SOME STUDIES ON THE BEHAVIOUR OF THE INDIAN ONE-HORNED RHINOCEROS (*Rhinoceros unicornis*) IN THE DUDHWA NATIONAL PARK (U. P.)

DISSERTATION

SUBMITTED IN PARTIAL FULFILMENT FOR THE DEGREE OF

Master of Philosophy

IN

Wildlife Science

BY

TARIQ AZIZ

CENTRE OF WILDLIFE & ORNITHOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)

1990

CENTRE OF WILDLIFE & ORNITHOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH- 202001

Tel: Office: 3942
Res : 4359

Dr. A.H. Musavi
Chairman

CERTIFICATE

This is to certify that the dissertation **"Some Studies on the behaviour of the Indian one-horned Rhinoceros (Rhinoceros unicornis) in the Dudhwa National Park, (U.P.)"** submitted for the award of M.Phil. degree in Wildlife Science of the Aligarh Muslim University, Aligarh, is the original work of Mr. Tariq Aziz. This work has been done by the candidate under my supervision.

January 13, 1990

(A.H. MUSAVI)
Centre of Wildlife & Ornithology
Aligarh Muslim University
ALIGARH.

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ACKNOWLEDGEMENTS

This dissertation is a part of a major research project of the Wild Life Institute of India in Dudhwa National Park. I am highly indebted to Mr. H.S. Panwar, Director, WII, for providing me an opportunity to work on the Reintroduced Rhinos of Dudhwa National Park.

I thank Dr. A.H. Musavi, Chairman, CWLO, AMU, whose supervision throughout the preparation of this dissertation was a constant source of inspiration. I thank my project supervisors Dr. John B. Sale, CTA, FAO, WII, and Mr. V.B. Sawarkar, Joint Director, WII, who introduced me to the science of studying animals. I also thank Dr. Ajit Kumar, WII, whose discussions gave a direction to me for interpretation of statistical information.

I take this opportunity to thank my colleagues Jamal A. Khan, Afifullah Khan and Miss. Nita V. Shah

for their suggestions and timely help. I thank a special friend for all the inspiring letters that enriched my lonely life in the forests.

I thank the domestic elephants and the Mahauts, whose unconditional cooperation made this work possible.

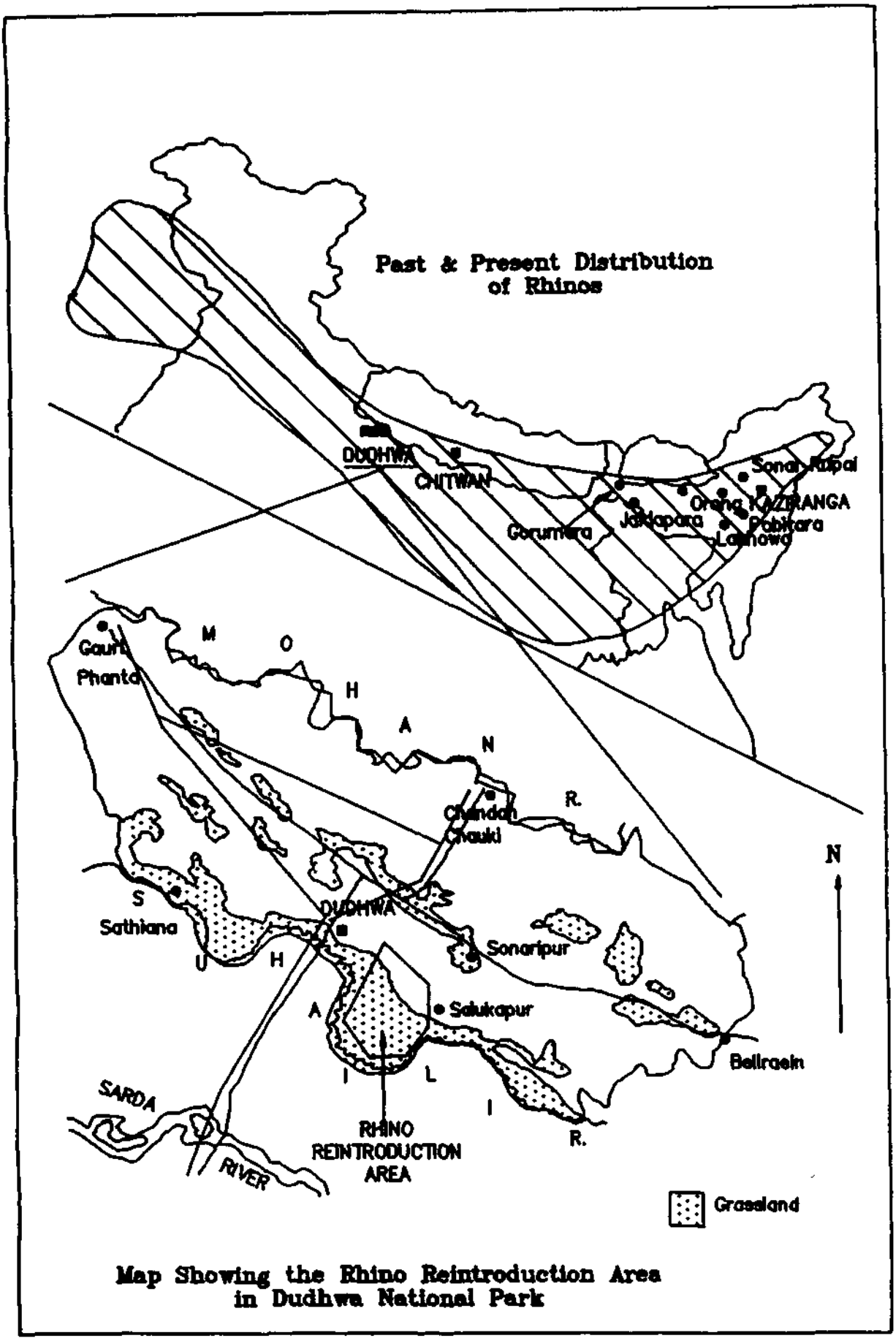
We salute Mr. S.D. Singh, Forest Range Officer, Rhino Unit, who was killed by a tiger while on duty in the Rhino Reintroduction Area of Dudhwa National Park.

T. A.

INTRODUCTION

Rhinoceros is presently found only in Africa and Asia. Africa has two species of rhinos, the Black Rhino (Diceros bicornis) and Square-lipped Rhino (Ceratotherium simum). Three species of rhinos are found in Asia, the Great Indian Rhino (Rhinoceros unicornis), the Javan Rhino (Rhinoceros sondaicus) and the Sumatran Rhino (Dicerorhinus sumatrensis). The only species of rhinoceros found in India is R. unicornis. Its range of distribution once extended over the flood plains of the Ganges and the Brhamputra from the Hindukush Mountain Ranges in the west to the present Indo Burmese border in the east. Mainly as a result of habital loss and poaching, only a few small to medium sized populations of this species have survived in North-east India and Nepal. (Fig. 1).

Rhinoceros unicornis is on the endangered list of the IUCN. The Survival Service Commission, Asian Rhino



Map Showing the Rhino Reintroduction Area in Dudhwa National Park

Fig. 1 : Past and present distribution of Rhinos in India and the map of Dudhwa National Park.

Specialist Group of IUCN emphasized the need for continuous efforts for protection and monitoring of the species. It also recommended that "steps must be envisaged to establish additional viable population units in suitable areas, preferably in the rhinos' former range " (Schenkel and Schenkel, 1979).

The present population of the species R. unicornis is estimated to be around seventeen hundred out of which about one thousand and eighty rhinos are in Kaziranga National Park and three hundred and fifty in Chitwan National Park. The rest are scattered as small populations in North eastern India (Sale & Singh, 1987). The population of rhinoceros has been slowly increasing since the turn of the present century and it can be surmised that it will proliferate faster if poaching is stopped. Other causes of population decline are large scale habitat losses due to recurrent flooding; and disturbances; epidemic diseases, the likelyhood of which is increased by contact with domestic live stock, and high rhino population densities in some habitats (Laurie, 1978).

The Indian Board for Wildlife set up a sub-committee in 1979 which recommended reintroduction of rhino in Dudhwa

National Park located in the terai region of Uttar Pradesh. This National Park has been found to have the essential habitat requirements of the species and is believed to be hospitable since rhinos had lived there till the beginning of the present century (Sale et al., 1981). In order to further ascertain if the Park could provide adequate food for the rhinos, a vegetation survey was undertaken by the sub-committee. It was carried out through the Botanical Survey of India (Hajra & Shukla, 1982). The survey indicated adequate quantity and quality of food for a small population of rhinos. Major food plants necessary for the rhinos are found in Dudhwa National Park.

Immobilization of rhinos for capture and translocation being the safest alternative, proper drug dosage for immobilization was determined by experimental capture of five rhinos in Assam. Et-orphine (0.0025 mg/kg) was used as an immobilizing drug while Diprenorphine was used as a suitable antedote for rapid and complete recovery (Sale & Woodford, 1981). Necessary experience and technical preparedness for chemical capture and transport of rhinos for the proposed translocations were acquired during the experimental capture of rhinos in Assam (Sale & Woodford, 1981).

Prior to the release of rhinos in Dudhwa National Park an area of about 19.76 sq.km. was enclosed by a 'power fence' to keep the rhinos confined to one area for better management.

The first ever translocation of the Great Indian Rhinoceros was undertaken in March, 1984. Five rhinos (2 Bulls & 3 Cows were immobilized and captured in Pobitara Sanctuary of Assam. They were airlifted from Guwhati (Assam) to New Delhi, in wooden crates specially designed for the purpose. The crated rhinos were driven from New Delhi to Dudhwa National Park in trucks, where they were released into individual stockades made and kept ready in advance. Subsequently, after a time lapse, allowing the animals to recover from capture and translocation stress, they were released one after the other into the Rhino Reintroduction Area (RRA) of Dudhwa National Park between April and May of 1984. Two adult females, however, died presumably due to translocation stresses of the two that died one female rhino aborted the foetus she was carrying and died due to Toxaemia (Gairola, 1987). The other female rhino that died had received some injuries during transit from Assam. She was immobilized for treatment which resulted in the paralysis of the right fore-limb, apparently due to nerve damage during

recumbency. Thus only two males and one female were left in Dudhwa National Park.

The second translocation was done in March, 1985. Four cow rhinos captured in Sauraha, north of Chitwan National Park (Nepal), were crated and driven to Dudhwa National Park and after a day's stockading, were released into the Rhino Reintroduction Area.

Thus a small population of seven rhinos (two bulls & five cows) made up of the two different genetic stocks, viz. Chitwan & Pobitara populations, was introduced in Dudhwa National Park.

Reintroduction of animals from secure stock elsewhere offers the prospect of scientific management avoiding part errors and trying again to support them as permanent elements of Fauna (Morris, 1986). In the case of Rhinoceros unicornis, establishment of another viable population has been necessary to ensure the survival of the species in the event of some mishap leading to the extinction of the only population. The reintroduction of this species in Dudhwa National Park should, therefore be regarded as a wise step for the conservation of Indian rhinoceros.

Several wildlife species had been reintroduced in different

parts of the world, viz. The Black Rhinoceros (Diceros bicornis) in Nairobi National Park in Kenya (Hamilton & King, 1969) and in Addo Elephant National Park in South Africa (Hall Martin and Penzhorn, 1971); The White Rhinoceros (Ceratotherium simum) in Krugor National Park (Piennar, 1970); Piere David's Deer (Elaphurus davidianus) in China and Scimitar Horned Oryx (Oryx dammah) in Tunisia, (Morris, 1986). Arabian Oryx (Oryx leucoryx) in Middle Eastern Countries (Filter and Scott, 1978); Roe Deer (Cervus capreolus) in South England (Corbet and Southern, 1977); Red Squirrels (Sciurns vulgaris) in Regents Park, U.K. (Bertram & Moltu, 1986) and in Scotland (Ritchie, 1920); Nene (Nranta sandavicensis) in Hawii (Dear & Berger, 1990); and the Eurasian Otter (Lutra lutra) in East Anglia (Jefferies et al., 1986 and Jefferies & Wayre, 1984).

The main objective of these translocations was to enhance the conservation status of the concerned species. After from a few of the above reintroductions follow up work was carried out till the population of the reintroduce animals settled down. However, little seems to appear in literature about the processes and problems of the reintroduced animals and the ecology of the reintroduction areas. India had sad experience in the reintroduction

programme of the Asiatic Lion (Panthera leo persica) in Chandraprabha Sanctuary. The reintroduced lions are believed to have died due to lack of adequate studies on the suitability of habitat prior to reintroduction and also because no active followup programme was undertaken.

On the experience of earlier reintroductions it had been realized that meticulous planning and followup work is essential for the success of any reintroduction programme. Considering these facts the Wildlife Institute of India took up monitoring of the reintroduced rhinos in Dudhwa National Park and a research project was launched in 1986.

As per the recommendations of the Asian Rhino Specialist Group of the IUCN, monitoring of the reintroduced rhinos for all purposes should continue until a self sustainable population of rhinos is formed in Dudhwa National Park. Moreover, it is believed that any reintroduction particularly of large mammalian species is sure to start a chain of ecological consequences in the very sensitive, apparently stable but fragile ecosystem of a National Park with several endangered species, and can turn more hazardous than beneficial. Thus, reintroduction of rhino in Dudhwa National Park required meticulous planning,

careful execution and intensive followup/monitoring both in the interest of the reintroduced species as well as of the resident species.

