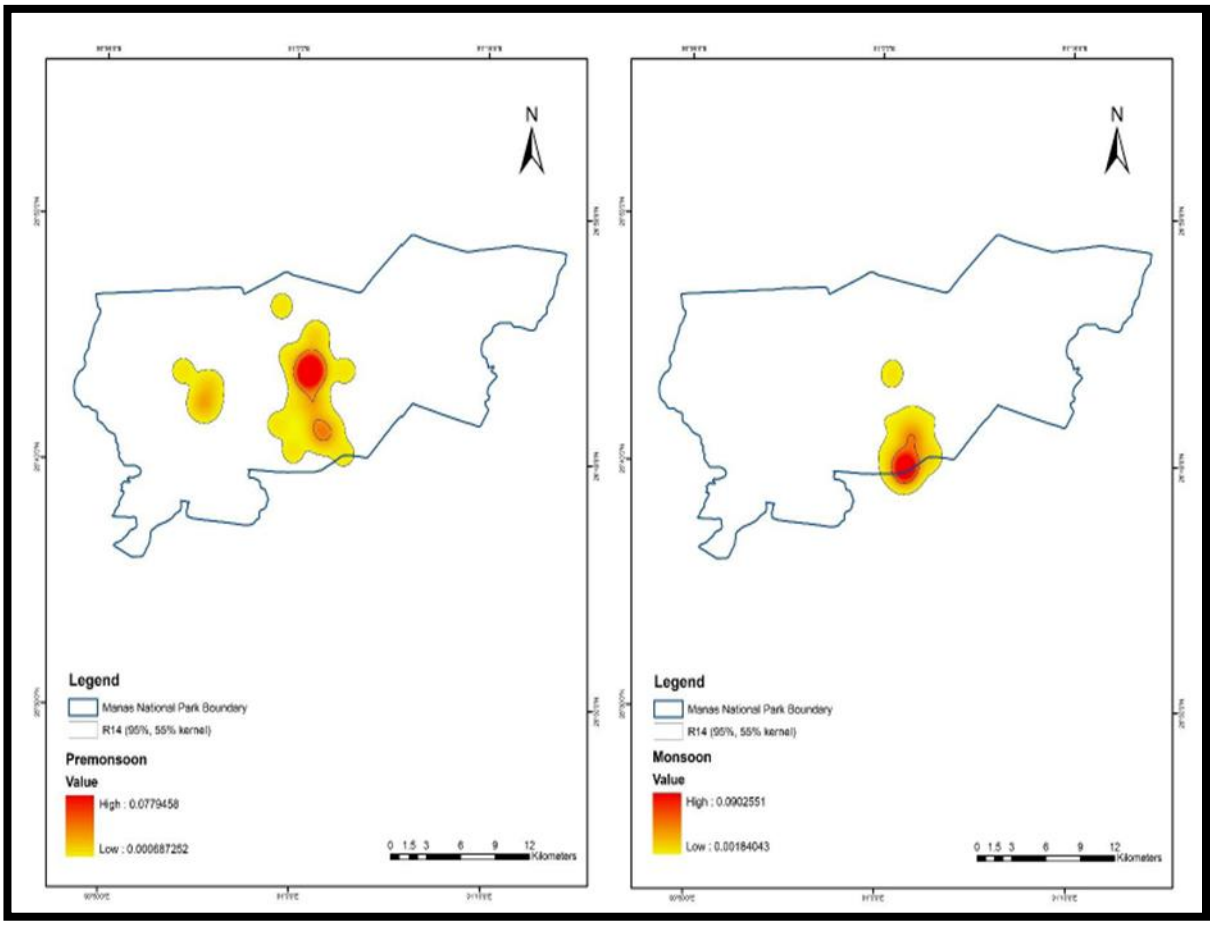

Fig.4.98 Rhino14's Pre-Monsoon Season Home Range

Fig.4.99 Rhno14's Monsoon Season Home Range

Seasonal Core Home Range of Male Calf Rhino 14

By FKD (95% & 55%)

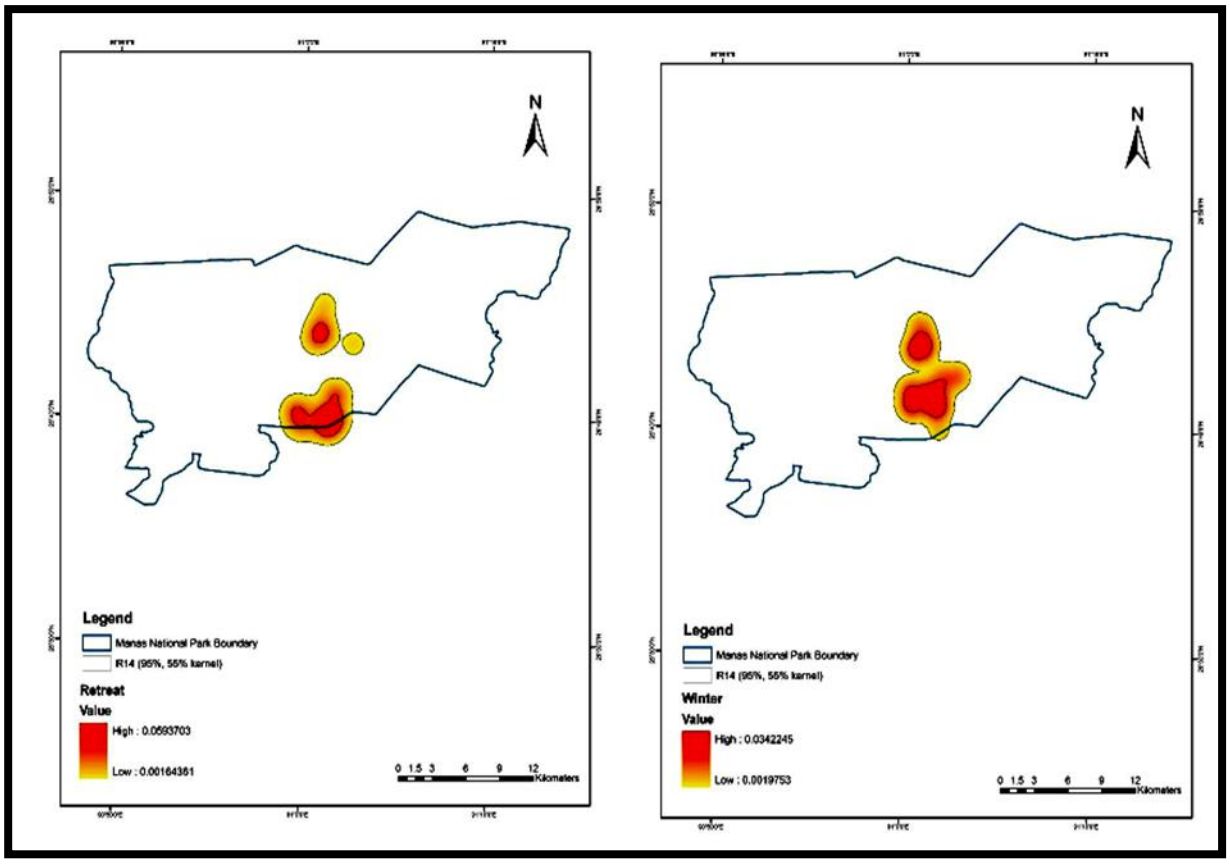

Fig.4.100 Rhino14's Retreating Monsoon Season Home Range

Fig.4.101 Rhino14's Winter Season Home Range

4.3.4. Overlapping Home Range Areas of Adult Males (R1, R2 & R5), Adult Females (R3, R6, R13 & R8) and Calves (R7, R14 & R11)

As per recorded data analysis, overall home range as well as core home range estimation (with MCP 100%, Kernel 95% and Kernel 50%), it was indicated that adult males (R1, R2 and R5), adult females (R3, R6, R13 andR8) and calves (R7, R14 and R11) moved around 280km^2 areas of MNP by maintaining central area of Bansbari range as core ranging center. However, adult male R5's 80% ranging areas cover only Bhuyanpara range of MNP while female calf R11's70% ranging areas cover western part under Kahitama beat of Bansbari range.

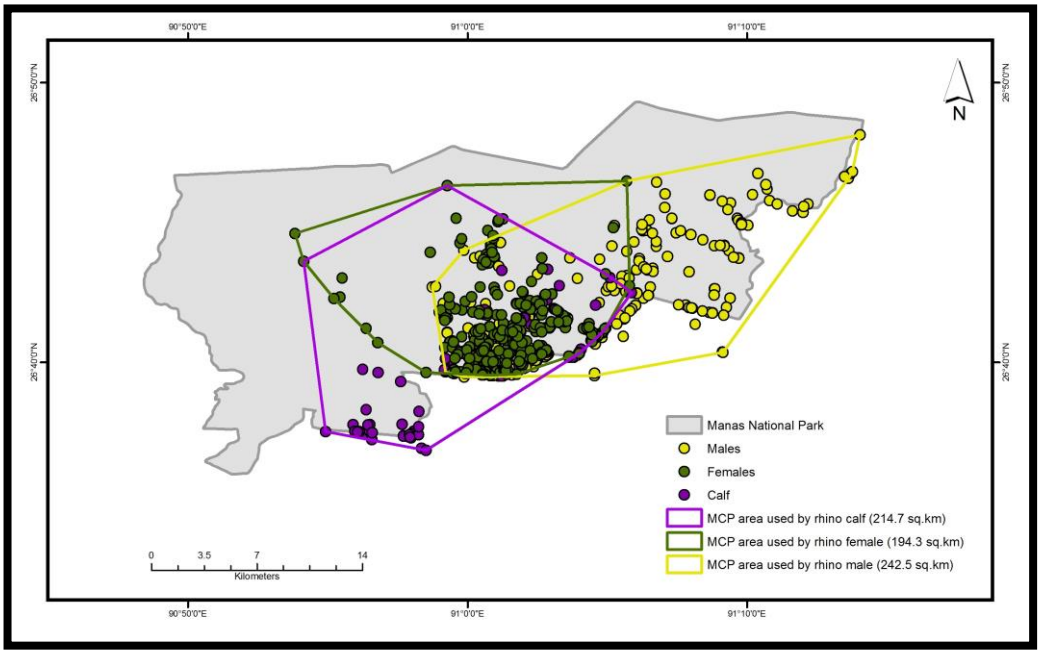

Fig.4.102 Overall Ranging Areas of Adult Males, Adult Females and Rhino calves

With the help of MCP (100%), overall home range overlapped areas of all three age groups in respective of the season were estimated. Adult males (R1, R2, and R5) had total ranging sizes of approximately 242 km^2 covering Bansbari and Bhuyanpara range.

Adult females (R3, R6, R8, and R13) had approximate ranging areas of 194km^2 covering all three ranges i.e. Bansbari, Bhuyanpara and Panbari range of MNP. Significantly, rhino calves'(R7, R11, R14) total ranging areas was larger than that of adult females. Rhino calves' total raging area was estimated to be 214.7km^2 covering 90% areas of the Bansbari range.

Female rhino calves (R11) even used some very difficult and inaccessible parts of Kahitama, Kapurpura, Naraynguri areas under Bansbari range (Fig.4.102).

4.3.4.1 Overlapping Home Range Areas of Adult Males (R1, R2 and R5) and Adult Females (R3, R6, R13 and R8)

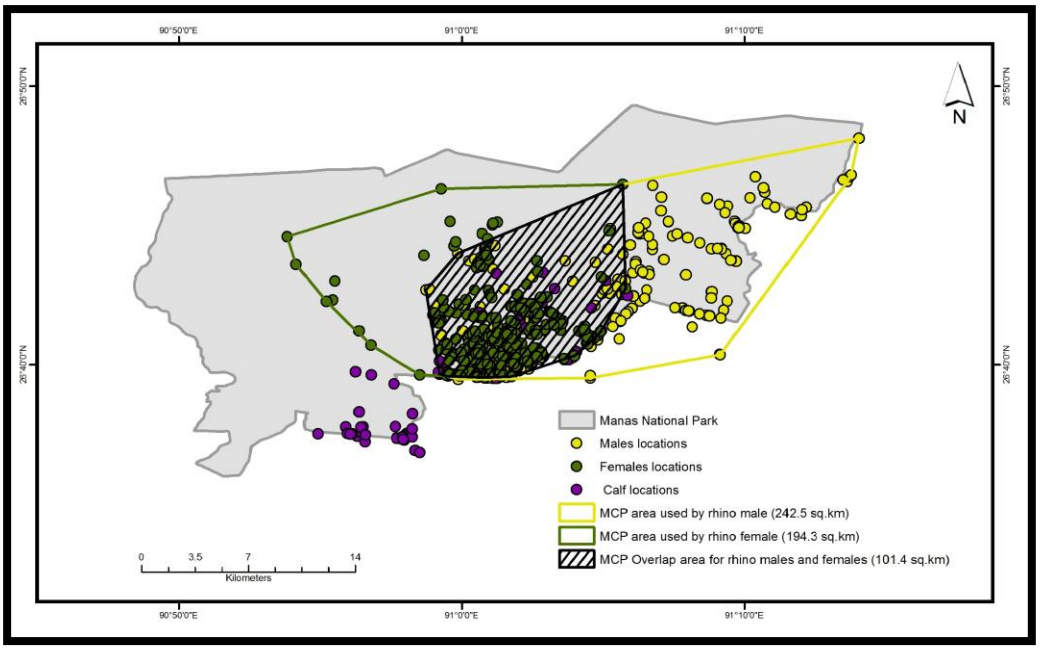

Fig.4.103 Overlapping Home Range Areas of Adult Males (R1, R2 and R5) and Adult Females (R 3, R6, R13 and R8)

Three adult males (R1, R2 and R5) and four adult females' (R3, R6, R13 and R8) rhinos overlap their ranging areas in Bansbari ranges and few areas of Bhuyanpara range. As per estimation, adult male R1 and R2 were using Bansbari range by maintaining lose territory and R5 occasionally visit the eastern part of Bansbari to seek the company of adult females. During this period, overall adult male and adult females ranging overlap area were about 101. 4 km^2. As per the analysis, adult males (R1, R2 and R5) shared 41.8% ranging areas of total ranging areas (242.6 km^2) with adult

females (R3, R6, R13 and R8). On the other hand, the adult females shared 52.18% ranging areas of total ranging areas (194.3km^2) with the adult rhinos (Fig.4.103).