The main part of this project was the study of utilization distribution areas of rhinos vis-a-vis the whole population of rhinos; individual rhinos and seasonal variations therein. The comparison of these results with other studies on rhino populations provides an insight into the habitat utilization patterns of the reintroduced rhinos.

The main objectives of the study are as follows:

1. To ascertain if the Rhino Reintroduction Area of Dudhwa National Park is qualitatively suitable for the reintroduced species.
2. To study the patterns of habitat utilization by rhinos in Rhino Reintroduction Area.
3. To estimate the maximum size of rhino population which can be sustained by the RRA.
4. To study the seasonal variations in utilization distribution of the species.

Dudhwa National Park

Dudhwa National Park is situated on Indo-Nepal border in Nighasan Tehsil of Lakhimpur-Kheri district. It lies between 28°18' and 28°42' north latitude and 80°28' and 80°27' east longitude. The Himalayan foot hills are about 30 kms to the north of the Park. The Rivers Suhaili in the south and Mohana in the north run along the boundaries of the park.

This forested area was taken over by the State Government from Khairigarh Pargana in 1861 and preserved as Forest Land. All forests of this Park were declared as Reserved Forests in 1937. Considering the value of Wildlife in this area, specially the Swamp Deer (Cervus duvauceli duvauceli), an area of 212 sq. km was declared as Sanctuary and named as Dudhwa Sanctuary. Ultimately, in 1977, this area was declared a National

TABLE - 1

CORE ZONE & BUFFER ZONE AREAS OF THE RANGES OF DNP

RANGE	CORE ZONE AREA (ha)	BUFFER ZONE AREA (ha)
Bankati	9665.79	2995.05
Dudhwa	13959.08	3717.00
N. Sonaripur	3298.58	5690.40
S. Sonaripur	8608.94	-
N. Bellarein **	7942.72	-
S. Bellarein**	5554.25	-
Total Area of DNP	49029.36	12402.45

* Range within which RRA is located.

** These two ranges have been merged into one.

Park with a 490 sq. km. core zone and a 124 sq. km. buffer zone and was put under the Park administration.

In the present set up, the buffer zone is located to the north of the core zone and still includes tribal 'Tharu' villages. Several uch villages have been shifted out from the core zone into the buffer zone. Most requirements of the Tharus are met by this buffer which has been developed and is being managed for the same. An area in and around the Park, approximately 5 kms wide, is inhabited by a human population of upto 30,000 inclusive of the Tharus. This population is partly dependant on the forest resources of the Park and needs to be managed (Singh, 1982).

The Park is a vast alluvial plain showing a succession of beds of sand & loam. The surface soil is sandy in the more elevated portions, loam in the level upland, and clay in depressions. The low lying grasslands get inundated in the monsoon and become very dry in summers. Some areas, however, remain marshy the year round. The mean elevation above sea level ranges from 182 m. in extreme north to 150m. in the south-east. The maximum and minimum temperatures in January are 22.2° and 9.1°C respectively and during this period, frost

TABLE - 2

COMPARATIVE STATEMENT : AREAS OF DIFFERENT FOREST CATEGORIES COMPUTED THROUGH SATELLITE DATA

FOREST CATEGORY	AREA (sq. km.)
Dense Sal Dominated Forest	387.54
Plantations	65.28
Grasslands	85.71
Open Forests with Grasses	33.89
Water Bodies & Wetlands	18.33
Cultivated Land	-

normally occurs in grasslands and is often severe. In May & June the temeperature fluctuates between 40°C & 45°C. Average annual rainfall is 1500 mm, most of which (about 80%) falls between June and September.

Apart from the two rivers, Suhaili and Mohana, the Park has several large and small lakes and swamps. The rivers get flooded in monsoon and inundate large areas of grasslands. The flood water characteristically carries large amounts of silt.

Forests of Dudhwa National Park were in the past, under intensive management for maximum timber exploitation on a sustained basis, as a result of which, selected, commercially valuable timber species were favoured while naturally occurring species of no or little commerical value were weeded out. The management, however, prescribed retention of fruit bearing trees. Plantation of Semal (Bombax malabaricum), Shesham (Dalbergia sisso) and Mulberry (Morus alba) having high food value for many wild animals promoted wildlife interests even before the creation of the National Park. The forest, on the basis of soil and altitude, can be classified into two: (i) the higher alluvial table land mainly dense woodland with Sal (Shorea robusta) as dominant tree species and (ii) Low lying terai grassland interspersed by woody species mainly Kath (Accacia catechu) and lakes & swamps. Apart from the grasslands, dense sal forests

species mainly Kath (Accacia catechu) and lakes & swamps. Apart from the grasslands, dense sal forests also have grasses only where contiguity is broken. Vegetation shows significant change around lakes and nullahs.

The following forest types based on the Management plan of Dudhwa National Park are recognized:

1. North Tropical Semi Evergreen Forest

This type of forest is found more or less on permanently wet soils consisting of fine clay rich in humus. Major tree species are :

Jamun (Syzygium cuminii), Gulnar (Ficus racemosa) Sehora (Streblus asper), Neora (Barringtonia actangula), Patju (Putranjiva roxburghii) and some ferns.

2. North Indian Moist Deciduous Forest Also Damar Sal Forest

It is mostly found on rich sandy loamy soil of good quality. Predominant tree species is Sal (Shorea robusta), while the following associated tree species are also found.

Asna (Terminalia alata), Bahera (Terminalia bellerica), Asidh (Lagerstroemia parviflora), Kusum (Schleichera oleosa), Maldu (Adina cordifolia). Underwood is mainly Rohini (Mallotus phillipensis), Sandhan (Ougeinia dalbergiodes), Jamun (Syzygium cuminii), Dudhi (Holarrhena antidysentrica). Undergrowth mainly consists of Bhant (Chlorodendron viscosum), Kasrant (Flemengia chappar), Uaya (Colebrookia oppositifolia), Ban nimbu (Glycosmics pentaphylla). Common climbers are Rangoi (Tiliacora acuminata), Maljhan (Bauhinia vahlii), Gang (Milletia auriculata). Rangoi sometimes forms a dense carpet on the ground.

3. Alluvial Plain Sal Forest

These forests are found where the ground tends to be low lying in comparison to the surrounding high level alluvium. It mostly consists of Sal (Shorea robusta) and Asna (Terminalia tomentosa). Other overwood species are Maldu (Adina cordifolia), Pula (Kydia calcyna), Pada (Stereospermum suaveolens), Kusum (Schleichera oleosa), and Ficus spps. Underwood mostly consists of Asidh (Lagerstroemia parviflora), Jamun (Cassia fistula), Bhilawa (Semi-carpus anacardium), Phalsa (Grewia subineoculis), Amlosa (Piliostigma malabarcicum), Sandan

(Ougeinia dalbergiodes) and Rohini (Mallotus phillipensis). Undergrowth generally consists of Gandhela (Murraya koenigii), Bhant (Chlorodendron viscosum), Kasraut (Flamengia chappar), Marorphal (Helictris isora), Bhakmal (Ardisia solanacea), Common climbers are Rongoi (Tiliacora acuminata) and Gauj (Milletia auriculata).

4. Western Light Alluvial Sal Forest

This type of forest is generally found along the banks of nullahs. A few Sal (Shorea robusta), and Asna (Terminalia tomentosa), stand over a middle story of Rohini, (Mallotus phillipensis) Jamun (Syzygium cuminii) and a dense grass Ulla (Themada arundinacea) are also found. Common climbers are Maljhan (Bauhinia vahlii), Gauj (Milletia auriculata), Rangoi (Tiliacora acuminata) and Aila (Acacia pennata).

5. Moist Sal Savannah Forest

These grasslands are locally known as 'Phantas' and extend over large areas. Most of the 'Phantas' are low lying lands elongated in the direction of the slopes suggesting presence of wetland and/or rivers in the past.

The grasslands of DNP are of two distinct types, viz.

(i) Narenga Swvannah (Upland phantas), and

(ii) Wet Savannah (Lowlying phantas).

The major portion of the grasslands of Dudhwa National Park comes under the first category. These grasslands are not generally stocked with tall Savannah grasses as a result of the annual controlled burning. Under such conditions the ground dries up leading to the development of a less markedly moist habitat with a tendency to water-log in the rains. As a result of this the tall Savannah retrogresses to a more xerophytic form with Kans (Saccharum spontaneum) and Seenk (Vetivaria zizanoides) association occupying a dominant position. The other grass species occurring in these phantas are Nunj (Saccharum munja), Retwa (Sclerostachya fusca), Charni (Imperata cylindrica), Ulla (Themada arundinaceae), Sindhoor (Bothriochloa intermedia), Dhav (Demostachya bipinnata), Jarakus (Cymbopogon martinii), Harang (Narenga porphyrocoma) and Doob (Cynodon dactylon).

It is in these types of grasslands that invasion of woods species like Kath - (Accacia catechu) and Semal (Bombax ceiba) is taking place at a fast rate particularly in the Rhino Reintroduction Area. The other tree species in these grasslands are Plaman (Syzygium cerasoides), Pinasar (Randia ulizi), Shesham (Dalbergia sisso) and

Haldu (Adina cordifolia).

In case of the lowlying wet Savannah type grasslands the soil condition corresponds to the typical marsh, permanently wet and saturated, badly aerated soil with some standing water in the depression in all months of the year except the driest. These depressions are colonized exclusively by Narkul (Phragmites Karka) and Nari (Arundo donax). Hydrophytes like Hydrilla verticillata, Nymphoides ciratata, Ottalia alismoides, etc. are commonly seen.

6. Alluvial Savannah Wood Land

Areas of low alluvial plateau are sporadically distributed in grasslands specially along nullahs. The main tree species in such woody patches are Semal (Bombax ceiba), Asidh (Lagerstroemia parviflora), Gutel (Trewia nudiflora), Aonla (Emblica officinalis), Jamun (Syzygium cuminii), Haldu (Adina cordiflora), Rohini (Mallotus phillipensis), Phalsa (Grewia grandis), Kakar (Garuga pinnata), Dhak (Butea monosperma), Maholi Chila (Casearia tomentosa), Amaltas (Cassia fistula) Chamror (Eheritia laeves), Sterculia villosa, Pula (Kydia calcyna) and Toon (Cedrela toona). In drier conditions in such areas Ber

(Zizzyphus) ssp. Katia (Flacourtia indica), Marorphal (Helictres isora) are common.

7. Tropical Seasonal Swamp Forest

These forests occupy areas around tals and nullahs. The principal tree species are Jamun (Syzygium cuminii), Gular (Ficus racemosa) Sehor (Streblus asper), Neora (Barringtonia acutangula), and Patju (Putranjiva roxburghii). Shrubs of Bhakund and Bhat (chlorodendron viscosum) are also present. Cane (Calamus teruis) and its forms are also found.

8. Plantations

Various exotic species have been introduced at different stages in this forest tract. Notable among them are Teak (Tectona grandis), Mulberry (Morus alba), Shesham (Dalbergia sisso), Semal (Bombax ceiba) and ssps. (Eucalyptus).

The Rhino Reintroduction Area

The Rhino Reintroduction Area (RRA), where the intensive study of the reintroduced rhinos was done, is located in the South Sonaripur range of the DNP. An area of about 19.76 sq. km. of the range is enclosed by a 'Power Fence'. It comprises of all of the Kakraha block and a part of

It comprises of all of the Kakraha block and a part of the Chotapalia block of the range.

The Rhino Reintroduction Area has, within the power fence as many as nine permanent large and small lakes (Fig. 2). The chain of these lakes lies along the Damar Sal Forest and Grassland ecotone. The chain of lakes and the two nullahs, Andhra & Chabakwa, are old courses of the river Suhaili. During monsoon a major part of the RRA gets flooded with water carrying large amounts of silt. Running water can be observed along the two nullahs and the chain of lakes while other areas have upto four feet deep standing water.

The power fence, which encloses the RRA was erected prior to the reintroduction with the objective of containing the rhinos in a manageable area for their monitoring, management and protection. It is a simple two-strand fence erected with the support of wooden poles ten meters apart. It was erected in consultation with FAO specialists of WII Dehradoon (Schutz, 1988). The fence is effective only for the rhinos. All other animals were seen crossing the fence by crawling under or jumping over it. Small mammals even managed to pass through two strands. Migratory elephants, however, managed to uproot the fence. Mckillop (1988) reported

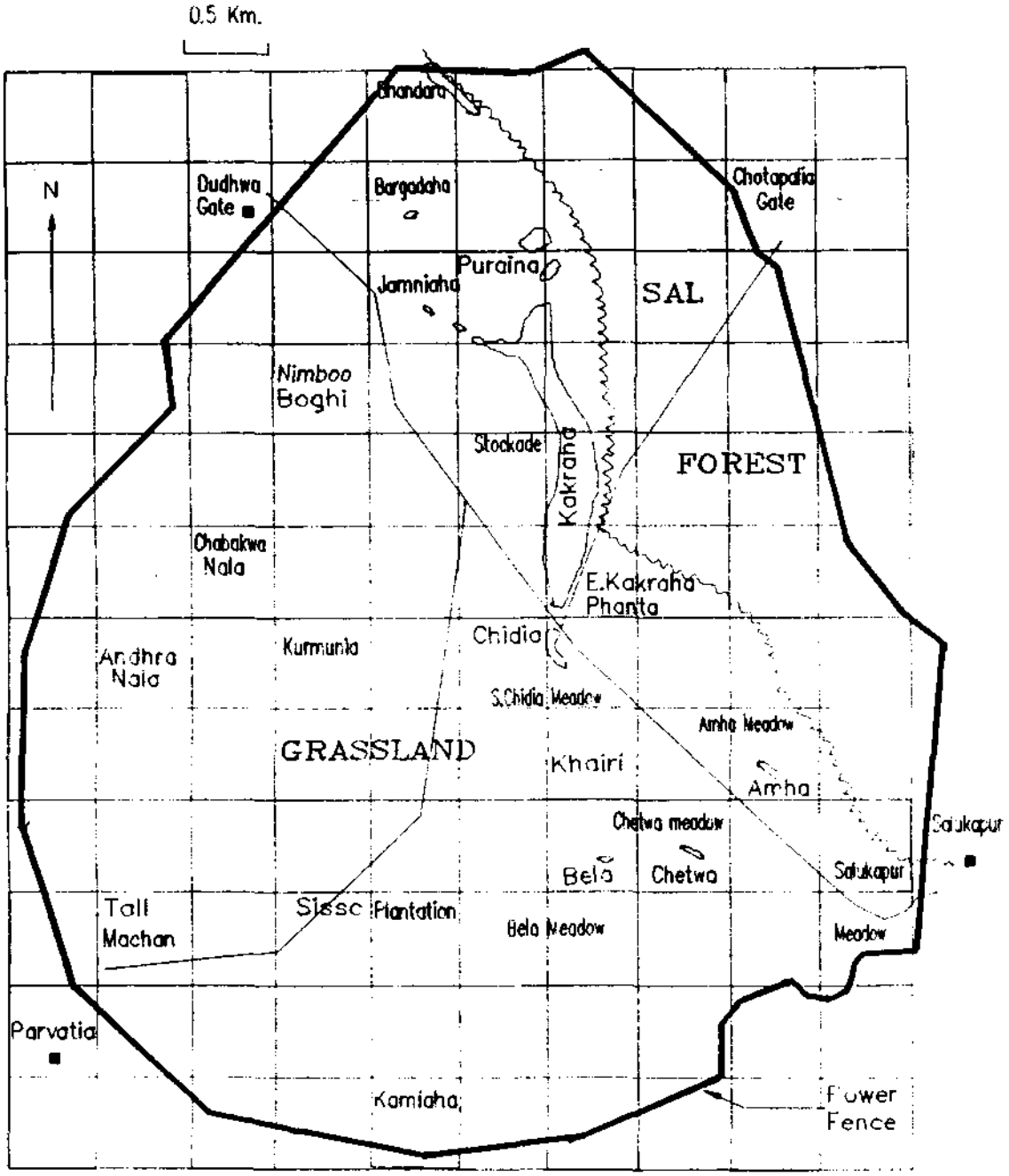


Fig. 2 : Map of Rhino Reintroduction Area.

that animals either after receiving shock on contact with the wires or sometimes even seeing others getting a shock, quickly learn to avoid coming in contact with electric fence. Once animals learn by experience, they do not try to cross the power fence during power failures and this proves the efficacy of this device in management. Keeping this in view the rhinos were kept in a smaller fenced area and forced to experience shocks from the fence prior to release in the RRA. Animals other than the rhinos, over a period of time learned to cross the fence. without coming in contact with it. But occasionally some animals while trying to cross the 'Power fence' meet with accidents causing the fence to break. Usually such mishaps occur with large ungulates. The fence was monitored for maintenance on a daily basis.

The RRA encloses some Damar Sal Forest (described earlier) of the Chottapalia block. The remaining part of RRA is all grassland (80% of RRA) interspersed with lakes, marshes and clusters of trees. The major vegetation types of the RRA, most of which have been described earlier, are listed below :

1. The North Indian Moist Deciduous Sal Forest

2. Western Light Alluvial Sal Forest

3. Alluvial Savannah Woodland

4. Moist Sal Savannah Forest

5. Tropical Seasonal Swamp Forest

6. Plantations

The Moist Sal Savannah Forest or the grasslands have been described earlier. Chaturvedi et al. (1985) also described the grasses of the DNP. Five major grass communities within the RRA were identified during the study. They are :

1. Narenga Savannah community

It is found on uplands of the phantas and is characterised by extremes of wet and dry conditions. Major grass associates having tendency to predominate are Saccharum, Schlerostachya and Imperata. Other associates are Desmostachya, Cymbopogon, Bothriochloa, Themada and Vetiveria.

2. Bothriochloa Grass Community

It occurs in similar conditions as above and has 60% dominance over associate species such as Naranga, Apluda, Echinochloa, Digitaria, Arthraxon and Cyperus.

3. Themada-aroundinacea Community

This occurs in plain grounds with about 80% of Themada dominance. Other associates are Digitaria, Dichanthium, and Cyperus.

4. Arundo donax Community

This occurs in marshy habitat and grows upto fifteen feet in height. The tallest culm of Arundo donax found during the study, measured seventeen and a half feet. A major associate is the Phragmities karka. Other associates are Typha and Hydroryza.

5. Demostachya bippinnata Community

This occurs in coarse alluvial soil. Major associates having tnedencies to predominate are Saccharum and Imperata. Other associates are Heteropogon and Dichanthium.

The grasslands of the RRA, like other grasslands of DNP, are burnt annually. This practice of controlled grass burning in the forests of this region is a very old one and its objective is to acvoid accidental fires in dry seasons leading to loss of timber.

This objective, however, has changed to that of arresting the grasslands in their existing successional stage. Nevertheless, the methodology of carrying out such operations remains the same - burning all grasses in early dry season by igniting them at various places and letting the wind do the rest. This approach, however, needs to be reviewed on scientific lines.

METHODOLOGY

Systematic tracking of rhinos was carried out and observations were either made from elephant back or while sitting on the machans. Studies on rhino's behaviour as well as interspecific and intraspecific interactions were made. Major events at the RRA and the changes they casued were also noted. All locations of the rhinos were fixed on a four inches: one mile map of the RRA. The XY coordinates of all Rhino locations on the hectare grid overlay were recorded.

Identification of the rhinos was done according to the method prescribed by Laurie (1979).

The study was conducted on a seasonal basis. The seasons being:

Winter	: Dec., Jan., Feb., March.
Summer	: April, May, June, July.
Mansoon	: Aug., Sep., Oct., Nov.

Data on rhino location was analysed for calculating Rhino utilization distribution (RUD) by the Harmonic Mean Transform of the McPaal program on an IBM Personal Computer. A brief description of the methodology is as follows :

It was observed that Rhinos did not equally utilize their entire utilization area (UA) and tended to occupy certain areas within their UA's with greater frequency, a method calculating the utilization area on the basis of intensity of use was used.

This method involves generation of "centres of activity" of the animal. The Rhino utilization distributions of rhinos in this study did have "centres of activity". Such "centre of activity" is defined as the geographical location within the home range of the point of greatest activity by Dixon & Chapman (1980). The term "centre of activity" was also used by Hayne (1949) to describe the arithemetic mean centre of the distribution of points of capture or location of an animal, even though this point may have no biological significance. Dice & Clarke (1953) referring to Hayne's "centre of activity" concept wrongly referred to it as the "geometric centre of all activity loci". Here, the geometric centre was confused with the geometric mean, which is a separate measure of areal

locations and is different from arithmetic mean centre. In later papers Harison (1958), White (1964), Tester and Siniff (1965), Sanderson (1966), Smith et al. (1973), Van Winkle et al. (1973) (1975) all refer to arithmetic mean centre as the geometric centre of activity. Only Stickel (1954) correctly called it "geographic centre of all points of location/capture".

Measure of average position of activity centre is the calculated Arithmetic Centre or Harmonic Mean Centre. Arithmetic Centre, however, has several disadvantages as a measure of animal activity centre (Dixon & Chapman, 1980). Harmonic Mean Centre is located within the area under consideration and is relatively insensitive to movements within ulilization area. Since it indicates true centre of activity of a utilization area its movements are likely to be sudden large shifts from one utilization area of high activity to another (Dixon & Chapman, 1980). This is illustrated in figures of the generated Rhino utilization distribution areas for Monsoon '87. The method for calculation of Rhino utilization distribution areas is based on an Areal Statistical Distribution of rhino locations. It utilizes Arithmetic Centre of rhino locations as described by Haynes (1949).

The Areal Statistical distribution or Areal Moments are both similar to Statistical Moments except that Areal Moments are based on 'reference grid sections' and not 'reference lines' or 'axes'.

Neft defined the formula for calculation of n^{th} Arean Moment, M'n, of the reference grid interesection j=4, as

$$1/p \int_p r^n \, dA$$

where p represents number of animal locations and 'r' is the radial distance between reference grid intersection and the element of dA (Fig. 3).

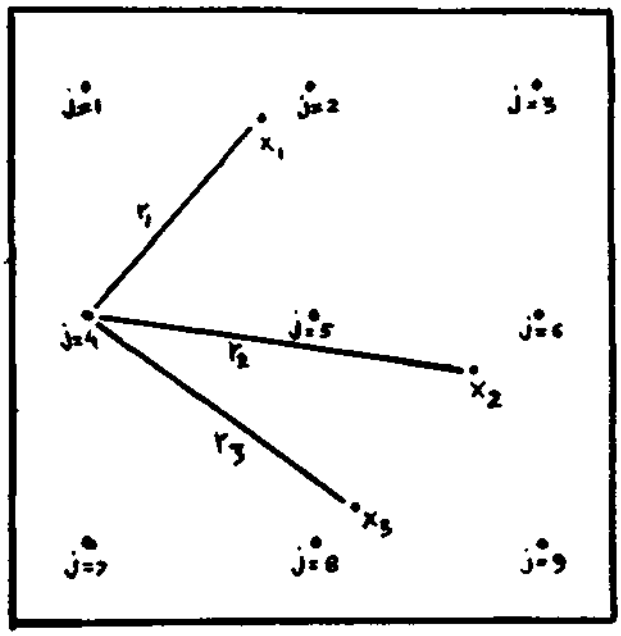


Fig. 3 : Hypothetical distribution of location x_1, x_2, x_3 on an arbitrary plotting grid with grid interections 'j'. The radial distances r_1, r_2, r_3 are shown for a single reference grid intersection j = 4

Since animal locations are discrete and finite, then n^{th} moment is,

$$M'n \quad \text{at } j4 = \frac{\sum_{x=1}^{P} r^n}{P}$$

Location of the n^{th} root of M'n ($n\sqrt{M'n}$) will represent measure of central tendency of animal locations and is called a measure of average position and dispersion.

Since $n\sqrt{M'n}$ represents minimum value of n^{th} areal moment, the minimum value of the 1st areal moment will be $1\sqrt{M'n}$ representing measure of average position and dispersion and also arithmetic mean centre.

Therefore,

$$1\sqrt{m_1'} \quad \text{at } j4 = \frac{\sum_{x=1}^{p} r^1}{P}$$

The inverse of above will become the harmonic mean centre and will be represented by,

$$-1\sqrt{M'_{-1}} \text{ at } j4 = \frac{1}{1/P \sum_{x=1}^{P} 1/r^1}$$

$-1\sqrt{M'_{-1}}$ represents the inverse of the first areal moment (IFAM) and is the measure of dispersion for animal location. The reference grid intersection at which the value of IFAM is minimum is the Harmonic mean centre of the activity area.

The calculation of Rhino utilization distribution area begins with calculation of $-1\sqrt{M_1}$ at each point of a rectangular grid super imposed over the set of Rhino location. Each quadrilateral of the grid is divided into

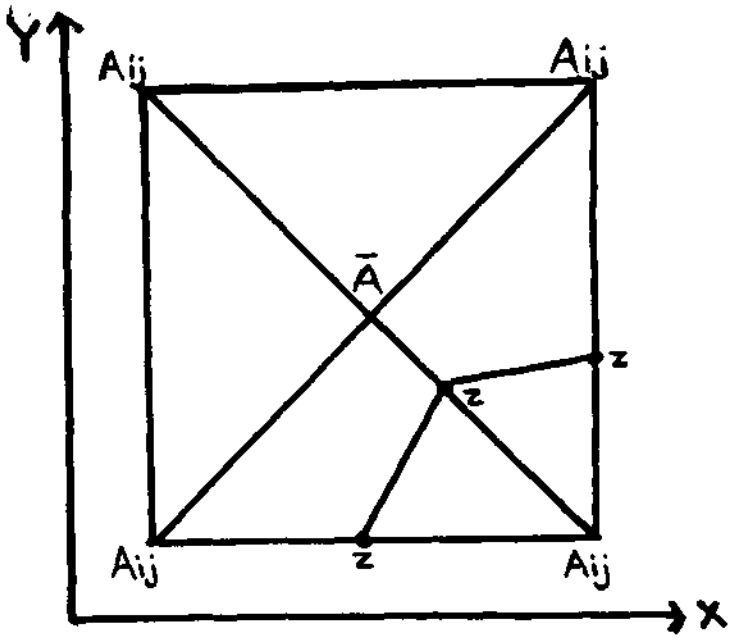


Fig: 4 : Diagram of a square from an arbitrary plotting grid. The Aij grid coordinates (equivalent tc points defined by j in Fig. 3) are shown on the corners of the square. Z represents the specific activity value.

four triangles by drawing the diagonals (Fig. 4). The value of $-1\sqrt{M_1}$ at each grid intersection, i.e. the corners of the grid in figure, is represented by Aij. The arithmetic mean of A. If it is determined that an

isopleth is, for instance Z, then its position is calculated by linear interpolation on sides of any of the four triangles. Point of equal values are connected to form an activity isopleth (Fig. 4).

Identification of Rhinos

The seven reintroduced rhinos at Dudhwa National Park were identified on the basis of method prescribed by Laurie (1978). Although, the rhinos were named by the Park authorities, their exact identification marks were not recorded. The rhinos after identification were given new names carrying information on their sex, origin, number and first alphabet of local name.