4.3.4.2 Overlapping Home Range Areas of Adult Males (R1, R2 & R5) and Calves (R7, R14 &R11)

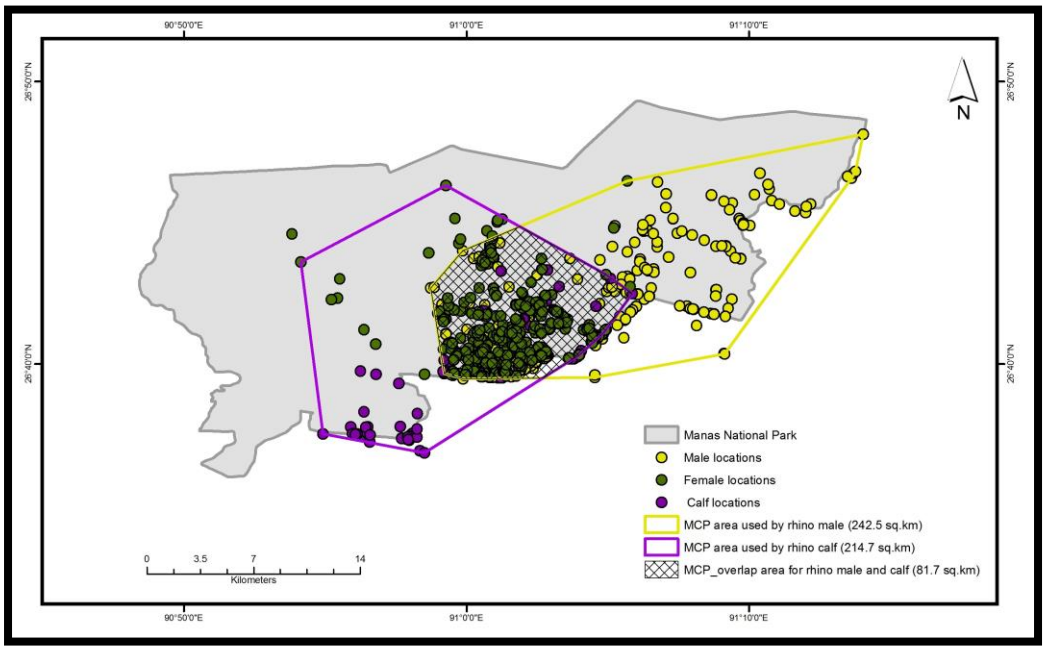

Fig.4.104 Overlapping Ranging Areas of Adult Males (R1, R2&R5) and Calves (R7, R14&R11)

A unique pattern was observed in adult males (R1, R2 and R5) and rhino calves (R7, R14&R11) ranging areas. After release, dominant males (R1 and R2) like to overpower all adult females and their calves. Female rhinos suffered most of the time so they usually moved away from common ranging areas. Sometimes, the reluctant adult females moved away from areas of common male dominance territory to lone areas by

crossing river Beki. During this period of study, adult male rhinos and calves have total overlapping ranging areas of 81.7 km^2. As per the analysis, adult males shared 33.6% areas of total ranging areas (242.6 km^2) with rhino calves. On the other hand, rhino calves shared 38.05% of their total ranging areas (214.7km^2) with adult rhinos (Fig.4.104).

4.3.4.3 Overlapping Home Range Areas of Adult Females (R3, R6, R13 &R8) and Calves (R7, R14 &R11)

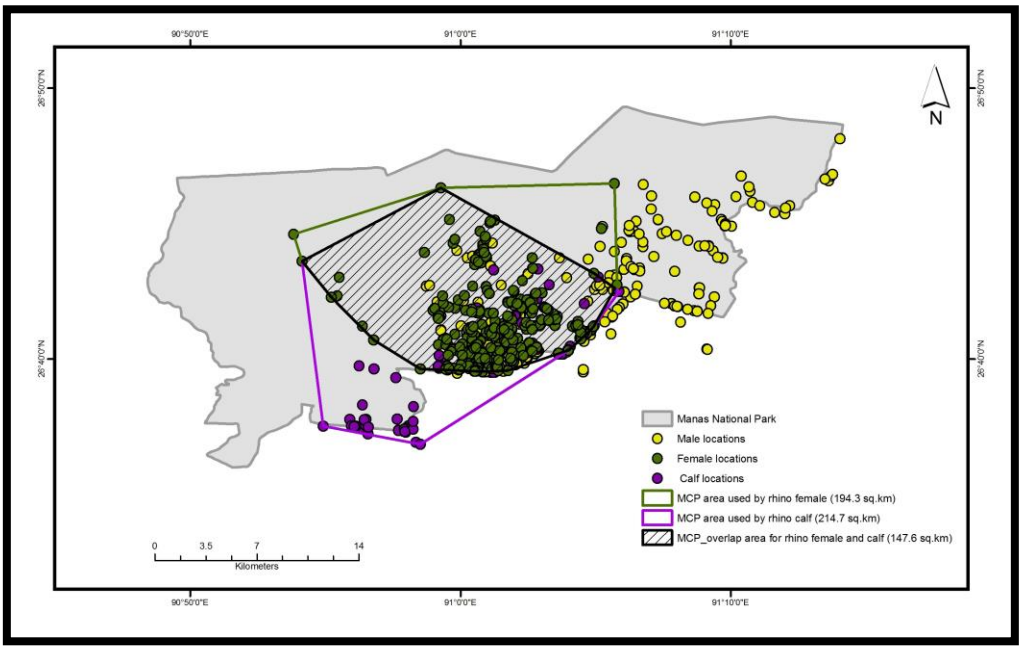

Fig.4.105 Overlapping Ranging Areas of Adult Females (R3, R6, R13 & R8) and Calves (R7, R14 & R11)

As per estimation, it was observed that calves' (R7, R14 and R11) ranging area was 9.3% bigger than their mothers. Adult female and calves overlapped 147.6 km^2

mainly in central areas of the Bansbari range. This was 75.96% of total raging areas of female rhinos and 68.7% areas of calves total raging areas (Fig.4.105).

4.4 Association Patterns

There was very close association among the adult males (R1, R2 and R5) and adult females (R3, R6, R13 and R8) observed during this period of study. This association was around 0-9 m radius calculated with MCP 100%. These associations constitute the adult males and adult females (2 -3 individuals). Among translocated rhinos, 7 types of associations were observed among adult male R1 with adult female R6, adult male R2 with adult female R6, adult male R5 with adult female R6, adult female R8 with adult male R2, adult female R13 with adult male R2, adult female R3 with adult male R2 and last adult female R3 with adult male R1. Among all types of association R2 and R6 associations was very common in rhino ranging areas of MNP. Among the translocated and rehabilitated rhinos, 6 types of associations were observed among, adult male R1 with adult female Mainao, Adult males R1 and R2 with two adult females Ganga and Jamuna, adult female R3 with Ganga and Jamuna, R3 with Mainao, R6 with Ganga and Jamuna , R6 with Mainao. Among these associations, R1 with Mainao and R6 with Ganga and Jamuna were common in the central part of Bansbari.

4.4.1Association among Translocated Adult Males and Adult Females

As per the analysis, it was observed that during pre-monsoon, adult males (R1, R2 & R5) and adult females (R3, R6, and R13 & R8) shared same areas (64.8km^2).

During pre-monsoon period, the association was only observed in central areas of the Bansbari range. R1 and R6 association was 8.3% while R2 and R6 association 22.3% which was maximum among all the rhinos. Adult male R2 and adult female R3's association was 7.4% and another adult male R1 and adult female R3's 1.7%.

During the monsoon, the adult males and females' association were observed within 56.0 km^2 area and this area is exclusively located in the central areas of the Bansbari range. In the monsoon, the maximum association was observed between adult male R2 and adult female R6 (9.9%), adult male R2 and adult female R3 (5.8%).

During the retreating monsoon rhinos' association area was 53.8 km^2 of central areas of Bansbari and some parts of Bhuyanpara range.

In the winter season, adult males and adult females' association further widened and covered both Bansbari and Bhuyanpara range. Total association area in the winter was about 80.7 km^2. In the retreating monsoon and the winter season, the maximum association was observed between only adult male R2 and adult female R6 (4.1% respectively) (Fig 4.106).

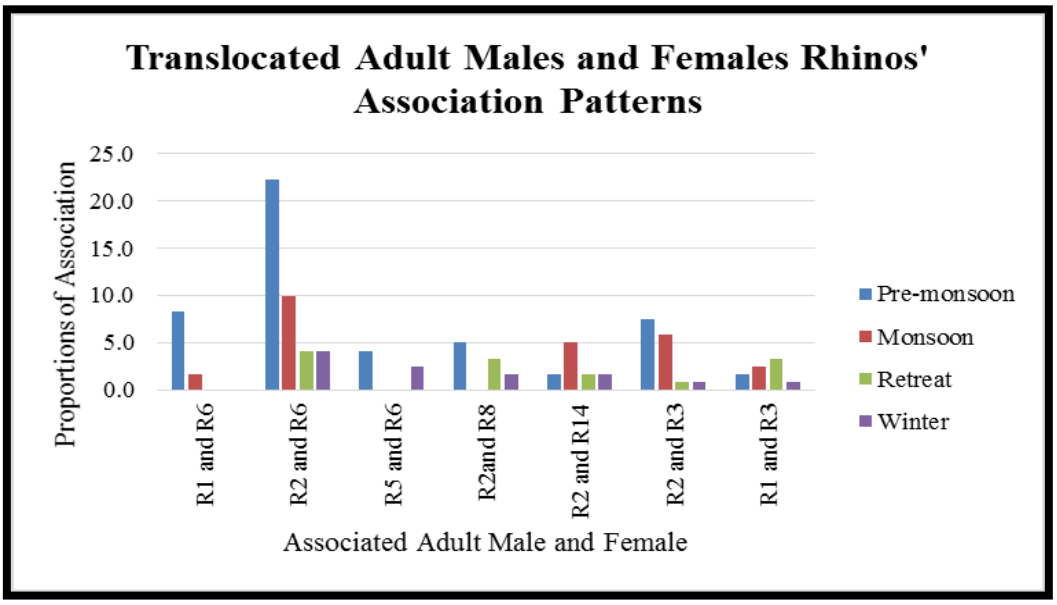

Fig. 4.106 Seasonal Association Pattern of Translocated Males (R1, R2 and R5) and Females Rhino (R3, R6, R13 &R8).

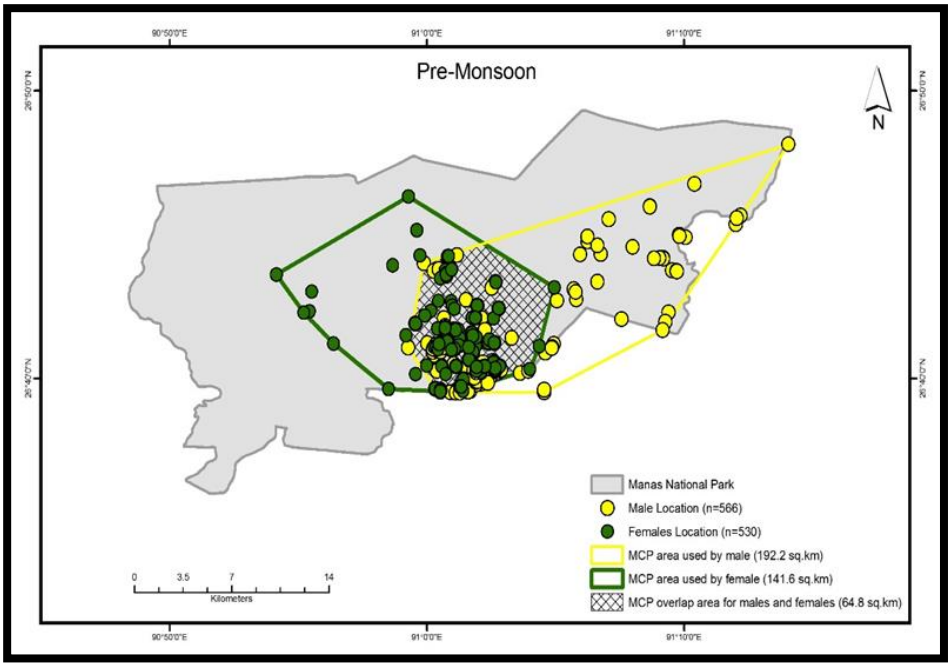

Fig.4.107 Adult Males (R1, R2 and R5) and Females' (R3, R6, R13 and R8) Association Areas during Pre-Monsoon

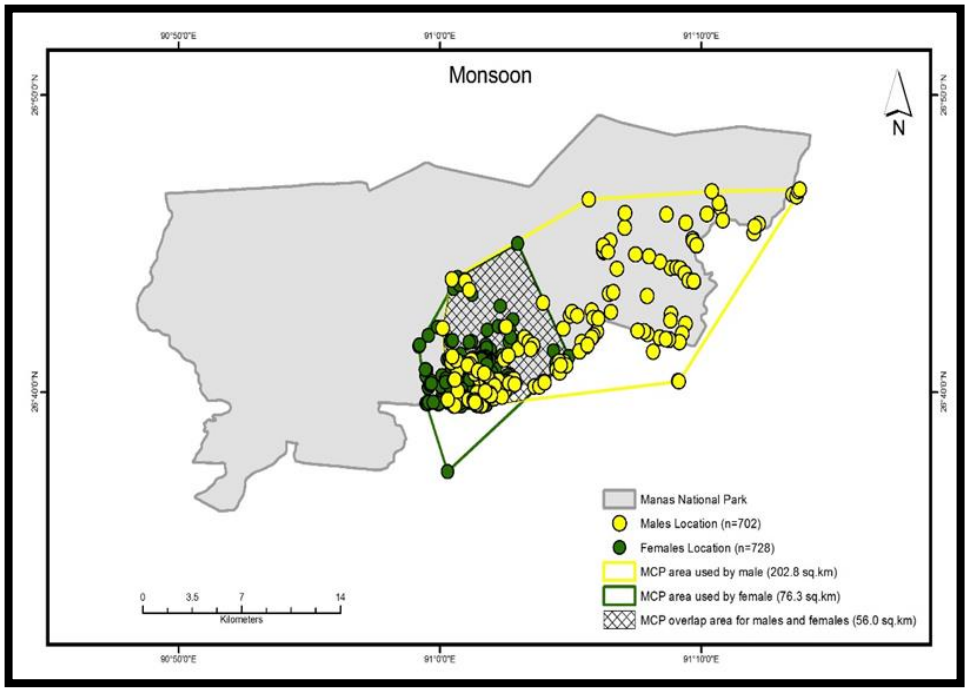

Fig. 4.108 Adult Males (R1, R2 and R5) and Adult Females' (R3, R6, R13 and R8) Association Areas during Monsoon