The seven reintroduced rhinos at Dudhwa National Park were identified as :

RAM 1- Raju/Assam/Male/One

BAM 1- Bankey/Assam/Male/Two

PAM 3- Pavitri/Assam/Male/Three

HNF 4- Himrani/Nepal/Female/Four

NNF 5- Naraini/Nepal/Female/Five

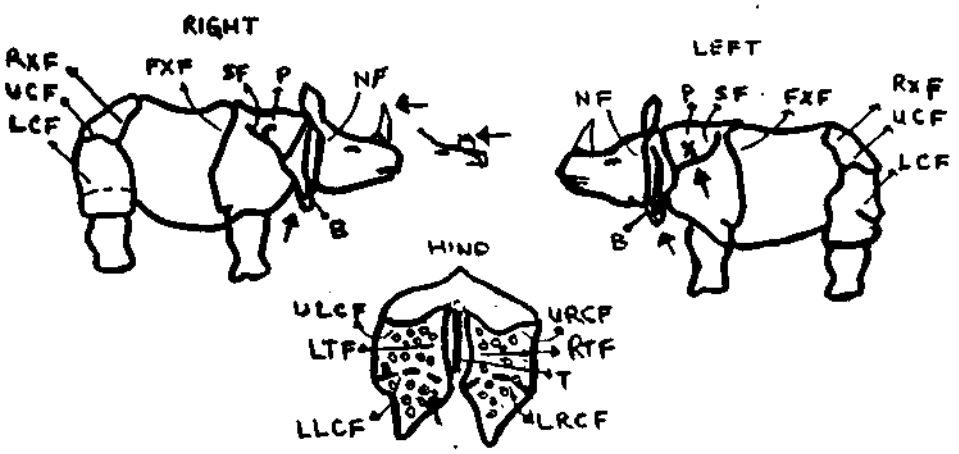
SNF 6- Swambara/Nepal/Female/Six

RNF 7- Rapti/Nepal/Female/Seven

Utilization Distribution of Rhinos

Utilization distribution of rhinos in the Rhino reintroduction Area (RRA) is based on 90% Harmonic mean measure isopleths of rhino locations in the four prefixed seasons. Such isopleths are lines enclosing areas of activity around the centre of activity of the animals. In some cases there centres of activity lie close to the electric fence which encloses the Rhino Reintroduction Area. A 100% Harmonic mean measure isopleth in such cases represents areas not within the enclosure. Such a situation does not arise in 90% Harmonic mean measure isopleths suggesting that 90% of utilized area, on the basis Harmonic mean transformes, lies within the enclosure. This also suggests that rhinos utilize areas close to the fence with low frequency. Considering the almost complete overlap in utilization distribution of all seven rhinos, isopleths for 70% & 50% HMM were generated to see if the rhinos show any degree of exclusion in activity areas. This also helped in identifying areas of higher activity for each rhino in each season; for all rhinos in each season and total utilization distribution of rhinos during the study.

RAM 1



Large Male; Large pointed horn (Approx. 11 inches) - later broke from the base leaving about 3 inches of stump; Thick cross folds; Cut on left prong; Sagging bib; Large tubercles on the hind part; Characteristic dragging of one or both feet while walking; Radiocollar fixed around the neck.

RXF/FXF = Rear/Front cross folds; P = Prong; NF = Neck fold; B = bib; UCF/LCF = upper/lower caudal folds; URCF/ULCF = upper right/left caudal fold; RTF/LTF = right/ left tail fold; LRCF/LLCF = lower right/left caudal fold; SF = Shoulder fold.

Fig. 5 : Identification card of Rhino RAM 1.

Utilization Distribution of Rhinos : Winter '87

Areas of utilization distribution of all seven rhinos fluctuate from a maximum of 9.5 sq. km. to a minimum 3.1 sq. km. The maximum area was used by RAM 1 (42.57% of RRA). Utilization distribution areas of all other rhinos lie within this large area used by RAM 1. The outermost locations of all rhinos, apart from the males lie in or around water bodies. All water points including Kurminia in the South West of the enclosure were used by the rhinos. Only Bhandara, a small pond in extreme north of the enclosure was left unused. Tall grass between Bhandara/Kurmumia and the chain of lakes was not burnt in 1986 and 1987. This made the grasses very coarse and of low nutritive value.

Utilization distribution area of all seven rhinos is 5.7 sq. km. (28.84% of RRA) this winter season. Thus ecological density of rhinos, on the basis of areas enclosed by Harmonic mean measure isopleths, in this winter was 1 rhino/0.81 sq. km. Areas used as per 70% Harmonic mean transform of all rhinos is 2.5 sq. km. This lies in the meadows around Kakaraha and Chidia Tal, suggesting that rhinos show high activity in this area (Append. I, II, III).

Density of rhino location (192 sightings on a 1/4 sq. km. grid shows wide distribution (Append. IV)

Utilization distribution of Rhinos : Summer '87

This season is characterised by shrinking and/or drying of the lakes and burning of grasslands. There is a general reduction in the area of utilization. Individual utilization distribution areas vary from a maximum of 6.4 sq. km. (RAM 1) to a minimum of 3.1 sq. km. (BAM 2). Unlike in winter, the utilization areas of the rhinos in summers lie close to the water bodies causing shrinkage of utilization areas. Use of Bargadaha, Purania, Bela, Chetwa, Jamniah and Kurmunia lakes reduce as water in these lakes dries. Rise in temperatures effect the rhinos, as a result of which they tend to spend more time in water. Utilization area of all seven rhinos reduces to 4.7 sq. km. (23.78% of RRA). Ecological density of rhinos on the basis of areas enclosed by Harmonic mean measure isopleths, in this season was 1 rhino/0.67 sq. km. Utilization area of all rhinos as per 70% Harmonic mean transformes is 2.7 sq. km. and covers Kakraha & Chidia lakes and the meadows around them (Append. I, II, III).

Density of rhino locations (Append. IV) on a 1/4 sq. km. grid shows phenomenal concentrations in and around Amha

TABLE - 3

AREA OF UTILIZATION BY INDIVIDUAL RHINOS IN DIFFERENT SEASONS; BY ALL RHINOS IN EACH SEASON; BY ALL RHINOS IN ALL SEASONS, BASED ON 90% HMM ISOPLETHS CALCULATED BY MCPAAL PROGRAMS HARMONIC MEAN TRANSFORMATION

RUD = Rhino Utilization Distribution; A = Area of Utilization (sq. km.); B = Percentage of Total Area of RRA.

	WINTER '87		SUMMER '87		MONSOON '87		WINTER '88	
RHINO	A	B	A	B	A	B	A	B
RAM 1	9.4	42.57	6.4	32.38	5.6	28.34	6.5	32.89
BAM 2	4.7	23.78	3.1	15.68	8.7	44.02	11.1	56.17
PAF 3	3.4	17.20	5.3	26.82	6.8	34.41	6.0	30.36
HNF 4	4.5	22.77	3.9	19.73	6.1	30.87	10.6	53.64
NNF 5	4.8	24.29	4.3	21.76	7.9	39.97	8.0	40.48
SNF 6	5.1	25.80	6.3	31.88	8.8	44.53	9.1	46.05
RNF 7	3.1	15.68	3.8	19.23	8.2	41.49	8.9	45.04
RUD: Total of each season	5.7	28.84	4.7	23.78	6.2	31.37	8.6	43.52

RUD of all seasons: 9.0 sq. km. (45.52% of RRA)

lake and stockade meadow & Chidia lake. A total of 66 out of 235 sightings lie in the Chidia like grid. Concentration of rhinos in and around Chidia lake is preferred over other lakes mainly due its permanent nature, a high density of aquatic flora and good shade. Nimbo boghi, North Kakraha and woodlands were mainly used as resting areas due to presence of good shade.

Utilization distribution of Rhinos : Monsoon '87

The onslaught of heavy rains in the monsoon floods the bordering Suhaili river resulting in inundation of most parts of the grasslands. Some parts of the grassland however, remain free from standing or running water. East Kakraha North Amha & North Bargadaha meadows remain only boggy. The grassland around Kurmunia lake and the Tall Cachan areas remain free from inundation during normal rains.

Drier parts of the enclosure form a major part of the utilization area in the monsoon season when other parts are inundated. Rhinos do spend time in water but feeding and resting is mostly done in areas without inundation.

The utilization distribution of individual rhino shows a

general perference for such uninundated areas. Two different activity centres, viz. at Bhandara/Puraina lakes in the North and Amha/Chetwa meadows in the South East of the RRA become prominent. A higher use of the upper table-land and of the Sal forest is also recorded. Areas of individual utilization distribution vary from 88 sq. kms. (SNF 6) to 5.6 sq. km. (RAM 1).

Utilization area of all seven rhinos goes up to 6.2 sq. km. (31.37% of RRA). Ecological density of rhinos in this season was 1 rhino/0.88 sq. km. Utilization area of all seven rhinos at 70% Harmonic mean transform is 3.9 sq. km. with extensive use of Kakraha/Chidia, Amha meadows and Bargadaha meadow. In this season Kakraha/Chidia lakes and meadows around them were areas where higher number of sightings were registered. The only deviation from previous season is the addition of Bargadaha meadow which recorded above 30% sightings (Append. I, II, III).

Distribution of rhino sightings was well spread out over northern, central and eastern parts of the enclosure. Highest number of sightings was recorded at Bargadaha tal (28) with more or less equal number of sightings at Amha grid. Intermidiate number of sightings were recorded at Kakraha/Chidia; E. Kakraha meadow; Puraina

TABLE - 4

AREA OF UTILIZATION BY INDIVIDUAL RHINOS IN DIFFERENT SEASONS; BY ALL RHINOS IN EACH SEASON; BY ALL RHINOS IN ALL SEASONS, BASED ON 50% AND 70% HHM ISOPLETHS CALCULATED BY MCPAAL PROGRAMS HARMONIC MEAN TRANSFORMATION

RUD = Rhino Utilization Distribution; A = Area of Utilization (50% HMM Isopleth); a = Percentage of RRA; B = Area of Utilization (70% HMM Isopleth); b = Percentage of RRA.

	WINTER '87				SUMMER '87				MONSOON '87				WINTER '88			
RHINO	A	a	B	b	A	a	B	b	A	a	B	b	A	a	B	b
RAM 1	2.6	13.15	3.3	16.70	0.9	4.55	2.3	11.63	1.1 1.3	5.56 6.57	3.1	15.68	1.4	7.08	2.6	13.15
BAM 2	0.9	4.55	2.1	10.62	0.6	3.03	2.0	10.12	0.8 0.3	4.04 1.51	1.9 1.8	9.61 9.10	2.2	11.30	4.3	21.76
PAF 3	0.8	4.04	1.7	8.60	1.2	6.00	3.0	15.18	0.4 1.3	2.02 6.57	0.5 1.9	2.53 9.61	2.9	14.67	3.7	18.70
HNF 4	2.0	10.12	3.1	15.68	0.6	3.03	1.6	8.09	1.4	7.08	3.9	19.73	2.8	14.17	4.7	23.78
NNF 5	1.3	6.57	1.8	9.10	1.5	7.59	3.3	16.19	0.7 0.8	3.54 4.04	3.6	18.21	0.1 2.2	0.50 11.30	3.9	19.73
SNF 6	1.3	6.57	1.9	9.61	0.9	4.55	3.3	16.70	2.9	14.67	4.2	21.25	1.6	8.09	3.9	19.73
RNF 7	1.1	5.56	1.7	8.60	1.0	5.06	1.8	9.10	2.1	10.62	6.7	33.90	1.6	8.09	2.5	12.65
RUD: Total of each season	1.3	6.57	1.9	9.61	1.4	7.08	2.7	13.66	0.9 2.1	4.55 10.62	3.9	19.73	1.5	7.59	3.3	16.70

RUD of all seasons: At 50% HMM Isopleth : 1.9 sq. km. [9.61% of RRA]
At 70% HMM Isopleth : 3.2 sq. km. [16.19% of RRA]

and Chetwa lakes. Rhinos used the Sal forest more for cover, dry grasslands for feeding and small catchments for wallowing (Append. IV).

Utilization distribution of Rhinos : Winter '88

Winter of 1988 is characterised by early burning of grasslands. Begining in early February selected patches were burnt successively, for over a period of thirty days.

Utilization area of rhinos in winter of '88 increased tremendously with a maximum of 11.1 sq. km. (BAM 2) and a minimum of 6 sq. km. (PAF 3). The utilization distribution of RAM 1 reduced to 6.5 sq. km. from 9.4 sq. km. in winter of '87. This happened due to agonistic intraspecific interaction with the other male BAM 2, who gained dominance over the senior male RAM 1 in Dec./Jan. As a result of severe agonistic interaction RAM 1 got badly injured and also lost its magnificent horn while fighting with the Junior male (BAM 3) in December, 1987.

The rhinos during this winter used 8.6 sq. km. (43.52% of RRA) for the first time. The area covering 70% Harmonic mean transform for each rhino extends in

and around Kakraha/Chidia/Amha/Chetwa lakes. This is similar to winter of '87 but has a longer area coverage (Append. I, II, III).

Distribution of sightings is uniform lacking major foci as in other seasons. This uniformity can be largely attributed to grass burning over a longer duration and in patches. Patches of grass delimited by natural or artificial boundaries were burnt successively, over a period of one month beginning from early February to early March. This uniform utilization distribution and increase in occupancy area of rhinos was a result of availability of fresh grass in different areas at different times. Areas that were not burnt because of various reasons last year (1987) and year befor last (1986) were also deliberately burnt. Unburnt patches at North Kakraha, Nimbo Boghi and Salukapur meadow were burnt resulting in use of these areas by rhinos specially for feeding.