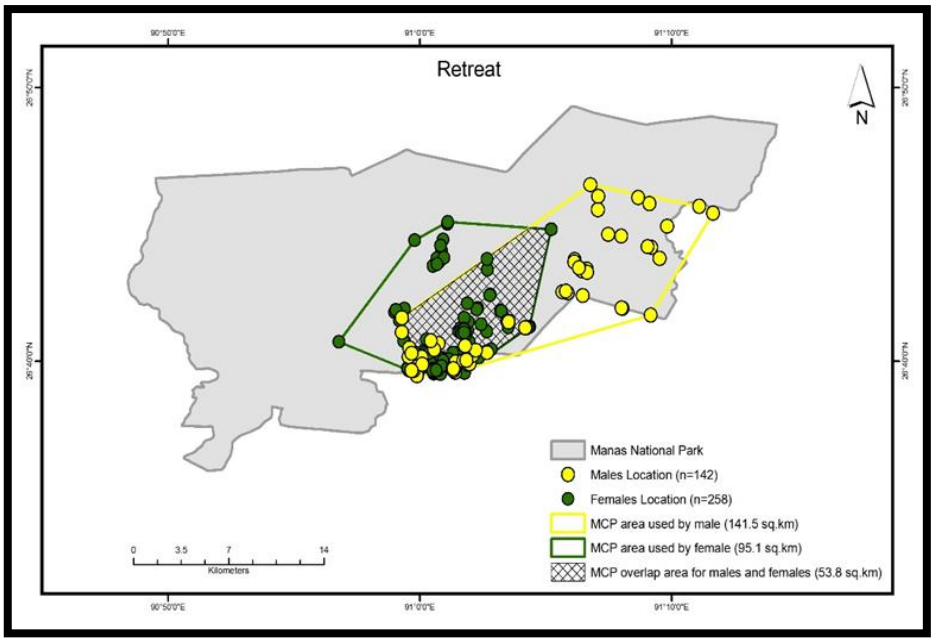

Fig. 4.109 Adult Males (R1, R2 and R5) and Adult Females' (R3, R6, R13 and R8) Association Areas during Retreating monsoon

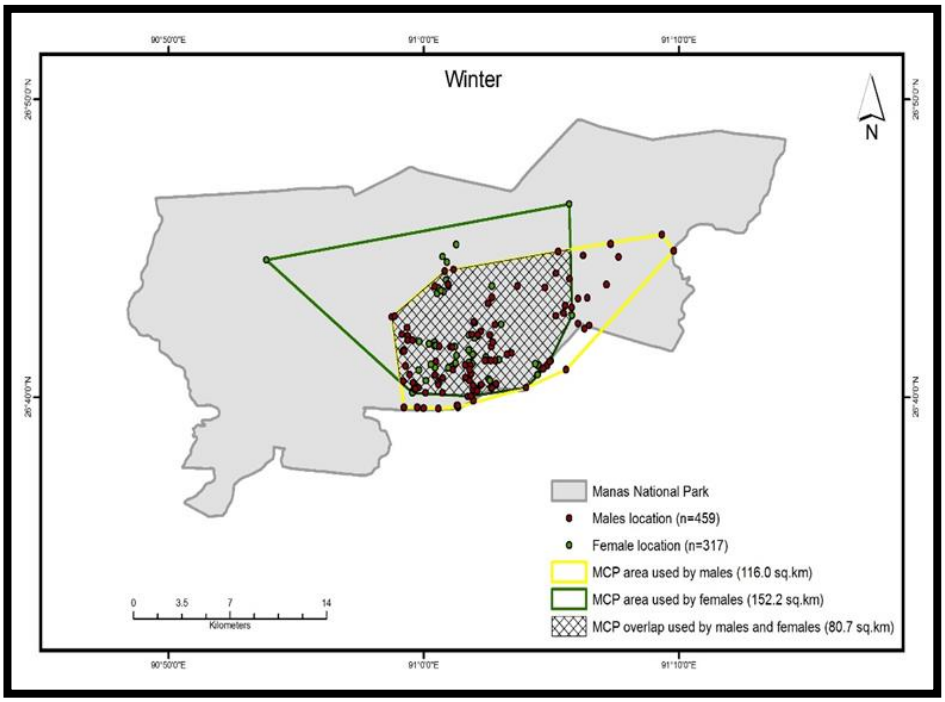

Fig.4.110 Adult Males (R1, R2 and R5) and Adult Females' (R3, R6, R13 and R8) Association Areas during Winter Season

4.4.2 Association of Translocated rhinos with Rehabilitated Adult Females

During the pre-monsoon, adult male R1 and rehabilitated adult female Mainao's association was 13.7%. Adult males R1, R2 and other two rehabilitated adult females Ganga and Jamuna association was 17.6% which was the maximum during this season. Besides, adult females R3 and R6 association with rehabilitated females was maximum in the pre-monsoon season. Adult male R1 and Mainao's (adult rehabilitated female) association was 9.8%, adult female R3 with Ganga, Jamuna 7.8% and R6 with Mainao

was 3.9% during the monsoon season. During the retreating monsoon, 3.9% association observed among adult males R1, R2, Ganga, Jamuna, Mainao and R6 respectively. During winter, R1 and Mainao's association was 3.9%, R1, R2, Ganga, Jamuna and Mainao's associations was 2.0%, R6 with Ganga and Jamuna 3.9% and rest other groups was 2.0% respectively

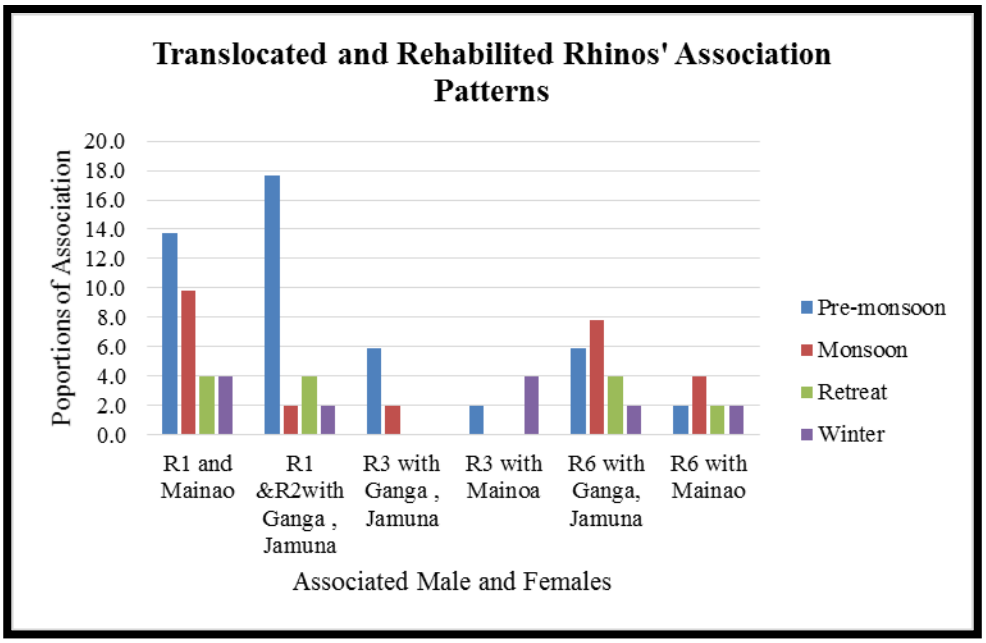

Fig. 4.111 Association Patterns of Translocated and Rehabilitated Rhinos

4.4.3 Association of Translocated Rhinos with other Wild Animals

Rhinos were associated with the other wild animals in MNP. Close association was observed with Elephant (n=48) (*Elephas maximus*), Wild Buffalo (n=56) (*Bubalus bubalis*), Gaur (n=14) (*Bos gaurus*), Wild pig (n=15) (*Sus scrofa*) and domesticated cattle and buffalos (n=143). During the association, elephants, wild buffalo, gaur, domesticated cattle and buffalo were associated as groups with more than 10 numbers. But wild pigs were always seen alone with rhinos. Highest, elephant association was observed with the female rhinos while highest cattle association (70%) was observed with adult males R1 and R2.

Among the birds, Common myna (*Acridotheres tristis*) (n=123), Jungle myna (*Acridotheres fuscus*)(n=76), Black drongos (*Dicrurus adsimilis*) (n=24), Cattle egret (*Bubuleus ibis*) (n=16), little egret (*Egretta garzetta*) (n=7) were observed to be associated with rhinos during grazing and wallowing moments.

4.5 Stray Incidents of Rhinos

There are no well-demarcated buffers along the boundary areas of MNP. So, reintroduced rhinos could not demarcate the boundaries of the protected area and easily entered adjoin fringe villages and occasionally raided crops. Significantly, rhinos translocated from the PWS (91.6%) have more stray occurrences than KNP (8.4%) (χ^2 =35.19, df = 1, $p<0.05$), within the period of 90 days after release at MNP. There were 195 stray incidences recorded among the animals during the period of 2008-2013

(Table.4.44). Stray incidence was more in adult male rhinos (n=121) than female rhinos (including one female calf R11) (n=.74). Out of 195 incidents, 95% (n=186) most took place in nearby areas (within 1-2km distances) of MNP boundary. Apart from close areas stray, 4% stray (n=8) incidents occurred in more than 3-4 kilometer and 1% of stray beyond 5 kilometers and more.

Table 4.44 Rhino Stray Incidents (2008-2013)

Sl No	Year	Number of stray incidents
1	2008	78
2	2009	20
3	2010	10
4	2011	61
5	2012	14
6	2013	12

It was observed that the rate of rhino straying got lowered every year. The lower rate of stray incidences may indicate that rhinos have adopted the new habitat of MNP (Linear regression R^2=0.2925).

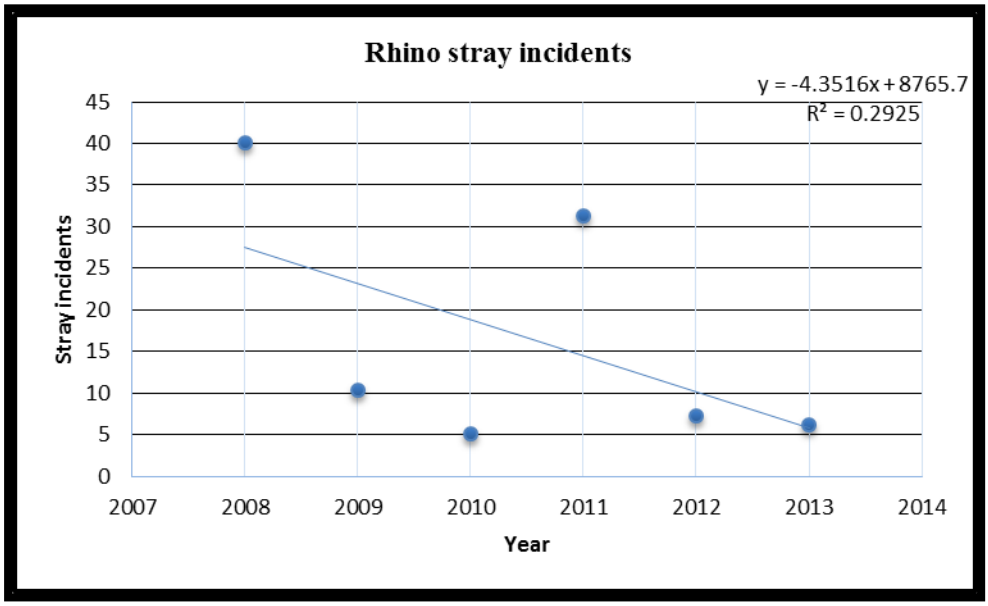

Fig.4.112 Decreasing Trend of Stray Incident among the Rhinos

4.5.1 Seasonal Pattern of Stray

The frequency of stray was the highest during monsoon season and less in the winter season. In pre-monsoon season, average male stray incidents were about 2±1 for adult males (R1, R2 and R5) and 2±1.7 for adult females (R3, R6, R13 & R8). During monsoon season, adult males' average stray incidents were 14±5 and female rhinos' average monsoon season stray incidents were 13.5±2.2. In the retreating season, minimum average stray incidents occurred among adult males (2±1.1) and adult females (1.6±1). During the winter season, adult males' average stray incidents were 2±1 and adult females' average winter stray was 2.2±1.2 (Figure. 4.113 and Figure 4.114).

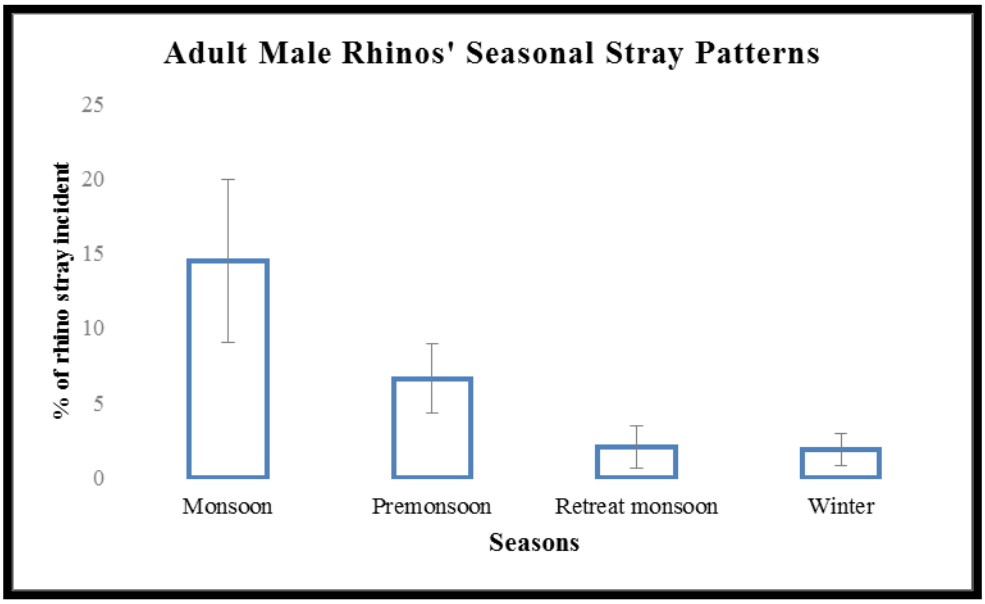

Fig.4.113 Adult Male (R1, R2 &R5) Rhinos' Seasonal Stray Patterns

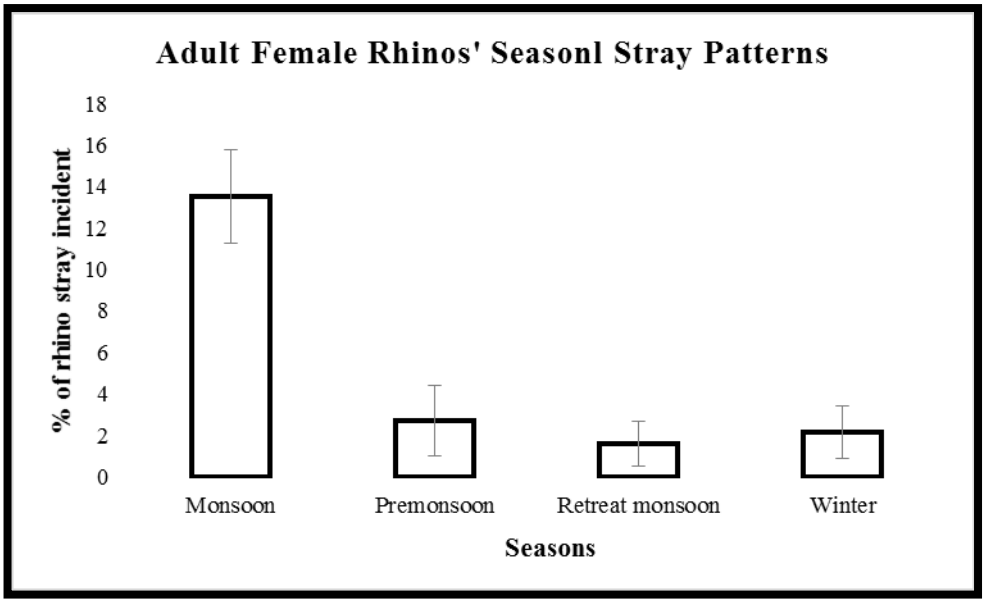

Fig.4.114 Adult Females (R3, R6, R13 &R8) Rhinos' Seasonal Stray Patterns

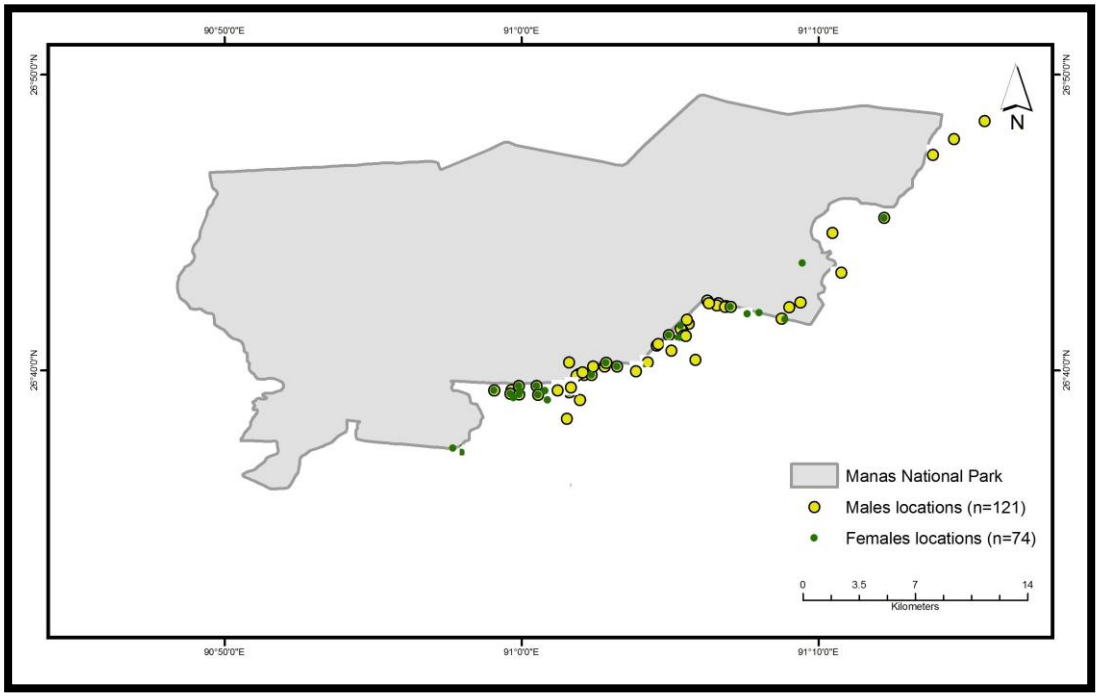

Fig.4.115 Stray Zones of Translocated Rhino's at Manas NP

4.5.2 Long distance Stray

All 10 rhinos have core seasonal home ranges established mostly along the southern boundary to MNP. So, rhinos frequently stray outside and again entered after spending 3-4 hours at night. Unfortunately, some rhinos got trapped in human-dominated areas and resulted in moving away further distances from the park boundary. There was only 4% stray which covered more than 3-4km and 1% which recorded more than 90km distance from the park boundary.

During the long-distance stray, R2 (adult male) traveled for average 12 km towards the eastern direction in thickly populated areas of northern Assam. It was tracked day and night and was finally captured at 100 km distance from the MNP (Fig.4.116).

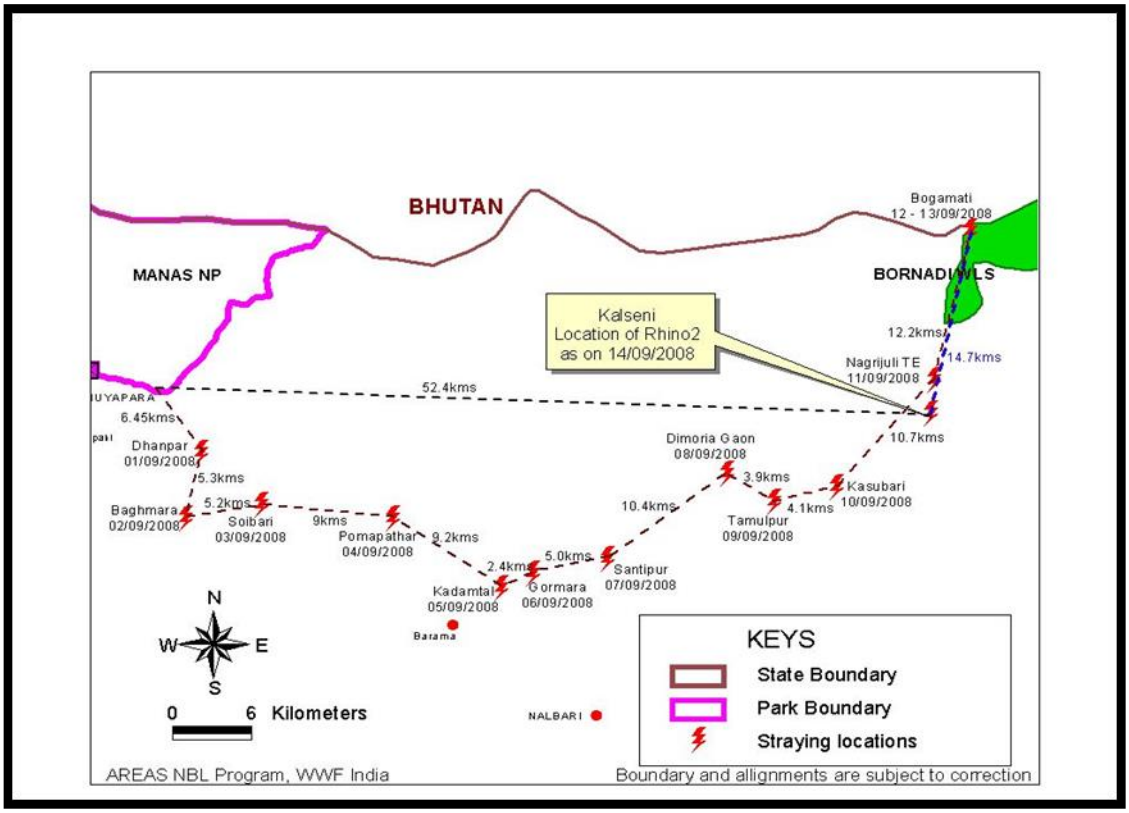

Fig 4.116 Long Distance Stray Track of Adult Rhino (R2) (Source. WWF-India)

4.6 Habitat Preference of Translocated Rhinos

As per remote sensing satellite imagery IRS P6 LISS III Satellite Image November, 2013, MNP has habitat pattern of grassland areas (Savannah and wet alluvial grassland) for 206.30 km^2, swamp and marshy areas of 17.50 km^2, water bodies (including river and other perennial water sources) of 22.55 km^2 and woodland coverage of about 233.20 km^2. For habitat preference study analysis, the encroached areas (4.09%) of MNP were not considered. After the release, rhinos were tracked maximum in grassland areas. During this period of study, total 4931 radio-tracked rhino habitat locations were recorded.

Table 4.45 Utilization-Availability data for Habitat types in the MNP (Adult Males R1, R2 &R5)

Habitat types	**Total Area (sq.km)**	**Proportion of total Area**	**Observed no. of instances**	**Expected no. of occurrences**	**Observed Proportion**	**Confidence interval on proportion of occurrence at a = 0.001**
Grassland	206.30	0.43019	965	415.1381503	0.511	$0.469 \leq p1 \leq 0.553$*
Swamp	17.50	0.03649	655	23.90261704	0.347	$0.306 \leq p2 \leq 0.387$ *
Waterbodies	22.55	0.04702	95	8.087999166	0.091	$0.066 \leq p3 \leq 0.115$
Woodland	233.20	0.48629	172	46.1974768	0.050	$0.032 \leq p4 \leq 0.069$ *
Total	479.55	1	1887	1887	1.000	
Chi-square = 18667.6, df=3, p<0.001						

*Indicates a difference at the 0.001 level of significance. (Utilization is based on 1887 locations by using radio telemetry techniques)

The Z value is determined as $Z_{a2k}=Z_{0.001(2\times4)} = Z_{0.000125}=3.662$

Where a = 0.001 and the number of habitat types (k) is 4 (z-score table value of 0.000125 = 0.001/2(4)).

Table 4.46 Utilization-Availability data for Habitat types in the MNP (Adult Females' -R3, R6, R13 & R8)

Habitat types	**Total Area (sq.km)**	**Proportion of total Area**	**Observed no. of instances**	**Expected no. of occurrences**	**Observed Proportion**	**Confidence interval on proportion of occurrence at a = 0.001**
Grassland	206.30	0.43019	1384	787.257	0.756	$0.720 \leq p1 \leq 0.793$*
Swamp	17.50	0.03649	271	66.781	0.148	$0.118 \leq p2 \leq 0.178$*
Water-bodies	22.55	0.04702	83	86.053	0.045	$0.028 \leq p3 \leq 0.063$
Woodland	233.20	0.48629	92	889.909	0.050	$0.032 \leq p4 \leq 0.069$*
Total	479.55	1	1830	1830	1.000	
Chi-square = 1792.366, df=3, p<0.001						

*Indicates a difference at the 0.001 level of significance. (Utilization is based on 1830 locations by using radio telemetry techniques.)

The Z value is determined as $Z_{a2k}=Z_{0.001(2\times4)} = Z_{0.000125}=3.662$

Where*as* = 0.001 and the number of habitat types (*k*) is 4 (z-score table value of 0.000125 = 0.001/2(4)).

Table 4.47 Utilization-Availability data for Habitat types in the MNP (Rhino Calves-R7,R14 &R11)

Habitat types	**Total Area (sq.km)**	**Proportion of total Area**	**Observed no. of instances**	**Expected no. of occurrences**	**Observed Proportion**	**Confidence interval on proportion of occurrence at *a* = 0.001**
Grassland	206.30	0.43019	881	522.257	0.726	$0.679 \leq p1 \leq 0.773$*
Swamp	17.50	0.03649	216	44.302	0.178	$0.138 \leq p2 \leq 0.218$*
Water bodies	22.55	0.04702	70	57.086	0.058	$0.033 \leq p3 \leq 0.082$
Woodland	233.20	0.48629	47	590.355	0.039	$0.018 \leq p4 \leq 0.059$*
Total	479.55	1	1214	1214	1.000	
Chi-square = 1414.881, df=3, p<0.001						

***Indicates a difference at the 0.001 level of significance.** . (Utilization is based on 1214 locations by using radio telemetry techniques.)

The **Z** value is determined as $Z_{a2k}=Z_{0.001(2\times4)} = Z_{0.000125}=3.662$

Where ***a*** = 0.001 and the number of habitat types (***k***) is 4 (z-score table value of 0.000125 = 0.001/2(4)).

As per *Bonferroni intervals* of all four categories of habitat types, the woodland was utilized less than expected, whereas swamps and grassland (the expected portion 0.036 and 0.430) lies below outside these intervals; therefore, it would be concluded that rhinos were showing statistically significant preferences for the "Swampy and Grassland habitat" more than it was expected. Although all the individual rhinos preferred swampy areas but compared to the adult females (R3, R6, R13 and R8) and calves (R7, R14 and R11) adult males (R1, R2 and R5) shows more preferences towards swamp habitat.

Chapter 5
Discussion

The Greater One Horned Rhinoceros translocation to MNP has helped to establish the rhino population at the Park. The programme was one of the key factors that helped Manas NP to get back its UNESCO (Natural) World Heritage Site status back in 2011. To make the programme successful, extensive protection measures were taken and all the rhinos were monitored during the initial period. The regular monitoring of the rhinos' was the basis of this present study and lots of aspects regarding the translocated rhinos' behaviour and habitat preferences came into light.

Following the release at MNP, all the translocated rhinos started to explore their surroundings to find the most suitable habitat in and around the release site. It is assumed that this exploration might help rhinos to become familiar and gradually settle into their new environment. According to Tal and Saltz (2014), a reintroduced animal changes its behaviour when it becomes more familiar with the new environment. As the adult male rhinos, R1 and R2 were first to be introduced at MNP, they directly or indirectly influenced the establishment of home ranges and the behaviour of the later released rhinos. No behaviour variations were observed among adult males (R1, R2 and R5) and adult females (R3, R6, R13 and R8) during an initial period of release (till 90

days). But there were little variations in behaviour observed among calves R7, R14 (male calves) and R11 (female calf) (Fig 4.3). The female calf (R11) was more frightened in comparison to male calves (R7 and R 14) as they were with their mothers and had a sense of protection all the time.

Just after the release, rhino's grazing activity was observed to be more than the other activities. Rhino calves (R7, R14 and R11) occasionally got separated from their mothers due to the presence of adult males and other species like wild elephants as well as buffalos. During those occasional separations, the calves were unable to suck milk and became dependent on grazing.

During the investigation period, adult males R1 and R2; adult female R6 and her calf R7; adult females R3 and R8 regularly visited anti-poaching camps (Rhino Camp, Chorfuli camp, Kuribeel camp) during night hours and ate kitchen wastages since the second day after the release at MNP. They also licked soil around the anti-poaching camps urinals. These groups of animals were translocated from PWS and maintained their anti-poaching camp's visits even after eight years of reintroduction. This behaviour helped the protection staff to track their records even without the radio-collars. But, the rhinos released from the KNP (R13, 14 and R11) did not exhibit similar behaviour and they usually keep their distance from the anti-poaching camps.

Following the release of the females and their calves, rhinos were frequently seen in association with dominant males especially during grazing and wallowing activities. However, in response to dominant behaviour by the males, the females and their calves subsequently moved away from the male territories to areas where they had

more solitude. Adult female R8 (without a calf) frequently changed her location in the period following her release. Later, she established an association with adult male R2.