Interaction with other Mammals

All species of Deer (Swamp deer, Barking deer, Hog deer, Spotted deer and Sambar) and wild boar exhibit extensive use of the meadows around the chain of lakes running

along the edge of the forest passing across the fenced area. The ecotone of forests with grasslands plays its own role in making this area an important one. Apart from this, use of the RRA by rhinos has brought about considerable changes in the grass community in the meadows. The rhinos, being coarse grass feeders, consumed large amounts of coarse dominant grass leaving lesser competition for short soft grass species and thereby facilitating their growth. The presence of short soft grass attracts herbivores which feed on them resulting in high prey base density in these areas. The interaction with smaller herbivores in the RRA is more facilitative than competitive. Easy access to water coupled with good prey base makes this area suitable for tigers. As a result of this tigers are found commonly in these areas throughout the year. The rhino reintroduction area, specially the area around the lakes is an overlap of several tiger territories.

Apparently six tigers frequently visit the area and with more intensive observations, they can be individually identified.

Rhino Utilization Distribution Through the Season

The utilization distribution of the rhinos changes in different seasons. The basic activity pattern however, remains the same; animals spend most of their time under cover or in water and come out to feed in the mornings and evenings. While in water they feed on aquatic vegetation such as Ipomea, Hyacinth, Lotus etc. This affinity of rhinos for water keeps them closer to water bodies. In summer the area of utilization distribution shrinks to minimum and remains confined around the lakes, while in winters, the temeprature drops, rhinos also wander away from water. Wider availability of green post-monsoon grass through winters leads to increase of utilization area. With the onset of summer season grasses gradually dry up and the rhinos are attracted to cool water and aquatic vegetation.

Comparative abundance of food and shade around water bodies are two important factors which attract the rhinos to this part of the RRA. Bargadaha, Puraina, Bela and major parts of Kakraha lakes lack shade and hence are less utilized by rhinos. Chidia tal, though small, has both food and shade plus a continuous supply of water from the Kakraha lake or the bore well nearby and hence it is used more during pinch periods. Number of sightings recorded during this study at Chidia 1/4 sq. km. grid is 140 followed by 92 at Kakraha 1/4 sq. km. grid and 76 at Amha 1/4 sq. km. grid. This higher frequency of sightings at Chidia 1/4 sq. km. grid is clearly suggestive of the preference of rhinos for this area.

Monsoon of 1987 was in late July. Heavy rains and water from northern catchment areas flooded the little Suhaili river bordering the Rhino Reintroduction Area. Major part of the grassland got inundated resulting in shortage of accessible food, specially in heavy water-logging areas. The flood, as it generally does, carried great amounts of silt which made deeply submerged flora less visible. The rhinos thus tend to feed in the grasslands and the Sal forests with no or little standing water. This results in wide distribution of rhinos in the RRA. Two major areas of utilization are in Amha 1/4 sq. km.

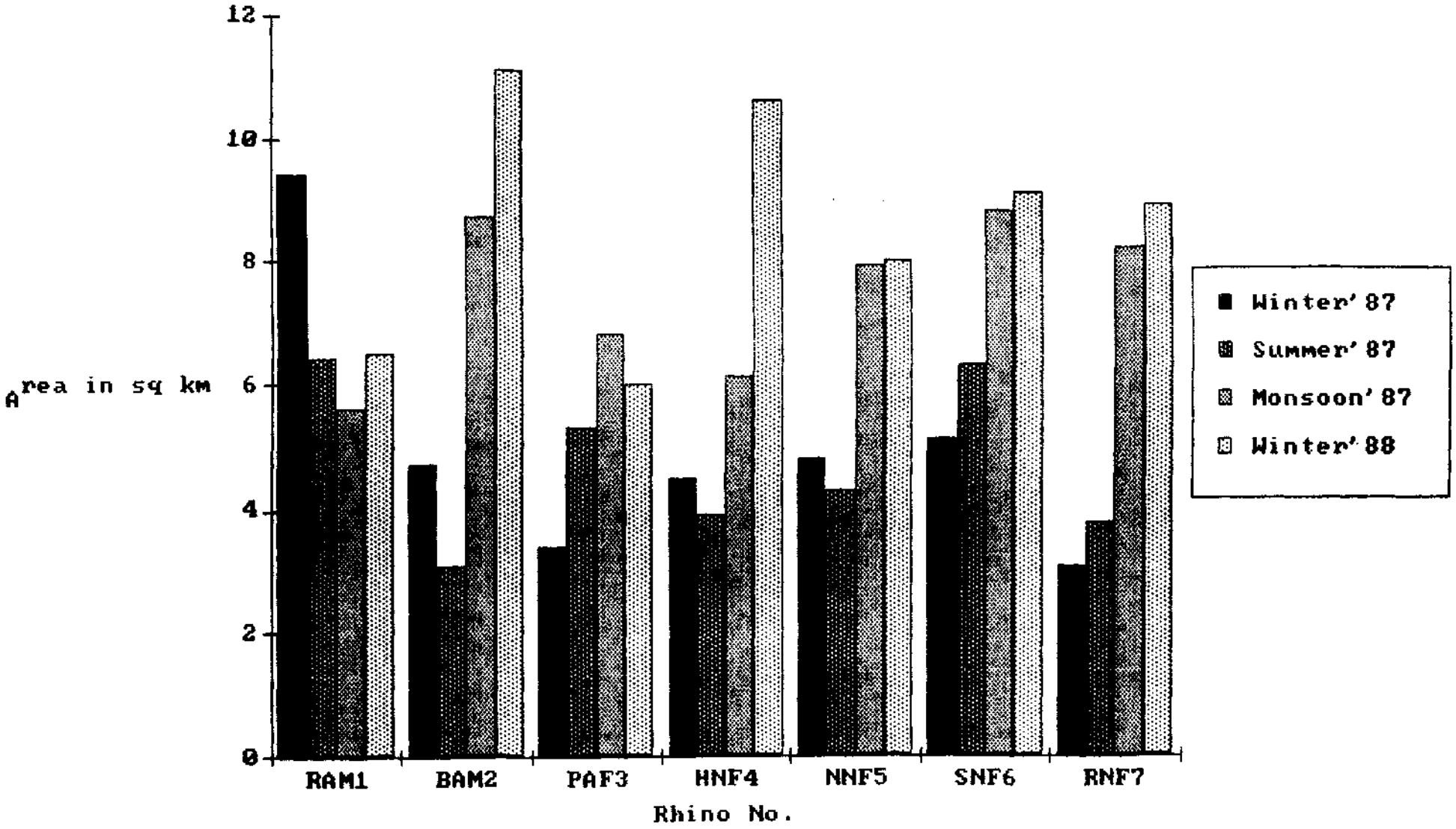


Fig. 6 : Utilization Distribution Areas of individual Rhinos in different seasons.

grid and the Bargadaha 1/4 sq. km. grid. A 90% Harmonic mean measure isopleth also plots these very areas, distinctively as areas of maximum utilization.

Rhino Utilization Distribution : Winter '89 vs. Winter '88

Marked differences between Utilization distribution area of winter '87 and winter '88 were observed. There was an increase in utilization area in winter '68. Increase in utilization distribution area during winter '88 can be attributed to the fire regime. Burning was done late in 1987 and the operation lasted for two days only. This resulted in a lot of areas remaining unburnt mainly due to changes in wind direction during burning. Certain areas were not burnt for over two years. Grass burning was done in patches and early in the winter season of 1988. Meadows which remained unburnt over the years were identified in 1988 and burnt. The burning lasted for about a month. Systematic burning was carried out in patches for maintaining enough cover and resulted in fresh green grass growth from February onwards. Availability of food in areas so far unused by the rhinos, resulted in wider distribution of rhinos within RRA achieving a highest utilization area of 43.52% of RRA, an increase of 14.68% from winter '87.

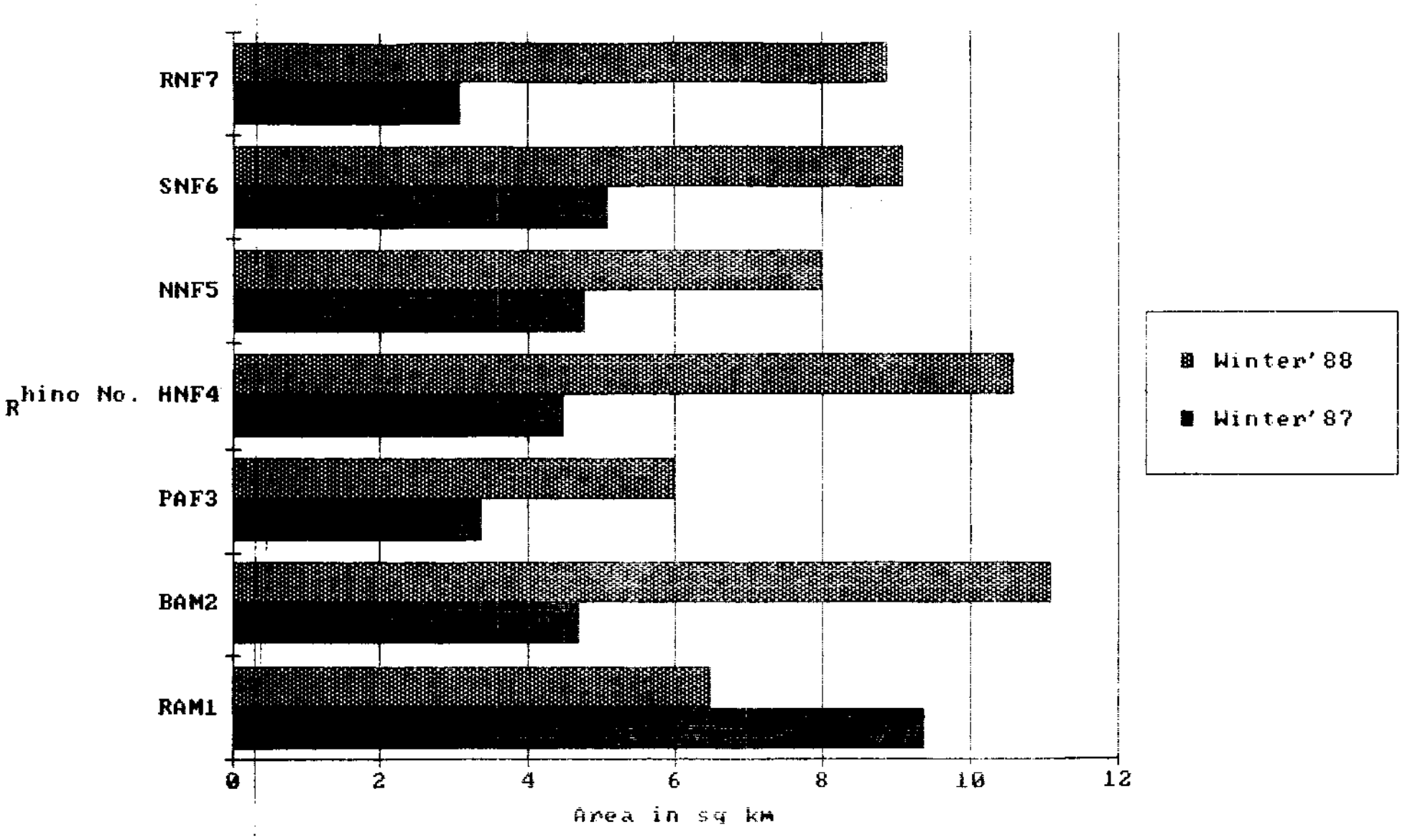


Fig. 7 : Increase in the Utilization Distribution Areas of individual Rhinos from winter '87 to winter '88. Note fall in UD area of RAM 1 only.

Systematic controlled burning of the grasses by making firelines in the grasslands and burning one square kilometer or so at a time would give better results.

Rhino Utilization Distribution : Overlap among Individual Rhinos

Utilization area of all rhinos shows more or less complete overlap. This clearly indicates that rhinos, though seem to be moving independent of each other, use the same areas at different times or together by maintaining distances among themselves. Social interaction though limited, is the only cause of two or more rhinos coming close to each other.

The 90% Harmonic mean measure isopleths of all rhinos in different seasons range over the same areas showing almost complete overlap. To see if there is any exclusion among individuals 70% and 50% Harmonic mean measure isopleths were also calculated. These isopleths too gave similar results, showing no exclusion.

One major finding of 70% and 50% Harmonic mean measure isopleths was that all rhinos in all seasons show greater preference for the area around Kakraha and Chidia lakes. The area in and around these lakes covering about

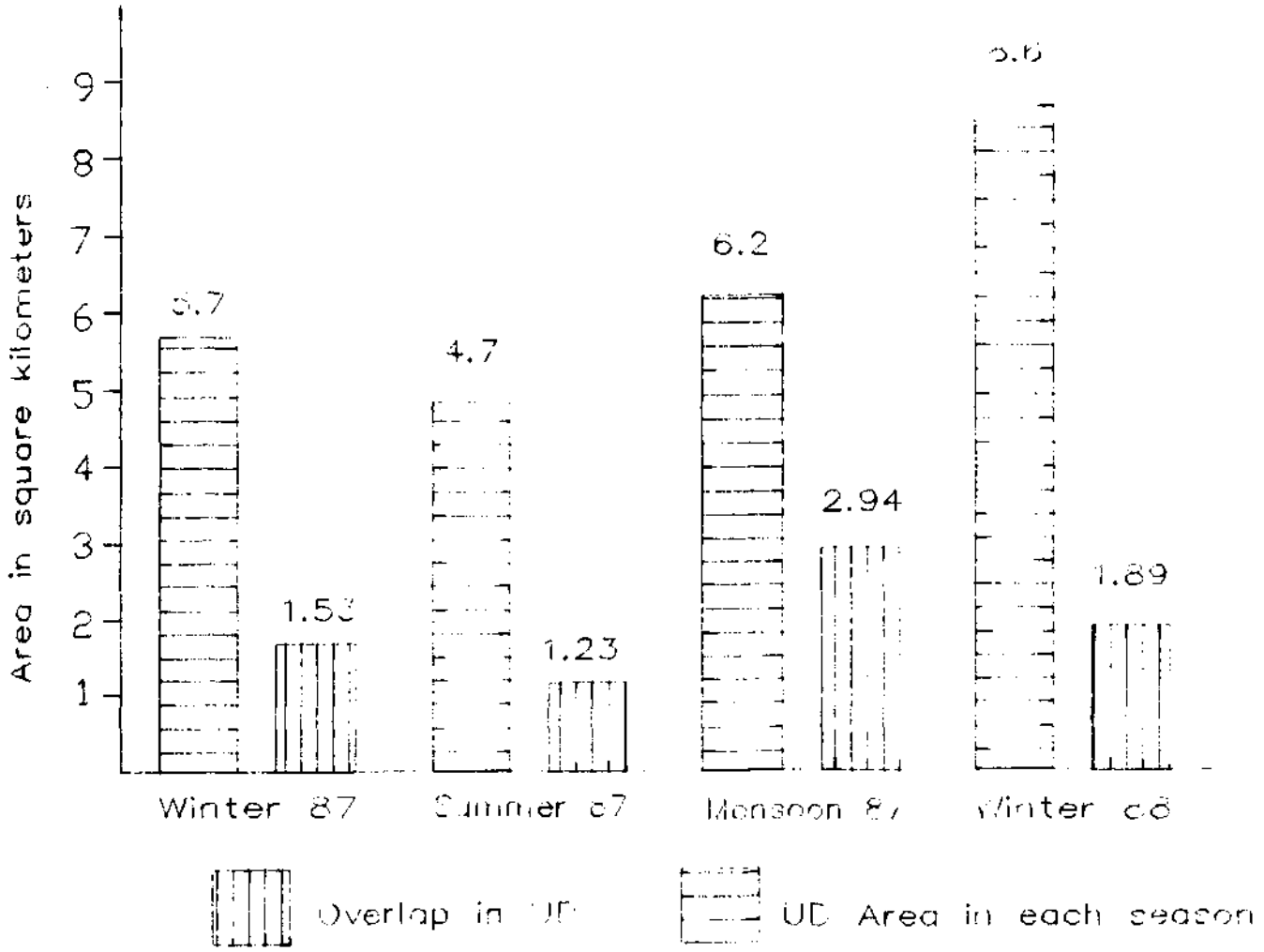


Fig. 8 : Graph showing total Utilization Distribution Area and Overlap Area among all seven Rhinos in each season.

4 sq. km. is definitely of great value for the rhinos, and should be left undisturbed.

In Monsoon '87, 70% and 50% Harmonic mean measure isopleths also include the Bargadaha meadow as an additional intensively utilized area by all seven rhinos. This meadow and the Kakraha/Chidia area need special attention as regards burning regimes and removal of all disturbances.

Rhino Utilization Distribution : Ecological Density

Crude density of rhinos which would include areas available but not utilized by the rhinos, is 1 rhino/2.82 sq. km. in RRA. This is in contrast to high crude density of 1 rhino/0.6 sq. km. at Kaziranga. Ecological density, which refers to only area of most suitable habitat, is at its lowest in winter of '88 (1 rhino/1.22 sq. km.) and highest in summer (1 rhino/0.67 sq. km.) at the RRA. The ecological density of rhinos at RRA when compared to Ecological density at Chitwan National Park (low of 1 rhino/1.4 sq. km. and high of 1 rhino/0.2 sq. km. Laurie, 1978) also suggests that the rhinos at Dudhwa are using a larger area than their cousins in Nepal. This clearly indicates

that the rhinos at Dudhwa Rhino Reintroduction Area face less competition for food, space and shelter. On the above considerations and data, it can be concluded that there is room in RRA for a few more rhinos.

Rhino Utilization Distribution : Rhino RAM 1 vs. Rhino BAM 2

The utilization area of RAM 1 (the senior male) reduced to 6.5 sq. km., which is less than the utilization area of most rhinos, from a dominant position of having the largest utilization area in the earlier seasons (Fig. 6). October onwards relationship between the two males of this population started changing. The challanges from junior male (BAM 2) resulted in severe fights. In monsoon itself RAM 1's utilization area (5.6 sq. km.) became less than BAM 2's (8.7 sq. km.). The intensity and frequency of the fights grew untill December, when RAM 1 broke its massive horn and got severely injured. In winter of '88 BAM 2 (utilization area 11.1 sq. km.) assumed and status of the dominant male in the population. RAM1 utilized only 6.5 sq. km.

The utilization areas of the two males at 70% Harmonic mean measure got separated during the winter of '87. Only half of the area 70% and 50% HMM isopleths shows overlap in the area of two males. This separation

became more distinct during the winter of '88. The junior male actually pushed the senior male out of the RRA. Subsequently, arrangements for a seperate enclosure for the senior male were made. The senior male lived there for some time and died.

The First Rhino Calf

The cow rhino NNF5 delivered the first calf in September/ October 1987. It is however, not clear yet if the calf died after parturition or was scavenged upon after being aborted. Bones and skin pieces were discovered much after the incident (Tariq, 1988).

Inter-specific Intractions : Rhino and other Mammals of the RRA

Mammals present in the Rhino Reintroduction Area are directly or indirectly interacting with rhinos. A detailed animal-wise discussion is as follows :

Tiger (*Panthera tigris*)

The enclosure, because of its chain of large number of well located lakes with tall and short grasses on the west and south and dense miscellaneous Sal forest at

higher level table-land on the east and north attracts a variety of ungulates. Permanent water bodies such as the Suhaili river along the border; Puraina-Kakraha-Amha link of lakes in the enclosure; Bankey tal (about three kilometers north of Kakraha) and Nagra tal (about twelve kilometers east of Kakraha) continue to have water in the summers. Since all these water points are along the southern boundary of the Park animals are attracted towards the South. This phenomenon may also be the reason for the higher density tigers in the RRA. These stray observations have assumed some importance and relevance after the suspected killing of the rhino calf by a tiger.

Bankay tal is shallow and becomes too open in the pinch periods with little water. It is also the tal most frequented by tourists. The Puraina-Kakraha-Amha link unlike the Suhaili River has a long stretch of mise. Sal forest - grassland ecotone and is comparatively free from human disturbance. This makes the link more attractive to animals. In the course of the present study observations were also made on the presence of tigers in the RRA and it appeared that the territories of several tigers (5 to 6) traverse the RRA. It was was also observed that the seasonal dynamics of tiger's territoriality leads tc changes in the numbers of tiger

territories traversing or partially overlapping the RRA. One tiger, perhaps the largest and oldest in DNP, however, was regularly observed in the Southern part of the study area which is suggestive of the possibility that the RRA at least partially overlaps its territory.

Apart from the possibility of a threat to rhino calf from the tiger, no other agonistic interaction between tigers and rhinos was observed. One of the observations is as follows :

27288/09458 South Chetwa meadow/Mating call of tigers heard, 0950-As we approached, mating calls grew louder; four rhinos (RAM 1, PAF 3, SNF 6 & MNF 4) feeding together absolutely undisturbed by the presence of tigers. 0955 - One domestic elephant went too close to the male tiger and got chased for a few meters. The rhinos were undisturbed and continued to feed at a distance of 20-25 meters away from the tigers. The tigers were later seen at Amha tal.

Rhino calves, upto the age of six months are known to be occasionally predated by tigers in other regions. They are seldom killed when they attain a sufficiently large size around that age. Though tiger and rhino happily co-exist in the most eastern habitats like Kaziranga, it is not advisible to let tigers and

rhino come too close to each other in the limited RRA. This view is based on the following considerations :

1. The main objective of Rhino Reintroduction is to find a safer alternative habitat for rhino other than the only one in the North East.
2. Rhino, the focal animal is handicapped in its defensive movements by the fence while the tiger is not and the rhinos survival in the RRA should not be risked by letting tigers come into the fenced enclosure.
3. Tiger is happily living in most other parts of DNP and its survival and well being will not at all be affected if it is kept out of the fenced area.

It has been suggested that some precautionary measures should be adopted to prevent mishaps.. These measures can be (i) Converting the present fence into a tiger proof fence or (ii) Separating the pregnant cow rhinos into a smaller part of the RRA after making it tiger proof.

Swamp Deer (Cervus duvauceli duvauceli)

Dudhwa National Park is the last stronghold of Swamp deer (Cervus duvauceli duvauceli) in the world. Its numbers are falling drastically in Dudhwa as well as

Kishanpur Sanctuary (now a part of the Project Tiger Reserve). To provide regular grazing material for grasslands, in the absence of coarse grass feeders such as rhinos and elephants, were burnt annually. Burning not only provided food but also helped in arresting ecological succession and maintaining grasslands. Coarse grass feeders are a natural source of check on grasslands and form an important component of the grazing mosaic where course grass feeders facilitate feeding of other herbivores, specially in monsoon when burning cannot be used as a tcol for manipulating grasslands to provide enough food for lesser herbivores.

Because of absence of such a grazing mosaic without rhinos (which were present in the DNP a century ago) and only seasonal presence of elephants, the ungulates (including Barasingha) take to crop fields in monsoon and face persecution.

Almost four years of occupancy of the grasslands of the rhino enclosure by rhinos have opened up glades in tall grasses helping lesser grasses to come up and compete with the dominant tall grass species. Such areas have become extremely important for other ungulates in the enclosure. A higher number of Swamp deer were recorded

using such areas in all seasons. Because of smaller number of rhinos the impact on the habitat is not very pronounced yet increase in rhino population in future and the continued utilization of this habitat by rhinos will hopefully facilitate grassland use by Swamp deer and other cervids in a bigger way.

Elephants (Elephas maximus)

Dudhwa once had permanent population of elephants. They now appear seasonally in the park. The Pachyderms migrate to the Park in Monsoon and stay there till late October. A few stray individuals may be found in November-December. In the Monsoon of 1987 a group of 18 elephants broke into the rhino enclosure from the south eastern part and stayed for two days before breaking out from the North Western part of the fence. The elephants of this area have not known large mammals like the rhino. An opinion suggested that agonistic interaction between the Rhinos and elephants could have been a cause of the death of the solitary rhino calf. The death of this calf was estimated to have occurred whenthe elephants were in the enclosure (Tariq, 1988).

Rare & First Reported Animal Species of Dudhwa

In the southern part of the Rhino enclosure, which has

big patches of short grass, Hispid hare (Caprolagus hispidus) was seen a number of times. Characteristic pallets of hispid hare were also seen in these areas. Flying squirrels were seen in the Chota Pallia Block in Miscellaneous Sal forests. Correct identification could not be done due to short periods of sightings. According to Parter (1980) the only flying squirrel north of the Ganges is the Red flying squirrel (Petaurista petaurista albiventer), a sub species of the common Giant Flying Squirrel.

At least four Bengal Florican (Eupodotis benghalensis) male birds were sighted in short grass areas of the rhino enclosure in late winters and summers for two continuous years. The bird being polygamous, there is a possibility of over a dozen birds visiting the grasslands for breeding.

A pair of Pied Harrier (Circus melanoleucos) were seen in the enclosure November, 1987.

CONCLUSION

The reintroduction of Great Indian Rhinoceros (Rhinoceros unicornis) in Dudhwa National Park for creation of a fresh population is a major step for enhancing the conservation status of the species in India. This reintroduction programme is expected to result in the creation of another viable population of rhinos in its old range of distribution.

A major part of this study on the reintroduced rhinos was done on habitat utilization behaviour. Since they were released in a 'power fenced' Rhino Reintroduction Area (RRA), their expanse of use was delimited. This was done for creating a special Rhino Management Area facilitating administration for better security, surveillance and research.

At the end of the translocations of 1984 & 1985 a total of seven rhinos (2 bulls & 5 cows) were reintroduced in

Dudhwa National Park. Total fenced area available for utilization by the Rhinos (RRA) is about 19.76 sq. km.

Data on rhino behaviour, locations and intractions was collected on a daily basis. Utilization distribution patterns were studied after analysis of data by Harmonic Mean Transformation Method (Dixon & Chapman, 1980).

The study on utilization distribution was done on a seasonal basis. All rhinos used about 45.52% of the RRA during the study with seasonal variations. Utilization areas are reduced in Summer due to concentration of locations in and around waterbodies (23.78% of RRA). In Monsoon inundation of grasslands results in wider interspersion of drier areas. The rhinos used dry patches of grasslands for feeding and resting intensively creating more than one activity center (Append. I & II). The utilization area increased to 31.37% of the RRA. The highest utilization area of 43.52% of RRA was recorded in winter '88 (Table 3). This significant increase from winter '87 (28.84% of RRA) was mainly due to better fire regimen for grass burning in 1988.

The degree of overlap in utilization areas of the seven rhinos is almost total. The rhinos, however, show temporal isolation from each other in habitat utilization.