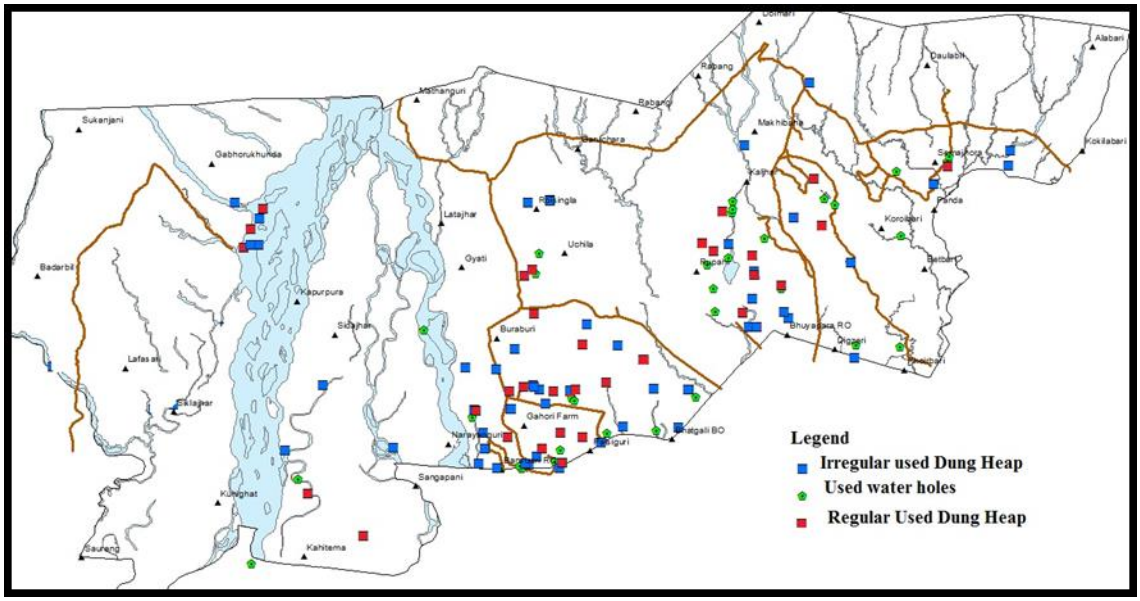

Fig. 5.1 Rhino Dung heaps and Used Water Body Locations in different parts of Manas NP

During the study period, a distinct seasonal variation in activity was observed among the rhinos. Maximum grazing activity was observed in the monsoon and in the retreating monsoon season whereas it was minimum during the winter season. In the winter season, minimum grazing activity was observed due to limited food and water sources in entire MNP. Therefore, browsing activity was noticed to be increased in winter season among all age groups of translocated rhinos. However, the browsing activity of adult males (R1, R2, and R5) was observed to be more than that of adult females (R3, R6, R13 and R8) and calves (R7, R14 and R11) during the entire investigation period.

Patar (2005) at KNP and Bhatta (2011) at PWS reported less grazing but more browsing activity during monsoon and retreating monsoon seasons in their respective general rhino behaviour studies. According to their studies, during monsoon and retreating monsoon season annual flood affected the rhinos grazing pattern as grassland areas were submerged under the flood in KNP and PWS. They also reported more grazing activities among the rhinoceros in KNP and PWS during the winter season.

In contrast to their studies, translocated rhinos at MNP did not show a similar pattern of grazing and browsing. MNP does not have regular flooding problem and availability of food resources reached its peak during the monsoon and retreating monsoon. As a result, more grazing activity was recorded during the monsoon and retreating monsoon seasons. The present finding indicated that the rhinoceros grazing and browsing activity patterns might vary in relation to availablity of food resources in different seasons. The seasonal changes of grazing and browsing activity pattern of translocated rhinos in relation to abundant food resources in MNP showed similarity with Laurie's study (1978) on general rhinos' behaviour at Chitwan NP.

Photograph 5.1 Adult male R1 was browsing *Bombax ceiba* sapling

Variations were observed in the temporal grazing pattern of rhinoceros in different seasons. In the pre-monsoon season, the temporal grazing activity of all age groups (adult males, adult females and calves) was almost similar (Fig 4.9, Fig 4.10, Fig 4.11). Maximum grazing activity was observed in the morning (6:00-10:00) and afternoon (14:00-1800).

During the monsoons, the temporal grazing activity was observed different among the translocated rhinos of MNP (Fig 4.17, Fig. 4.18, Fig 4.19). The adult male rhinos' (R1, R2 and R5) grazing activity was longest during night hours (18:00-6:00) while adult females (R3, R6, and R13 and R8) and calves' (R7, 14 and R11) longest grazing activity was observed during afternoon hours (14:00-18:00). Rhinos might avoid grazing at day times due to hot and humid conditions during the monsoon seasons.

In the retreating monsoon seasons, same temporal grazing pattern was exhibited by all groups of rhinos (Fig 4.25, Fig 4.26, Fig 4.27). During the winters, adult females and calves displayed two grazing peaks in the morning (6:00-10:00) and afternoon hours (14:00-18:00). But adult males displayed three small grazing peaks (6:00-10:00; 10:00-14:00; 14:00-18:00) in the winter season (Fig 4.33, Fig 4.34, Fig 4.35).

Temporal grazing patterns in different seasons were also reported by some previous worker in their general rhino behaviour studies. According to Owen-Smith (1988), temporal feeding patterns of megaherbivores are different with sex and generally, females eat for longer periods. Dinerstein (2003) reported that rhinos at Chitwan NP Nepal exhibit five diurnal small grazing peaks in the winter season and bimodal activity was observed in the hot-dry season. Patar (2005) observed that rhinos in KNP used to graze during the late afternoon, evening, night and morning. Hazarika and Saikia (2012) also indicated variations in temporal grazing pattern with rhinos from different age groups in respect to the season in RGONP. It may be mentioned here that a further understanding of temporal grazing pattern in relation with different season can help in better management of species at particular protected areas.

In the present study resting activity was found to be maximum during the winter season and the pre-monsoon season. Maximum resting activity was observed among adult males (R1, R2 and R5) during winter, and in rhino calves (R7, 14 and R11) during the pre-monsoon season. In their new habitat, adult males were observed to move from one place to another in search of a female companion in the winter season. It was natural that they would be more exploratory when there were so few rhinos in such a vast area and might get less time to rest. During winter, maximum fighting was recorded among the adult males. Normally these fighting occurred during evening period. As

adult males spend much energy in defending their loose territory, they might need more rest than the adult females and calves.

Similar findings were also recorded by Dinerstein (2003) at Chitwan NP. He suggested that the adult males spend much energy in defending their territory and keeping track of the females. Therefore, they utilize the remaining time to take rest rather than grazing.

Adult female R6 and R8 took more rest in the month of March-April, 2013 and both of them gave birth in the month of April and May, 2013 respectively. Another adult female R3's resting activity was observed maximum in the month of August, 2013 and she gave birth in the last week of September, 2013. Therefore, adult female's increased resting activity may indicate their pregnancy. Resting behaviour can also indicate sick, injured and aging rhinos so more study is required in this aspect.

There were not many seasonal variations in temporal resting activity observed among the studied rhinos. Adult males displayed three resting peaks in pre-monsoon, adult females' one resting peak and calves exhibited two small peaks of resting in the morning (6:00-10:00) and afternoon (14:00-18:00) (Fig.4.9). There were no specific resting patterns observed among rhinos in monsoon, retreating monsoon and winter seasons.

Throughout the study period, maximum walking activity was observed in the monsoon season and it was maximum among adult females (R3, R6, R13 and R8) and calves (R7, R14 and R11). During monsoon, rhinos might walk more in search of more quality food from their ranging areas. Walking activity was also influenced by the dominating behaviour of adult males, the presence of other wildlife (eg. Elephants), domesticated cattle and illegal human presence in the core home range areas. The

grassland burning during the winter seasons might also influence the increased walking activities of rhinos. However, no specific temporal pattern of the walking activity was seen among the rhinos in all seasons.

Wallowing activity was found to be the dominant after grazing among translocated rhinos at MNP. Adult males (R1, R2 and R5) were found to wallow more often than adult females (R3, R6, R13 and R8) and calves (R7, R14 and R11). It was observed that though rhinos wallowed in all seasons, wallowing activity was highest during the hot monsoon season.

Present investigations on translocated rhinos indicated that wallowing behaviour might be a way to get relief from hot and humid condition. Previous workers Laurie (1982), Owen-Smith (1988), Dinerstein (2003) at Chitwan NP, Patar (2005) at KNP and Hazarika *et al.* (2013) at RGONP also agreed that wallowing of rhinos in general is due to adjustment with the heat stress.

Dutta (1991) described that rhinos prefer to wallow in mud or static water bodies, but never in running water like streams or rivers. In contrast to Dutta's study, translocated rhinos in MNP were observed to often wallow in running water channels in both Bansbari and Bhuyanpara ranges.

During the winter season, when water sources dried up, translocated rhinos of present study found to depend on perennial water sources. These water sources include rivers, streams, springs, *beels*[1] and ponds. In Bansbari range, a total of 28 water sources and in Bhuyanpara range, 14 perennial water sources were regularly observed to be used by the translocated rhinos. Altogether 91 water sources all over the MNP were found to

[1] A 'Beel' is a lake like wetland with static water in Brahmaputra flood plain.

be used by all rhinos to wallow during the pre-monsoon, monsoon and retreating monsoon depending on availability of water (Appendix III-VI) (Fig.5.1).

The studied rhinos sometimes ate aquatic plants found along the shallow river bottoms. It may be mentioned that this habit of eating aquatic plants led them along with the rivers which eventually results in rhino stray at outside the national park boundary.

During the pre-monsoon season, adult males along with the adult females in the Bansbari range moved outside the Park boundary and entered shallow water bodies to the south of the Park to eat aquatic plants including species like *Hydrilla verticillata, Hymenachne psudointerrupta, Hydrocotyle sibthropioides, Leersia hexandra, Lemna perpusilla, Pistia stratiotes, Vallisneria spiralis.* The present study has shown that translocated rhinos not only wallow for thermoregulatory purposes but also display a preference for specific aquatic plants and it was observed as unique characteristics of translocated rhinos at MNP. So, there is ample scope to study the wallowing time and behaviour, as well as wallowing locations, in the future.

Photograph 5.2 Adult Female R6 was Taking Rest Inside Burned Grassland in Winter Season

The distinct seasonal variations in temporal wallowing pattern were observed among the studied rhinos at MNP. During the pre-monsoon, 3 wallowing peaks were observed with adult males (R1, R2 and R5) (Fig 4.9) and calves (R7, R14 and R11) (Fig 4.10) while 2 with adult females (R3, R6, R13 and R8) (Fig 4.11). During monsoon, 2 long duration wallowing peaks (morning (6:00-10:00 hours), noon (10:00-14:00 hours) and one short duration wallowing peaks were observed in the afternoon (14:00-18:00 hours) with adult males (Fig 4.17) but in case of adult females with calves 3 short duration wallowing peaks were observed (Fig 4.18 and Fig 4.19). In the retreating monsoon, three wallowing peaks were observed among the adult males (R1, R2 and R5) (Fig 4.25) while adult females with calves underwent wallowing in the noon and afternoon hours (Fig 4.26). There were little variations in the wallowing activity among the studied rhinos was observed during the rainy days with a cool breeze in monsoon and retreating monsoon season. Wallowing frequency reduces in winter time substantially due to lowering temperature. In the winter, the rhinos were observed to enter water bodies only to eat aquatic plants during the morning, noon and afternoon period.

During the study period, it was observed that the fishing activities by fringe villagers affected wallowing activities of rhinos. Sometimes, the rhinos shared the same wallowing pits with buffaloes and other domesticated cattle near the southern boundary of MNP. This might lead to disease contamination from domesticated cattle to rhinos and other herbivores and this highlighted disease surveillance need for rhinoceros. Regular cattle vaccination at the adjoining villages of MNP can be a preventive action for the same.

Throughout the study period, temporal activity budgeting was very less (except winter) in the mid-day (10:00-14:00 hours) as compared to morning (06:00-10:00 hours), afternoon (14:00-18:00hours) and night hours (18:00-06:00 hours) (Fig 4.12; Fig 4.20; Fig 4.28; Fig 4.36). During the mid-day periods, rhinos' usually took shelter inside the dense vegetation and under water bodies as relief from the heat or to eat aquatic weeds. So, the observation was very limited due to low signals of VHF transmitter when rhinos stay under water.

During this study, every effort was made to minimize the human disturbance to the rhinos. So, care had been taken not to disturb the animals as recommended by IUCN, Guidelines for the *in situ* Reintroduction and Translocation of African and Asian rhinoceros, 2009 (Emslie *et al.*,2009).

During this period of study, 1230 low radio-tracked locations of rhinos (26%) of total observed locations were discarded from behaviour observation and 80% of these radio-tracked locations falls at mid-day hours of the day. So, this might be attributed to wallowing or resting activity.

Photograph 5.3 Rhino2 was wallowing at Pahumara nala-1 Photograph 5.4 R1 wallowing at Gwathaibari *nalluh*

It was found that there were no marked differences in the behaviour patterns among the translocated rhinos at MNP and the behaviour of the general rhinos at KNP (Dutta,1991; Patar,2005), RGONP (Hazarika and Saikia,2012), PWS (Bhatta,2011), Chitwan NP (Laurie,1982; Dinerstein;2003). The overall behaviour budgeting, as well as preferences of different habitat or births of newborn calves, indicated adaptation by translocated rhinos at MNP.

Photograph 5.5. R1 and R2 were eating Aquatic Plants at a Water Body of Kahibar

During investigation period, slight behaviour variation was observed in two source populations of PWS and KNP. Adult female R6 (translocated from PWS) underwent courtship mating with adult male R2 (translocated from PWS) after 90 days from release at Manas. Adult female R6 with her male calf R7 remain associated during feeding and wallowing with adult male R2 and R1 (both translocated from PWS). Source population from KNP took much time to associate with the rhinos translocated from PWS. Source population from Pobitora was seen to be accustomed with patrolling elephants and presence of a human.

Dutta (1991) mentioned that rhino population in Bagori (Western Range of KNP) was more aggressive due to less intensity of tourist there. All KNP source population was captured at Bagori area and they were found to be wary of human approach and retained their hostility towards the man even after transloacted to MNP.

Photograph 5.6 Adult Female R3 was eating Aquatic Weeds in a Shallow River Channel Madrijhora in Rainy Weather

Photograph 5.7 Adult Male (R1) was Wallowing with Rehabilitated Females Ganga and Jamuna

Photograph 5.8 A Camera Trap Images of Adult R8 defecating over a dung heap

Photograph 5.9 Adult female R8 returns to same dung site and sniffed before defecating.

Regarding the food preferences of rhinos, intense study was done during the study period. Altogether, 139 food plants species from 39 families were recorded to be preferred by the translocated rhinos at MNP. During the initial period, just after the release, the rhinos preferred grazing grounds in tall grassland areas of Buraburijhar, Rhino camp, Kuribeel and Forte. They might feel secure under tall grassland just after release at MNP. Soon, they came out of the cover and started using short grassland areas. As per observation, it was witnessed that rhinos ate grass, herbs, shrubs, tree sapling along with aquatic plants and their home ranges were determined by places with abundant grasslands.

During the investigations, no significant variations were observed in the food habits among adult males (R1, R2 and R5), adult females (R3, R6, R13 and R8) and calves (R7, R14 and R11).

Among different food, grass species were the major preferable food for all the age groups of translocated rhinos at MNP. *Arundo donax, Cynodon dactylon, Imperata cylindrica, Saccharum sp.,* grasses were the most preferred species throughout the year and constitute major diet species of translocated rhinos at MNP. *Asteraceae spp., Centella asiatica, Eclipta alba, Eclipta prostrata, Floscopa scandens, Houttuynia cordata, Oxalis corniculata, Pteridium aquilinum* were common herbs and *Boerhavia diffusa, Enhydra fluctuans, Jussiaea repens, Lemna panicostate, Pistia strafiotes and Polygonum barbatum* were the aquatic plants preferred by rhinos throughout the year. *Bombax ceiba, Butea monosperma, Careya arborea, Cassia fistula, Dillenia pentagyna, Gmelina arborea, Macaramga denticulate* were tree species preferred by rhinos of

MNP all-round the year (Table 4.36). Browsing of the trees was maximum in the winters and minimum during the monsoon seasons.

Present study on the translocated rhinos grass species preferences showed resemblance with previous works by Laurie (1978) at Chitwan NP, Dinerstein (2003) at Chitwan NP and Bardia NP, Patar (2005) at KNP and Bhatta (2011) at PWS. Though variations in grass species preferences were observed among rhinoceros in different sites but *Arundo donax, Cynodon dactylon, Saccharum sps* constituted the major part of the annual diet of rhinos in all four rhino bearing areas including MNP. In MNP these four grass species were found to be distributed in translocated rhinos' ranging areas of MNP in association with other grasses, herbs, shrubs and trees.

During the present investigation, it was observed that *Arundo donax, Saccharum sp., Imperata cylindrica* were commonly found in Kuribeel, Buraburijhar, Rhino camp, Forte camp, Chorfuli areas' grassland in Bansbari range and Rupahi, Kanchanbari, Aboidara and Kaljhar areas' grassland of Bhuyanpara range. These were the common rhino ranging areas for grazing.

Cynodon dactylon-Cyperus rotundus-Vetiveria zizanoides association was observed in Pulsiguri, Katajhar, Tinmile areas of Bansbari range and Kaljhar, Dhonbeel and some parts of Digjhari areas of Bhuyanpara range. These grasslands found along the southern boundary of the park, were highly preferred by the rhinos and the cattle.

During the winter, few grasslands with *Cyperus auricomum, Cyperus digitatus* and *Vetiveria zizanioides* were dried and it influenced the ranging patterns of the rhinos. It was observed that the tall grasses (e.g. *Eraianthus sp.*) prevalent during the winters were not preferred by the rhinos. Aquatic plants like *Eichhornia crassipe, Elocharis*

fistulosa, Monochoria vaginalis and *Vallisneria spiralis* were preferred during the pre-monsoons, monsoons, and retreating monsoons but not in the winters.

Vallisneria spiralis is one of most preferred aquatic plants by the rhinos and as a result, sometimes the rhinos move out of the park to eat these plants. Crop raiding was gradually declined after the home ranges were established but in Bhuyanpara range, rice fields in encroached areas were often raided.

During the winters, the anthropogenic pressure increased in the rhino habitats along the periphery of MNP. Unregulated grassland burning, livestock grazing, a collection of reeds and thatch, fishing in swampy areas and other water bodies caused major disturbances. Hence, these activities found to influence the food preferences directly and ranging pattern of rhinos and other animals. Habitat condition in Bhuyanpara was considered as suitable for the rhinos in earlier studies and official records before rhino translocation at MNP (Patar *et al.*2007; Bezbarua, 2008). But maximum numbers of rhinos, however, observed to utilize to the central locations of the Bansbari range. It may be due to the encroachment in a part of Bhuyanpara range for paddy cultivation and weaker protection level than that of Bansbari. So, better protection is required for proper maintenance of the rhinos' habitat.

Newly released rhinos in Manas did not disperse far away from release sites and dispersal distance decreased when a new number of rhinos were added through translocation process (Linear regression R2=0.4803) (Fig 5.2; Table 4.38). It was observed that 70% of the rhinos dispersed almost in the same direction towards eastern bank of River Beki from the release site. Dispersal of rhinos was influenced by placement of crate and ramp direction at the release site. Except for adult males R1 and

R2, all other crates faced north so that the rhinos could directly reach Buraburijhar River after release which is situated just 100m away from the release site. Through the river channel, rhinos were finally able to reach the eastern bank of the River Beki.

To prevent long distance dispersal, Rhino release site was selected at central locations of the park with the favorable condition of perennial water source i.e. Buraburijhar and large patches of grazing areas (Fig 1.5). Some measures were undertaken to prevent rhino's dispersal to distant areas. Before the release of the first group of rhinos at Manas, about 300kg of dry rhino dung was carried from PWS and was spread around the Buraburijhar for dung midden. This seemed to reduce the movement of the first two adult males (R1 and R2). As the later groups of the rhinos were released, the gradual decrease of the first day movement of each group was observed to be less which may be due to the presence of previous groups of rhinos including three rehabilitated rhinos (Mainao, Ganga and Jamuna) and the presence of five large dung heaps, perennial water sources, grazing areas around the rhino release site. These observations can be correlated with the suggestions of earlier works by Linklater *et al*. (2006) that the rhino's scent marking behaviour influenced familiar environment for reintroduced rhinos as the scent of conspecifics in the release sites of black rhinoceros reduced the dispersal and encourage the formation of home range. As per LeGouar *et al*., (2012) the proximity to the other individuals can be the key factors to influence the dispersal pattern of the reintroduced animals.

Linklater and Swaisgood (2008); Patton *et al.* (2010) observed the similar pattern of dispersal with newly released black rhinoceros (*Diceor bicornis*) in their respective studies. They observed that decline in minimum daily travel distance was an

indicator that reintroduced animal began adopting new environment. In Bardia NP, Nepal reintroduced rhinoceros were dispersed to different areas after release as recorded by Jnawali (1995). As the dispersal pattern of newly released rhinos is more important for their adaptation in the new habitat as well as for the security of rhinos (Emslie *et al.* (2009), so further studies are required to document different factors of dispersal in all the future GoH translocation program

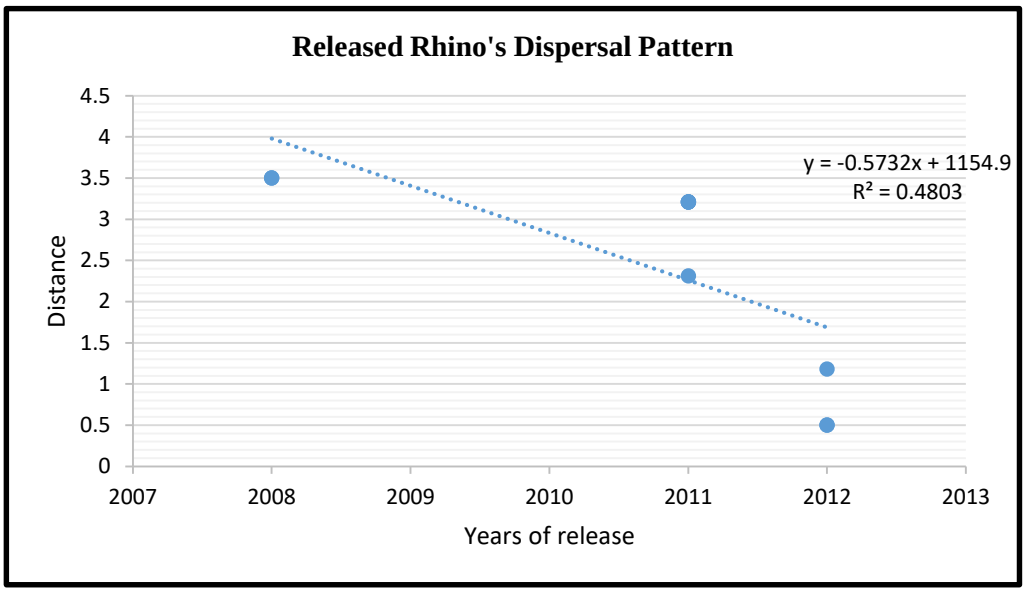

Fig. 5.2 Dispersal Distance of Translocated Rhinos at Manas NP

Radio telemetry (VHF-Very High Frequency) was found to be the most reliable equipment for regular day to day monitoring and homing of rhinos as well as the estimation of the home ranges. With the help of Ultra High Frequency (UHF) Radio Collars, some precise locations of one adult female (R3) were tracked. As per the observation, adult females (R3, R6, R13 and R8) were not so much exploratory and established the home ranges after almost 60 days from the release. But the male rhinos were found to be quite exploratory and the establishment of home range was gradual after average ~200 days from the release (Fig 4.42). After the establishment of the home

range, corresponding exploratory nature also observed to be decreased which is in conformity with the earlier worker (Tal and Saltz, 2014).

Overall average home range was estimated to be 108.65 km^2 for all the translocated rhinos at Manas. The average annual home ranges estimated for adult males (R1, R2, and R5) were 156.6 km^2 and adult females (R3, R6, R13 and R8) were 90.24km^2 (Table 4.39). The average annual home ranges estimated by the present study were larger than what had reported on translocated rhinos at Bardia NP (adult male 41.8 km^2 and adult female 25.1km^2) by Jnawali (1995). Correspondingly, translocated adult male rhinos' annual core home range size was estimated to be 30.83km^2, whereas adult females and calves home range was estimated to be 16 km^2 and 19.97 km2 respectively.

Annual home range sizes of the translocated rhinos in MNP were found to be similar with that of the general rhino studies by Laurie (1978); Dinerstein (2003), Subedi (2012), Adhikari (2015) at Chitwan NP Nepal; Hazarika (2007) at RGONP; Bhatta (2011) at PWS. In all the mentioned studies, it was observed that adult males occupy larger home range than adult females just like that observed in case of translocated rhinos MNP (Table 4.40). Adult males' and adult females' core home range sizes of translocated rhinos of MNP were larger than that of adult male and females at Chitwan NP as reported by Dinerstein (2003), Subedi (2012); Adhikari (2015).

The home range sizes varied seasonally. Likewise, the different rhino home range size varied in different seasons in MNP (Table 4.41, 4.42 and 4.43). During the investigation period, the translocated rhinos did not show a uniform pattern of seasonal home range sizes. But the core home range estimated with FKD (55%) has insignificant variations. There were variable seasonal home range sizes observed among the rhinos in

MNP which was directly linked to the availability of water sources, food plants, mates and the disturbance factors. Buraburijhar, Chorfuli, Forte camp, Kuribeel, Rhino camp of Bansbari range and Rupahi, Kanchanbari, Aboidara and Kaljhar areas of Bhuyanpara range were in the core home range areas of all rhinos where plenty of preferred food plants and wetlands are present. Various anthropogenic pressures, cattle grazing, unregulated grassland burning was observed to affect rhinos' seasonal core home range sizes.

Out of the total translocated rhinos, 7 rhinos (R1, R2, R3, R5, R6, R7 and R8) were translocated from PWS and three (R11, R13, and R14) were from KNP. In PWS, total annual rhino ranging area was estimated from 9.09 km^2 to 27.42km^2 by Bhatta (2011). Same source population after the reintroduction at MNP increased their home range up to 242 km^2. The ranging size of MNP rhinos was almost equal to the six numbers of the present PWS size (38.80km^2). Overall annual and core home range sizes were bigger than that of all previous studies. Jnawali (1995) argued that low population density and low availability of prime habitat dominated by *Sccaharum sopntaneum* are the main reasons behind the bigger rhino home ranges at Bardia NP. The increment to bigger home range sizes of rhinos at MNP might have attributed to the several combined causes as follows:

1. Low rhinoceros population density in the larger area (500 km^2) might be one the factor for the significant increment of home range sizes at MNP to access more resources food, water, and mates. Jnawali (1995) recorded similar findings with the translocated rhinoceros at Bardia NP. Subedi (2012); and Adhikari (2015)

also recorded similar finding in the estimation of general rhino home range study at Chitwan NP, Nepal.

2. Explorative nature of the translocated adult males (R1, R2 and R5) at new habitat might induce them to increase their home range sizes.
3. Various anthropogenic factors such as unregulated grassland burning, cattle grazing might also have influenced the translocated rhinoceros at MNP to have larger home range sizes.
4. Dominating behaviour of adult males R1 and R2 might also have influenced the larger home range sizes the adult females (R13 with male calf R14), the adult male R5 and the female calf (R11).
5. The invasion of the tree like *Bombax ceiba and Dillenia pentagyna* shrubs like *Chromolanea odorata, Leea asiatica,* and herbs like *Ageratum conyzoides* have degraded some prime grassland habitat (Lahkar *et al.*,2011). Due to improper management of habitat, several water bodies dried up or significantly shifted to drier and woodland type of vegetation (Sarma *et al*., 2008). These factors may influence the increment of larger home range size of rhinos to have sufficient resources within their used areas. Laurie (1978) observed that lower vegetation diversity was one of the reasons behind larger ranging areas of Chitwan NP rhinoceros. Subedi (2012) also agreed on the similar situation in the same area.
6. Rhinos used to obtain 9% of their diet from the adjoining agricultural crop fields of the park boundary. This opportunity of getting highly nutritious food intake was checked after installation of 11km solar powered fence (Photograph 5.17) along the Southern boundary of Manas (Beki River Bank to Pahumara river

bank) from the year 2009 and might compel mainly the adult males (R1 and R2) rhinos to move to larger areas to forage.

7. These studies used extensive telemetry data set which was generated from the day and night monitoring activities in respect to seasons for six years (2008-2013). This might signify better outcome of the home range analysis for the translocated rhinos. These findings showed the resemblance with the earlier worker Subedi (2012). He was also used radio-telemetry extensively with his studied rhinoceros at Chitwan NP.

Adult male (R1, R2 and R5), adult female (R3, R6, R13 and R8) and calves (R7, R14 and R11) overlapped their ranging areas all-round the year. This finding agreed with all the other previous studies on translocated and general rhinoceros ranging patterns which indicated that Greater One Horned Rhinoceros is not a territorial animal. Adult males R1 and R2 maintained loosely defined territories in Bansbari range. Adult male R5, which was introduced 3 years later, mainly stayed in the easternmost parts of Bhuyanpara range, occasionally visiting the eastern part of Bansbari to seek the company of adult females. Fighting incidents were common among the males when they confronted each other. In these fights, adult male R5 was always a loser and which eventually forced him to stay away from territories occupied by another two adult males R1 and R2. It was observed that maximum overlapping of the ranging areas in the Bansbari range encompassing short grassland areas, swamp and water bodies with a better level of protection level prevail as compared to other two ranges.

The territorial tendency among the male rhinoceros was also reported by Laurie (1978); Dinerstein (2003) and Subedi (2012) in their study with behaviour of general

rhinoceros studies at Chitwan NP, Nepal while Jnawali (1995) reported translocated rhinoceros territorial tendency at Bardia NP, Nepal.

There were six types of individual specific association recorded among translocated rhinos and also with the translocated and rehabilitated rhinoceros (Fig 4.106 and 4.111). Except for the adult mother with male calves, all association was observed on temporary basis in MNP. This result agreed with all other previous studies (translocated and general rhinoceros studies) that greater one-horned rhino's social bonding is not very strong. Loose social bonding of GoH was also reported by Laurie (1978) in Chitwan NP, Nepal; Dutta (1991) and Patar (2005) at KNP; Tripathi (2013) at newly established population at Dudhwa NP.