They come together only during social interactions or in preferred feeding areas.

The crude density of rhinos in RRA (1 rhino/2.28 sq. km.) is very low in comparison to that of Kaziranga (1 rhino/0.60 sq. km.). The ecological density calculated in terms of actually utilized areas gives a better clue about resource availability and competition. The highest ecological density of rhinos in RRA was recorded during pinch periods of Summer '87 (1 rhino/0.67 sq. km.). This ecological density when compared to that of Chitwan National Park (1 rhino/0.2 sq. km.) clearly suggests that rhinos in RRA are facing little or no competition for resource.

Considering the size of RRA (19.76 sq. km.) and the ecological density of reintroduced rhinos for all season (1 rhino/1.29 sq. km.), the RRA should be able to hold a population of about 15 rhinos easily. Development of watertanks in the southern region of RRA and planned fire regimen can enhance the status of habitat vis-a-vis the rhinos. The likely upper limit of rhino population that can be sustained by the RRA, computed by the ecological density in Chitwan National Park, is about ninety eight rhinos. This figure may not be true for the

RRA because of obvious habitat differences and resource availability between the two, the RRA and Chitwan National Park. A more realistic figure is obtained by using the higher ecological density shown by the rhinos of RRA in Summer which is almost equal to the crude density of Kaziranga National Park. The upper limit of rhino population that the RRA can thus sustain is of thirty rhinos. It can be concluded from the above discussion that the RRA can sustain a population of thirty rhinos and this can be stretched to a population of ninety eight rhinos with better management of the habitat.

The 'power fence' is a very important component of the Rhino Reintroduction Programme. The question of removing or increasing the fenced area can only arise when the rhino population crosses a limit of about fourty. If the current population of rhinos is to increase by intrensic reproduction than the need to remove or increase the fenced area will arise well after a decade.

The interaction of the rhinos with other herbivores of the RRA is a facilitative one. Rhinos - coarse grass feeders - open up areas for soft grasses which are preferred by ungulates. There seems to be little competition for

resources between the rhinos and other herbivores of the RRA. Once the rhinos population in the RRA reaches around thirty, the factor of tiger predation on rhinos calves will become insignificant. As far now a definite check on this factor is required for success of the Rhino Reintroduction Programme which started with a rhino population of as low as seven.

The utilization areas of winter '88 show a significant increase over that of winter '87. This is attributed to a better regimen of the annual grass burning. Further improvement in the fire regimen can enhance the utility of habitat for both rhinos and other herbivores. Presence of enough cover and food in the grasslands will not only help the rhinos but also the Swamp deer (Cervus duvauceli duvauceli), the other endangered species in the RRA.

The present population status of the reintroduced rhinos is not desirable. Currently there is only one adult bull rhino with five cow rhinos. Considering the factor of inbreeding syndrome it becomes quite apparent that more rhinos should be translocated and released in the RRA of Dudhwa National Park.

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APPENDIX I

Utilization distributation of the seven reintroduced rhinos at DNP in the four seasons .Isopleths based on 70% & 50% of sightings by the Harmonic Mean transformation of Mcpaal Program.

A = Winter 1987
B = Summer 1987
C = Monsoon 1987
D = Winter 1988

Fig.1: RAM1
Fig.2: BAM2
Fig.3: PAF3
Fig.4: HNF4
Fig.5: NNF5
Fig.6: SNF6
Fig.7: RNF7

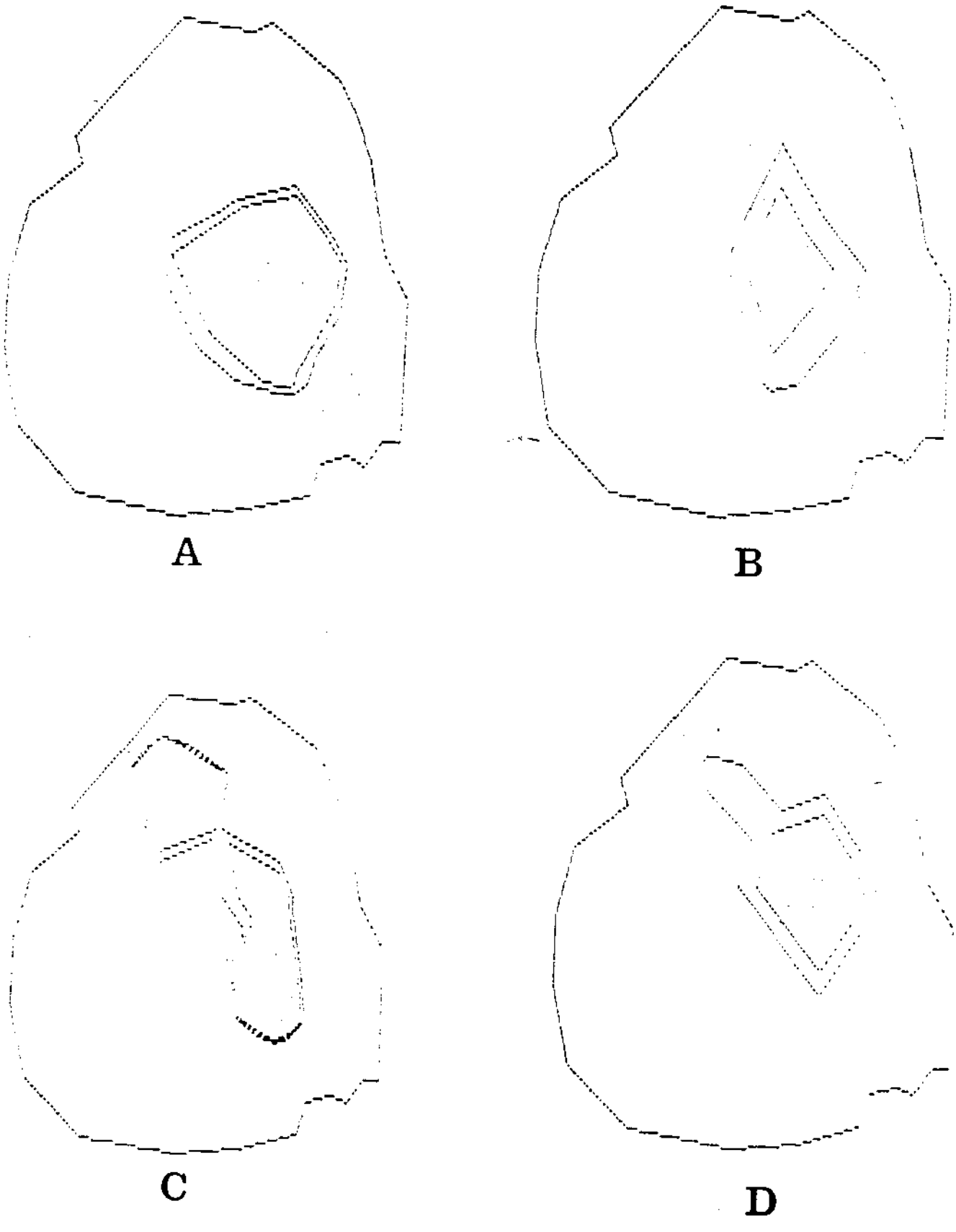


Fig.1 RAM1

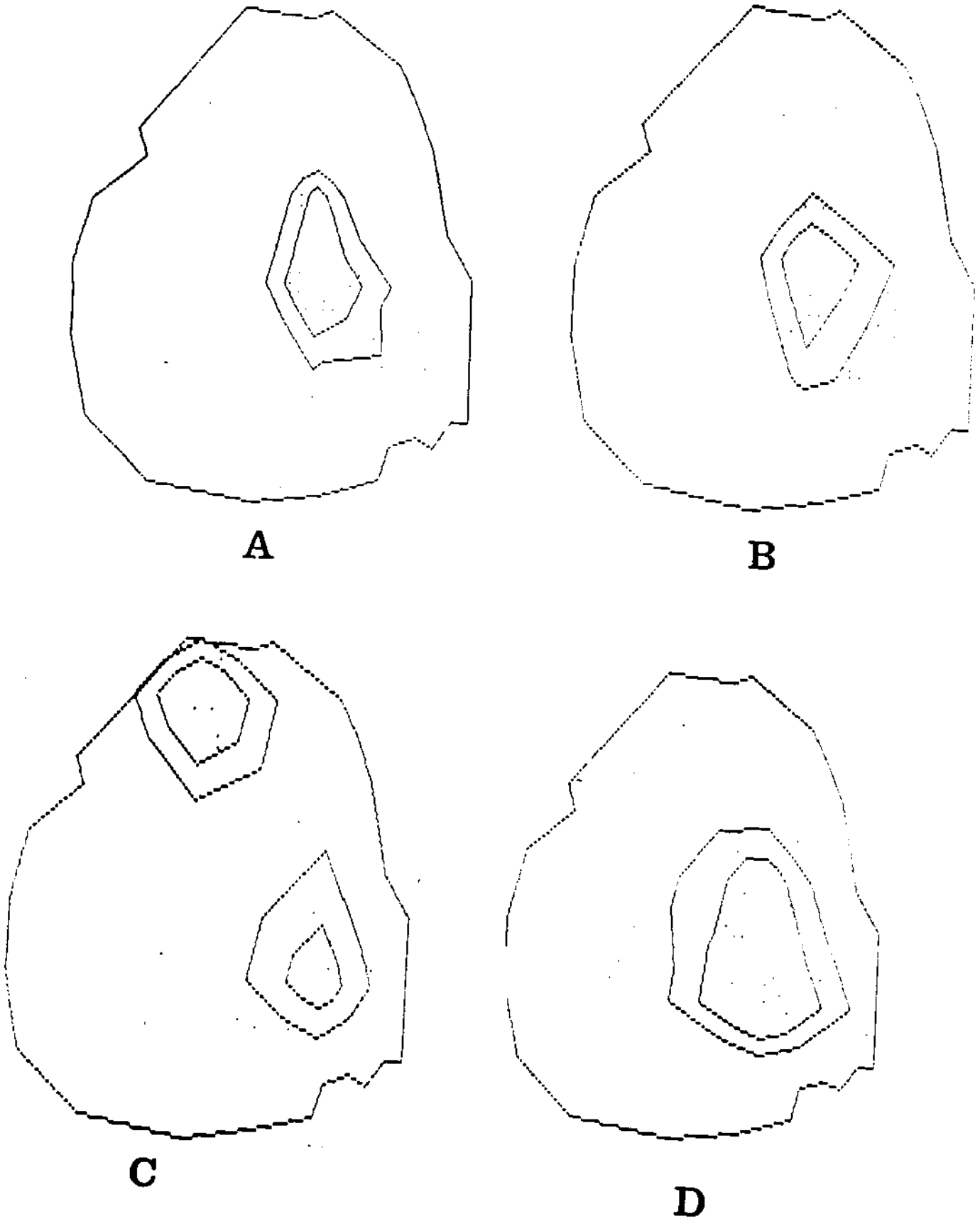
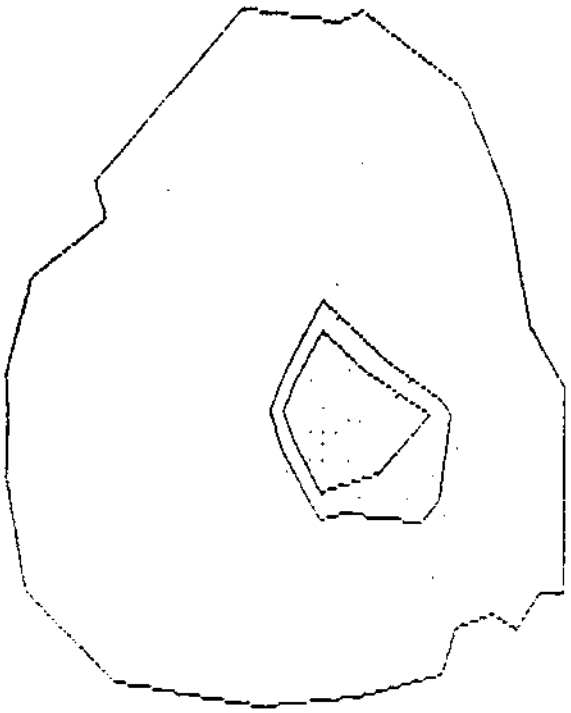
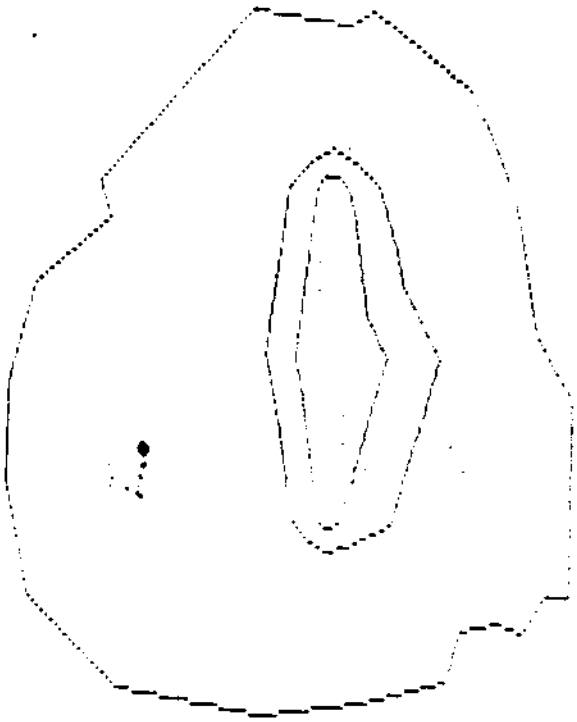