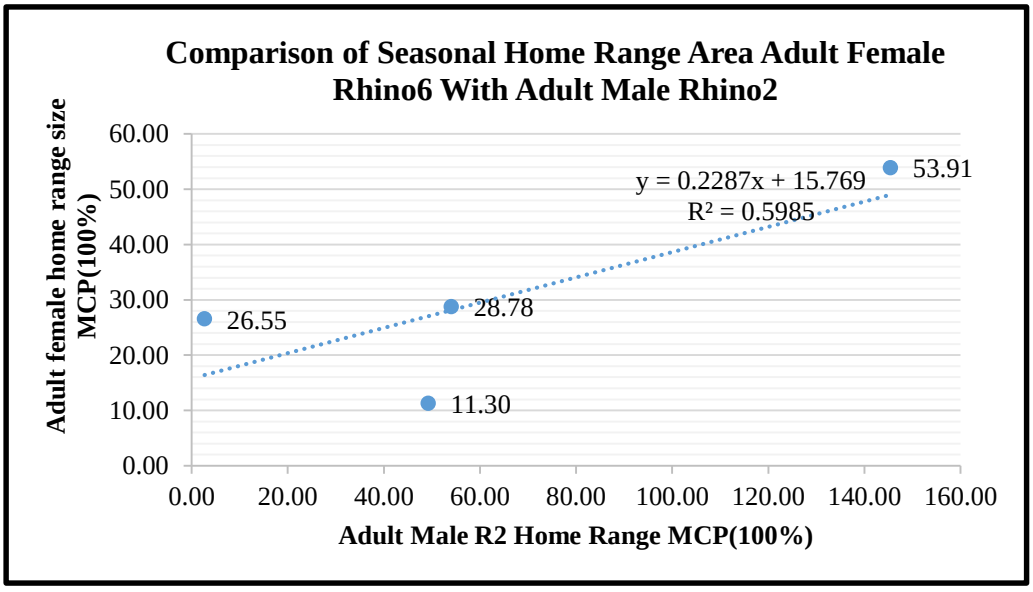

Fig. 5.3 Comparison of Adult Female R6 Seasonal Home Range Area with Adult Male R2

The temporary association was commonly observed in the Bansbari range and this can be related to available resources (fodder and water) and might be due to better protection measures present in that area (Fig.4.107-4.109). Dominant adult males R1

and R2 were associated together when the other rhinos were not present. Adult males (R1 and R2) with translocated females (R3, R6, R13 and R8) and rehabilitated female's (Ganga, Jamuna and Mainao) association frequencies were varied on different observations.

Among the association, adult male R2 and adult female R6 had a common association in Bansbari. R6 (adult female) underwent courtship mating with R2 just after 90 days from release. There was no conflict seen in sharing home range areas of R2 (adult male), R6 (adult female) and R7 (male calf) (Linear regression R^2=0.5985) (Fig5.12). They even associated for about 14-20 days together. Owen-Smith (1988) mentioned 3-member association of Indian rhinoceros is very rare in normal rhino bearing areas (Chitwan NP, Nepal) and never persist for more than 2-3 days. The present investigation, however, countered this findings as the translocated rhinos exhibited a long-term association among the three animals.

Patton and Cambell (2010) recorded that the black rhinoceros formed four types of association after 18-month release in OI Pejeta Conservancy in the Laikipia area of central Kenya. Similarly, Patton *et al.* (2012) reported two types of cow calf association during before and after calving. Owen & Smith (1988) reported three types of association of African white rhinoceros at Umfolozi NP, South Africa.

Photograph 5.10 Adult Male R1 with three Rehabilitated Females at Pulsiguri

Photograph 5.11 Adult Male R2 with R6 and her male calf (R7)

Though information on mating among the rhinos was available, no mating was vizualized during this period. All courtship observation were recorded in the late evening or night. The maximum premating courtship running was observed from the period of pre-monsoon and monsoon period (March-September) and most births occurred in the dry and early pre-monsoon seasons. Chases, loud vocalization were observed during the courtship running (Owen-Smith 1988). Mating information might be true as all translocated and rehabilitated adult females gave birth to calves after 4 years of release at MNP. Even rehabilitated adult female Ganga and Mainao gave birth to two calves within an interval of two years at MNP. Laurie (1978) reported peak courtship behaviour in the winter to pre-monsoon (January-March) and maximum birth occurred in the monsoon seasons in Chitwan NP.

In MNP, all translocated females gave birth in secluded places of the park within thick grassland and dense woodland areas (Sidhajhar, in between Buraburijhar, Charfuli, Uchila and Chengmarijhar). Owen-Smith (1988) also mentioned similar secluded site selection nature of adult female rhinoceros of GoH in their natural habitat.

Wild elephant was observed to be associated maximum with the female rhinos. Rhinos translocated from PWS were found to be at close affinity with the domesticated cattle and wild buffalos. Talukdar (1999) mentioned that around 2,500-3000 cattle grazes in the core of PWS every day in association with the wild rhinos. So, the rhinos translocated from Pobitora might have more familiar association with the cattle as compared to that of KNP.

Birds have the symbiotic relationship with rhinos. Common myna (*Acridotheres tristis*), Jungle Myna (*Acridotheres fuscus*) was observed to develop the frequent association with rhinos. Jungle Myna association sometimes helped monitoring staff to locate rhino even in very tall and deep grassland areas. Patar (2005) recorded similar symbiotic association with rhinoceros at KNP.

Photograph 5.12 Adult Male R1 with a herd of Wild Gaur (*Bos gaurus*)

Photograph 5.13 Adult Male R1 and R2 with a herd of Cattle

Translocated rhinos in MNP were subjected to stray as they did not have the notions of the park boundary. Following were the reasons for the observed related stray incident of rhinos at Manas:

1. After the release, the rhinos often stray out at night in search of food in adjoining agricultural fields. The translocated rhinos of MNP used to obtain 9% of their diet from agricultural fields during the initial days after release. This was prevented after the installation of the solar powered electric fence at the southern boundary of Manas (Photograph 5.17).

   Rhino stray incident often created conflict with the villagers. Rhinos relocated from PWS had more stray frequencies than those of KNP. At Pobitora, stray and crop raiding of rhino is regular activity as reported by Talukdar (1999); Bhatta (2011). So, the translocated rhinos might bear the

straying nature and continued even after the relocation. This observation might be true as rhinos translocated from KNP stray less than those of PWS as because there are not regular rhino stray occurred at KNP.

2. *Vallisneria spiralis* is one of most preferred aquatic plants of the rhinos and as a result, sometimes the rhino moves out of the park to eat these plants at nearby water bodies.
3. In Gwathaibari (fringe village of Bhuyanpara range), R1 (adult male) liked to stray near the community worship place (Bathou Temple) to lick mineral soils.
4. Sometimes, accidental separation of mother from calf led to straying. R17 (adult female) and R18 (male calf) strayed outside as a result of the accidental separation of mother and calf just after release.
5. Courtship running, the association of domesticated cattle and buffalo, illegal human entry inside the protected area were some of the reasons for rhino stray outside the park. Straying as a result of the courtship running was also reported by Laurie (1978, 1982) at Chitwan NP; Bhatta (2011) at PWS.

Translocated rhinos exhibited maximum straying at evening and night and less in the morning hours (Photograph 5.14). No stray occurred during the day time. Bhatta (2011) reported only night stray at adjoining crop field of rhinos at PWS. In contrast to translocated rhino's stray pattern, rehabilitated adult females of MNP (Ganga, Jamuna, and Mainao) were habituated with stray at daytime as mentioned by Barman *et al*. (2014).

During the investigation period, translocated rhinoceros stray incident was found maximum from the month of March to September (Pre-monsoon and Monsoon) and very less in winter. This observation would not relate to the studies of Dinerstein (2003) at Chitwan NP, Bhatta (2011) at PWS; Hazarika and Saikia (2012) at RGONP who have recorded maximum stray during the winter seasons.

During this study period, R (2) adult male strayed for about 100 km from the park boundary. This happened due to much human outcry around the rhino stray area. Therefore, rhino moved average 15-20 km at night to get secured environment. So, a better crowd management, support from civil administration and local media role is vital to managing such situation.

Photograph 5.14 One Stray Rhino at night in Nearby Tea Estate of Bansbari range

Photograph 5.15 Forest staff patrolling at Night to Drive Stray Rhino inside National Park Boundary

Photograph 5.16 Staff and Patrolling Elephants Lined up at Southern Boundary to Push Rhino Deep inside the Park

Photograph 5.17 Solar Electric Fence Erected at Southern Boundary of Manas to Prevent Rhino Stray

During the study period, the rhinoceros showed maximum preferences to grassland and swamp habitat then the woodlands (Table 4.45, Table 4.46, and Table 4.47). In the grassland and swamp habitat, a large number of natural and artificial water bodies are present which were used by rhinoceros. However, large water body like the river Beki was avoided except occasional drinking incidents.

Preferences of the woodland habitat were found more during the winter seasons as more browsing is available there than any another habitat. In the winter seasons, rhinos were observed to take shelter in woodlands to avoid cool breeze at early morning and evening but used the water bodies distributed in grassland and swamp habitats during the day hours. Subedi (2012) and Adhikari (2015) recorded the similar pattern of habitat preferences with seasonal shift in Chitwan NP. Sharma *et al.* (2008); Hazarika

and Saikia (2011) reported no seasonal shift of the habitat preferences of rhinoceros in RGONP and rhinoceros used wet grassland and water bodies throughout the year. Bhatta (2011) reported considerably higher preference of the woodland throughout the year in case of rhinos at PWS which was not observed in the present study.

Translocated rhinos at MNP mainly preferred the short grassland areas of Rhino camp, Tinmile, Buraburijhar, New Buraburijhar, Chorfuli, Pulsiguri, Kuribeel, Katajhar, Narayanguri and Songlapani areas of the Bansbari range. In Bhuyanpara range, rhinos' preferred grassland areas were Rupahi, Aboidara, Kaljhar, Kanchanbari, Makhibaha, Dhanbeel, Digjhari and Betbari.

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Photograph 5.18 Grassland of Kaljhar Area (Bhuyanpara Range)

Photograph 5.19 Grassland of Rupahi area (Bhuyanpara range)

Photograph 5.20 Savannah Grassland of Chorfuli area (Bansbari range)

Photograph 5.21 Grassland of Kuribeel area (Bansbari range)

Photograph 5.22 Swamp Habitat of Kahibari Area (Bansbari range)

Photograph 5.23 Swamp Habitat of Bhatghali area (Bansbari Range)

The establishment of a new GoH population at MNP through the wild-to-wild translocation program under Indian Rhino Vision 2020 opened a new dimension in the conservation efforts for this magnificent pachyderm. It can be expected that rhino's translocation program at MNP will also contribute to the mixing of genes from individuals from PWS and KNP populations. The findings of the present study may be helpful in other countries where there are plans to establish new populations of GoH in the near future.

Improvement of protection as well as patrolling infrastructure and continuous community support of conservation helped to secure the situation of MNP. Swargowari (2012) stated that the rhino introduction program contributed much to an increase in

ecosystem integrity when the rhinos were present alongside other wild animals including elephants, tigers, and wild buffalos.

The newly established GoH population at MNP is doing well and the rhinos had started breeding. The present population (August 2015) of rhinoceros is about 32, including adult female (10), juvenile male (7) and new-born calves at Manas (14) and one (1) rehabilitated female calf (total population constitute translocated, rehabilitated and Manas born calves). However, while the newly established population is doing well, poaching remains a significant threat. During 2011–2015, 8 translocated rhinos were killed by poachers including 4 (R1, R2, R5 and R8) of the studied animals. These animals were adult males and one adult female which affected the population growth pattern of the newly established rhinos. A population viability analysis by IUCN Conservation Breeding Specialist Groups carried out in 2015 indicated that unless poaching is eradicated, the continued reintroduction of rhinos is unlikely to result in a viable population in MNP and the rhino population faces the threat of extinction in the next two to three decades (Ellis *et al.,* 2015). Therefore, more intervention is required for the improvement of the entire protection system of the Manas National Park near future. Improved protection, proper scientific management of habitat, regular awareness in the fringe villages instilling a pride of rhino conservation in MNP will be helpful to maintain a future viable rhino population.

Overall findings from the present study on "To Study Behaviour and Habitat Preferences of Translocated Rhinos (*Rhinoceros unicornis*) at Manas National Park, Assam, India" are summarized as follows:

- During the first 90 days from the release, all rhinos were observed to be explorative. Female rhinos showed comparatively less interest in exploring

and established their home ranges during 60 days after the release. But male rhinos were quite exploratory and gradually established the home ranges after average ~200 days from release. After the establishment of home ranges, the corresponding exploratory nature was also observed to be decreased. So, the intensive monitoring after translocation should be more than 200-365 days as indicated by this study.

- For both intensive and long term seasonal monitoring, it is essential to have sufficient budget, adequate and trained manpower and trained elephants who have rhino exposure. It is also important that periodic health check-up of the rhinos by trained veterinarian are organised for better understanding of health condition of rhinos.

- During twenty-eight days after release, rhinos were seen to be moving to other two ranges (Panbari and Bhuyanpara) by crossing rivers like Beki and Hakowa. This indicates that even a small rhino calf (R14) can swim over fast flowing rivers.

- There were distinct different patterns of behaviour (grazing, browsing, walking, wallowing and resting) temporal dynamics variations observed among all the studied rhinos. So, the protection and monitoring approach should be maintained in such way that all translocated rhino are monitored uniformly.

- Wallowing was the dominant activity after grazing among the translocated rhinos at MNP, with increased wallowing in the monsoon season, and adult males wallowed more often than adult females and calves. It was observed that rhinos wallowed in all the seasons but it was maximum during the hot monsoon season. This study has also shown that the rhinos not only wallow for thermoregulatory purposes but also display a preference to eat the aquatic plants.

- Although rhinos like to change the locations for their wallowing season to season, there were some locations where permanently used by all groups of rhinos. Therefore, regular protection vigil necessary in those identified locations.

- It was found that there were no marked differences in behaviour patterns of translocated rhinos at MNP and other rhino range areas of India and Nepal. The overall behaviour budgeting, as well as preferences of different habitat or births of the new born calves, indicated that translocated rhinos have adapted well in MNP. These robust behaviour data base and related rhino information can be a base line for further researches on rhinos (both native and translocated) and other mega herbivores.

- Altogether, 139 plants species from 39 families were preferred by rhinos in different seasons. Out of 139 species, 23 species were short grass, 11 tall grasses, 23 aquatic plants, 11 shrubs, 30 herbs, 3 creepers, 26 trees and 12

crops. *Cynodon dactylon, Arundo donax, Imperata cylindrica, Saccharum spontaneum, Saccharum elephantinus* grasses were the most preferred food plants throughout the years. These seasonal abundance of these rhino preferred species in different locations may be good subject to research at Manas.

- Radio telemetry (VHF-Very High Frequency) was found to be the most reliable source for regular day to day monitoring and homing of rhinos as well as the estimation of home ranges. The battery durability of UHF (Ultra High Frequency) collar was minimum (approximate 3 months) and data download process in wild situation was not handy. Disturbed radio signals (sometimes low and sometimes high), signal coming from same direction for 3-4 days must be investigated immediately as this might indicate drop of collar and life risk of animal.

- Ear notching is effective tool to identify translocated animal inside dense vegetation even in water bodies after the radio-collar stopped functioning.

- Radio collar belt around the neck of rhinos must be investigated regularly with binoculars. As the rhinos grow there may be possible chances of strangulation or serious health hazards. The dysfunctional radio collar belt must be removed immediately.

- The annual home range sizes of the translocated rhinos were found consistent with all other previous studies where the adult males occupy larger home

ranges than the adult females. The average annual home range estimated for adult males was 156.6 km^2 and adult females 90.24km^2. Thus male rhino need more protection care than females. During 2011–2015 (August), 8 translocated rhinos were poached including 4 (R1, R2, R5 and R8) of the studied animals. Among the four three of them were adult males (R1, R2, R5) so larger home range might vulnerable to poaching.

- The increment of the bigger home range size of rhinos at MNP could be attributed to lower rhino population density, the dominating behaviour of adult male rhino R1 and R2, the exploratory nature of the rhinoceros, anthropogenic pressures and improper management of grassland habitat and water bodies.

- There were variable seasonal home range sizes among the rhinos at MNP which can be directly linked to the resource availability like water sources and preferable grass species. Water was one of the limiting factors shaping the seasonal home ranges observed during study period. Bigger and regular use dung piles were always inside the rhino core home range areas. So weekly vigilance is necessary to know the position of the rhino and ensure its protection. There may by future research scopes on establishment of dung heaps in relation with seasonal home range.

- Adult males (R1, R2 and R5), adult females (R3, R6, R13 and R8) and calves (R7, R14 and R11) overlapped their ranging areas all-round the year. Though R1 and R2 maintained loosely defined territories in Bansbari range, both the

adult males influence other rhinos' ranging patterns. The translocated rhinoceros also overlapped the entire raging areas of rehabilitated rhinos. There may be vast research scopes on ranging and association patterns among future generations from translocated and rehabilitated rhinoceros at Manas.

- All courtship observations were recorded in the late evening or night. The maximum pre-mating courtship running was observed from the period of pre-monsoon and monsoon period (March-September) and most births were occurred in the dry and early pre-monsoon season. Mating information might be true as all translocated and rehabilitated adult females gave birth to calves after 4 years of release at MNP. All the females gave birth in secluded places of the park within thick grassland and dense woodland areas.

- Rhinos translocated from Pobitora WLS were found to be at close affinity with domesticated cattle and buffalos then rhinos from KNP.

- Translocated rhinos from PWS might have straying nature before the translocation which was resumed after the relocation. As per the food preferences, the rhinos used to obtain 9% of their diet from agricultural fields during the initial days after the release. Eating aquatic food plant like *Vallisneria spiralis* outside the park boundary, mineral licks, mating chase and accidental separation of mother and calf after release were some other reasons behind the rhino stray at MNP.

- Stray incidents occurred at an average of 15 days after the release. The timing of the translocated rhinos straying was either early in the evenings or late nights while rehabilitated rhinos at MNP were habituated to straying at day times. During the straying, rhinos tried to enter paddy fields and vegetable orchards.

- Extensive monitoring (24x7) is necessary to keep the straying in check and around the boundary lines of the park. Support from the adjoining areas and local administration is also necessary to keep the rhinos within the park boundary during the early periods after the release. Necessary rescuing logistics, tranquilizing drug, gun, trained veterinarian and some amount emergency fund required to manage sudden long distance rhino stray crisis.

- Rhinoceros were showing more preferences to grassland and swamp habitat than the woodland habitat. Water bodies inside the grassland and swamp facilitate the rhinos to access to thermoregulation as well as to eat aquatic plants.

- Various Anthropogenic pressures, improper habitat management affected rhinoceros behaviour, food plant preferences, and ranging and habitat preferences. So, better protection, proper habitat management, regular awareness in the fringes of MNP villages instilling a pride of rhino conservation as in KNP and PWS is urged through this study.

- Sometimes the rhinos shared the same wallowing pits with buffaloes and other domesticated cattle near the southern boundary of MNP. This might lead to disease contamination from the domesticated cattle to rhino and other herbivores. This highlighted the disease surveillance for rhinoceros and regular cattle vaccinations at the adjoin villages of MNP as a preventive action for the same.

- The establishment of a new GoH population at MNP through the wild-to-wild translocation program under Indian Rhino Vision 2020 opened up a new dimension in conservation efforts for this magnificent pachyderm. It can be expected that rhinos' translocation program at MNP will also contribute to the mixing of genes from individuals from PWS and KNP populations. This study's findings may be helpful in other countries where there are plans to establish new populations of GoH in the near future.
- A population viability analysis by IUCN Conservation Breeding Specialist Groups carried out in 2015 indicated that unless poaching is eradicated, the continued reintroduction of rhinos is unlikely to result in a viable population in MNP and the rhino population faces the threat of extinction in the next two to three decades. So improved protection, proper scientific management of habitat, regular awareness in the fringe villages instilling a pride of rhino conservation in MNP will be helpful to maintain a future viable rhino population.

From the study of the different aspects of the behaviour and habitat preferences of the translocated rhinoceros, it was observed that after the translocation from their earlier

natural habitats (PWS and KNP) the rhinos in the MNP has exhibited maximum tendency to adapt in the new environment retaining some behaviour characteristics as it was. Though some amount of habitat and food plants differences were observed in the MNP from the PWS and KNP, the translocated rhinoceros became habituated with the new environment within a year. The behavioural changes for adaptation is one of the noticeable finding in the present investigations. Translocated rhinoceros have adapted well and started breeding in Manas. During 2011-2015, 14 calves were born which clearly indicated reintroduced rhinos' adaptation in the new environment. But to establish behavioural changes of the translocated rhinos and their habitat preferences for adaptation in the new habitat, further monitoring and research is needed.

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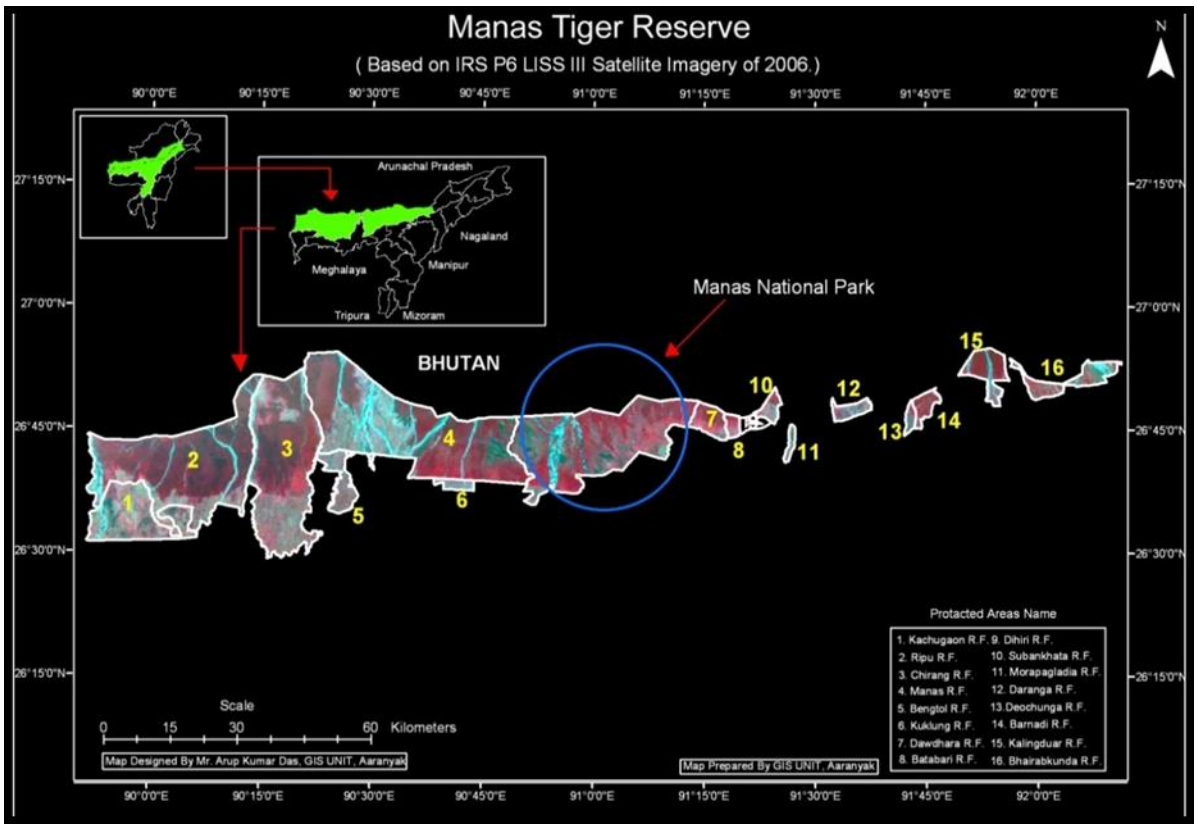
Appendix-I

Details of Rehabilitated Rhino at Manas NP

Year	No. of Rhinos	Name of Rhino	Gender
2006	1	Mainao	Female
2007	2	Ganga & Jamuma	Female
2008	1	No Name	Female
2012	2	Raja Ramu	Male
2013	1	Purabi	Female
2014	3	Hari,Jadu and Gopal	Male

Appendix-II

Manas Tiger Reserve with Core and Buffer areas



(Source Aaranyak)

Appendix-III

River Channels/Nalluh Used by Rhino at Bansbari Range

Sl. No	Name of the River Channels/ Nalluh	Nearest camp	Approximate Breadth (m)	Water availability (months)
1	Chorpuli Camp S/W nala	Chorfuli camp	12	7
2	Buraburijahar nala	Buraburijhar camp	12	12
3	Buraburijahar Mora nala	Buraburijhar camp	15	12
4	Buraburijahar River	Buraburijhar camp	18	12
5	Madrijhora nala	Pulsiguri camp	20	12
6	Gwathaibari nala	Pulsiguri camp	8	12
7	Gwathaibari 2 No. nala	Pulsiguri camp	6	12
8	Kasimdoha	Pulsiguri camp	30	8
9	Burimora nala	Buraburijhar camp	10	12
10	Kuribeel 1 no nala	Kuribeel camp	20	12
11	Kuribeel 2 no nala	Kuribeel camp	30	12
12	Kokilabari nala	Kuribeel camp	20	12
13	Pohumara nala 1	Forte camp	8	12
14	Pohumara nala 2	Forte camp	7	12
15	Alengayan nala	Rhino Camp	9	5
16	Sidhajhar nala	Rhino Camp	40	10

Appendix-IV

Waterholes Used by Rhinos at Bansbari Range

Serial No	Name of the Waterhole/ Leti	Nearest camp	Approximate size(m^2)	Water availability (month)
1	Delivery leti	Buraburijhar camp	50	12
2	Pulsiguri leti	Pulsiguri camp	40	8
3	1 No. elephant Camp N- leti	Rhino Camp	10	8
4	Tinmile leti	Tinmile Camp	10	12
5	Kuribeel camp Near	Kuribeel camp	10	8
6	Chorfuli pukhuri	Chorfuli camp	100	12
8	Ruisingla pukhuri	Uchila camp	100	12
9	Narayanguri leti	Narayanguri camp	30	8
10	Chorfuli pukhuri	Chorfuli camp	100	12
16	Kodom pukhuri	Pulsiguri camp	100	12
17	Bispani camp N/E leti	Tinmile camp	20	12
18	Kuchiabeel leti	Katajhar camp	100	6
19	Kuchiabeel big leti	Katajhar camp	200	12
20	Kuchiabeel leti	Katajhar camp	50	12
21	Kuchiabeel leti up	Katajhar camp	30	8
22	Kasimdoha leti	Pulsiguri camp	50	8
25	Lohit pukhuri	Second gate camp	10	8
26	Heliped E Side leti	Second gate camp	5	9
27	Kuribeel camp near leti 1	Kuribeel camp	4	6
28	Kuribeel camp near leti 2	Kuribeel camp	4	6
29	Kuribeel camp n/e Side Leti	Kuribeel camp	5	12
36	Forte camp leti	Forte camp	8	12
37	Bhumuk nala	Kuribeel	60	12

		camp		
38	Kuribeel big leti	Kuribeel camp	100	12
39	Gormora 1No leti	Tinmile camp	50	12
40	Gormora 2 No leti	Tinmile camp	80	12
41	Langpati leti	Tinmile camp	100	10
42	Fotika leti	Kahibari camp	100	10
43	P.G. Bathan leti	Pulsiguri camp	100	8
44	Kasimdoha leti	Pulsiguri camp	10	8
45	Nikhildoha leti1	Second gate camp	5	8
46	Dhodongbaha leti	Buraburijhar camp	10	8
47	Rhino camp west Side leti	Rhino Camp	20	5
48	Goroi mari beel	Rhino Camp	100	5
51	Magurjani beel	Narayanguri camp	100	10
52	Gundhari beel	Sidhajhar camp	500	12
53	Balajan beel	Sidhajhar camp	200	10
54	Palsiguri camp North side leti	Pulsiguri camp	200	8
55	Bhatghali doha	Bhatghali	100	10

Appendix-V

River Channels/ Nalluh Used by Rhinos at Bhuyanpara Range

Sl No	Name of the River Channel/ Nalluh	Nearest camp	Approximate Breadth (m)	Water availability (month)
1	Abaidara river	Khanchanbari Camp	20	12
2	Sengmari nala	Betbari Camp	10	12
3	Kuwangdara nala	Khanchanbari Camp	15	8
4	Chikaganda River	Rupahi Camp	20	12
5	Chikaganda nala	Rupahi Camp	12	12
6	Digaljar nala	Rupahi Camp	30	6
7	Chikaganda Daimukh	Rupahi Camp	20	12
8	Kakaidong River	Khanchanbari Camp	20	12
9	Huken daisa	Panda Camp	25	12
10	Kalapani	Segun Camp	30	12
11	Teklai	Segun Camp	30	12
12	Kaljhar	Kaljar Camp	40	12
13	Dhonbeel	Dhonbeel Camp	10	8
14	Digjhari	Digjiri Camp	20	12

Appendix-VI

Waterholes Used by Rhinos at Bhuyanpara range

Serial No	Name of the Waterhole/ Leti	Nearest camp	Approximate size (m^2)	Water availability (month)
1	Ganda beel	Bhuyanpara Range HQ	100	11
2	Bhakruduar leti	Digjiri Camp	200	6
3	Makhibaha Pukhuri	Makhibaha Camp	300	12
4	Narenguri jhar leti	Dhonbeel Camp	100	7
5	Nepal pukhuri	Maoji Camp	200	6
6	Kakoidonga beel	Digjiri Camp	100	6
7	Pudum pukhuri	Digjhari Camp	100	8
8	Kesai pukhuri	Daimari Camp	200	7
9	Modon Bundh	Dhonbeel Camp	300	10
10	Narenguri Bundh	Dhonbeel Camp	200	12
11	Bamunkhal Bundh	Dhonbeel Camp	200	12