Fig. 2 BAM2



A



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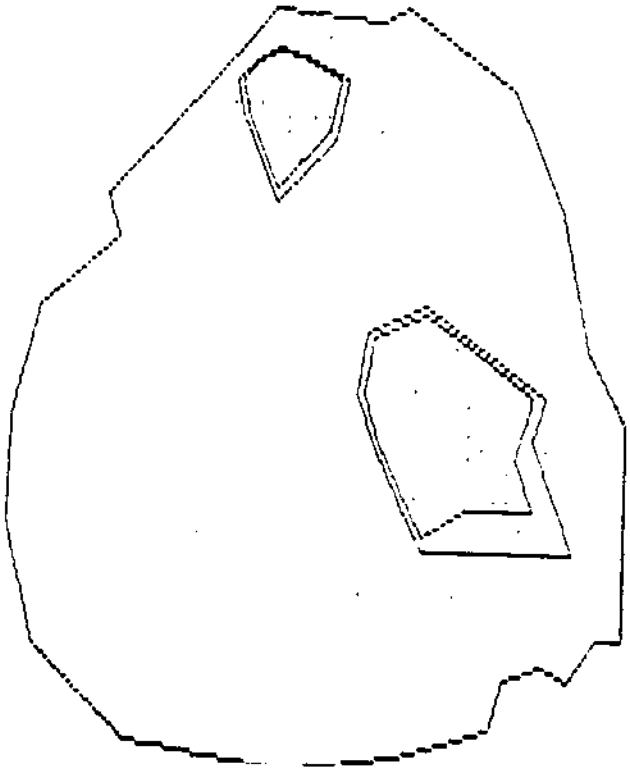

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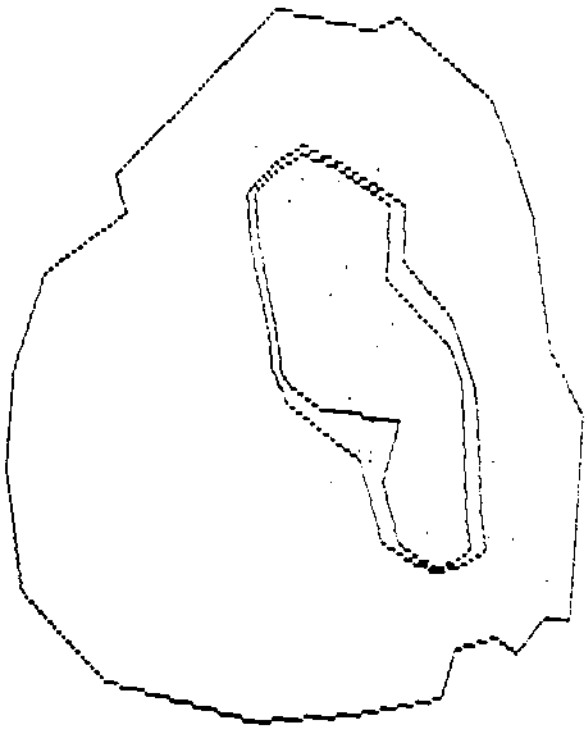

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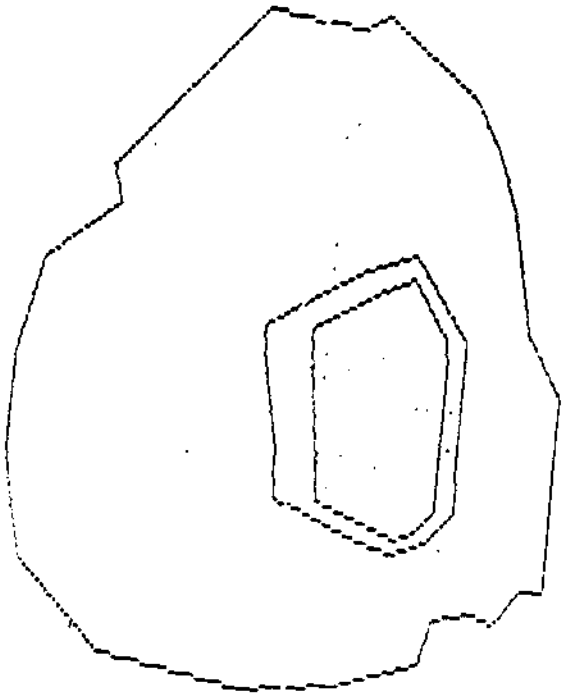
Fig. 3 PAF3



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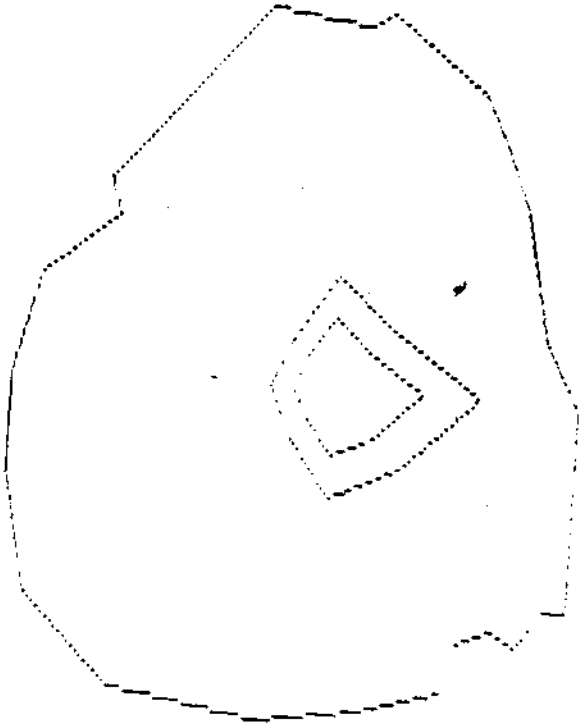

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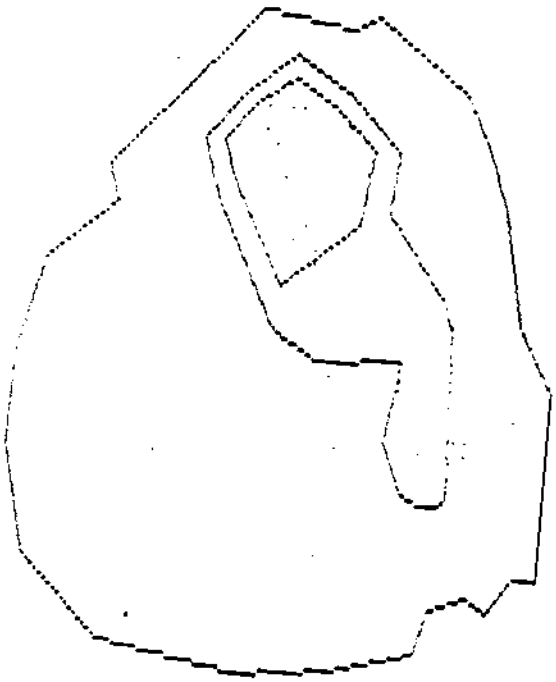

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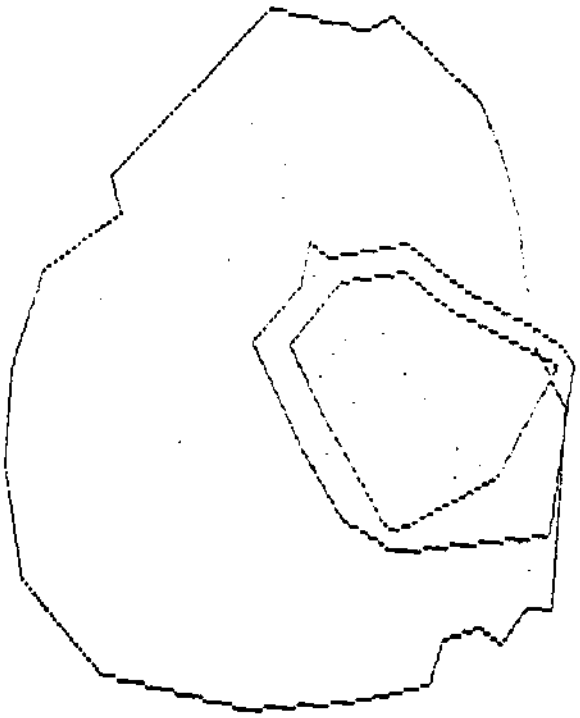

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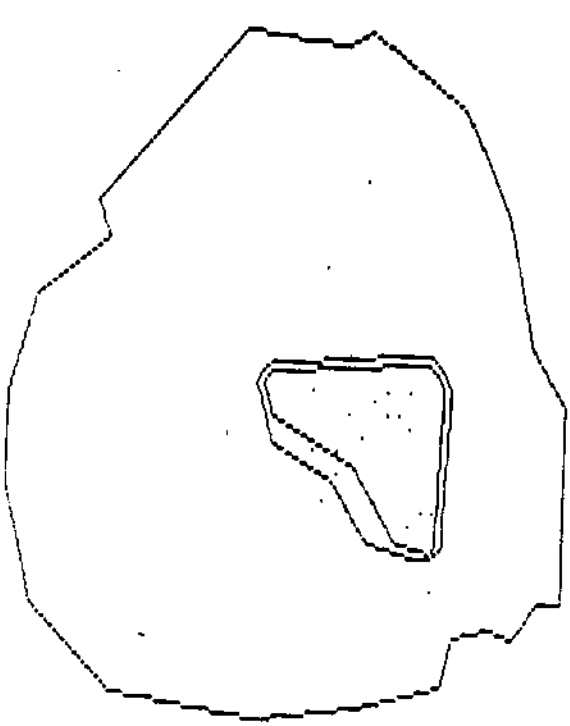
Fig .4 HNF4



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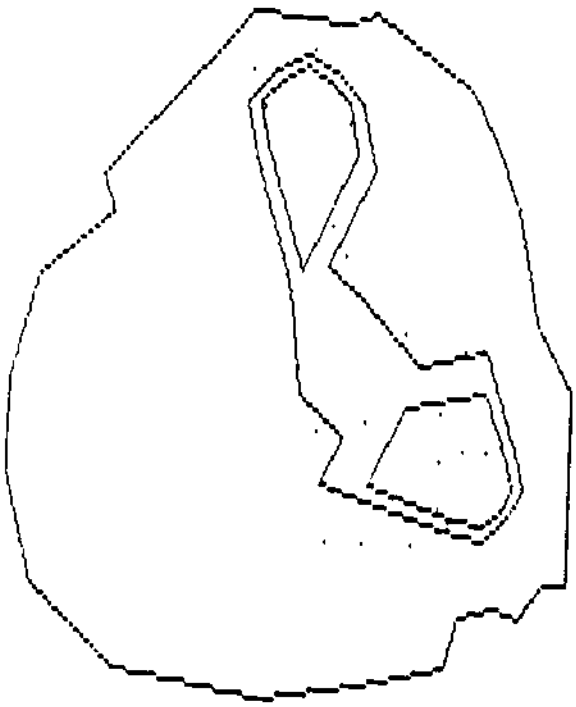
B



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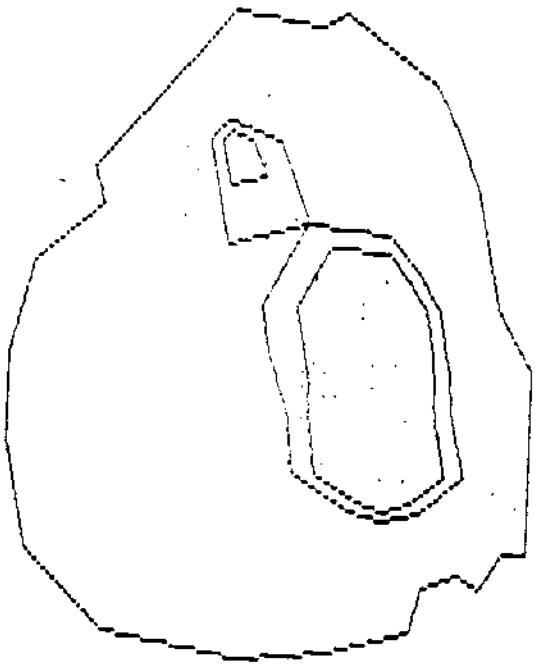
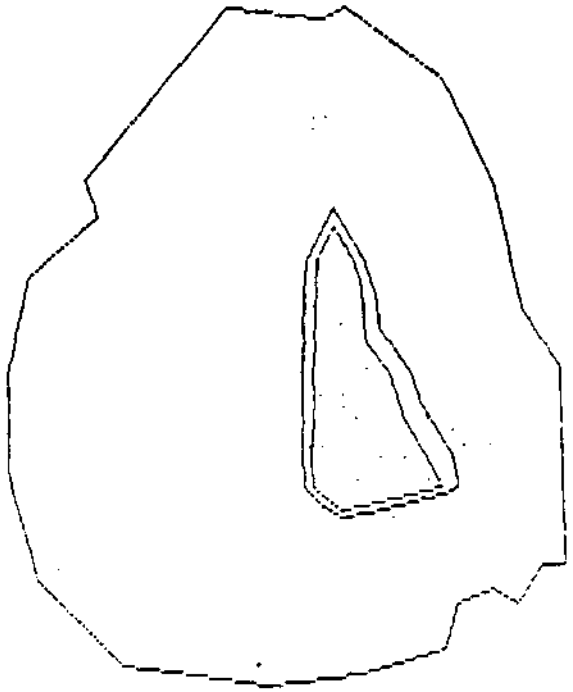


D

Fig.5 *NNF5*



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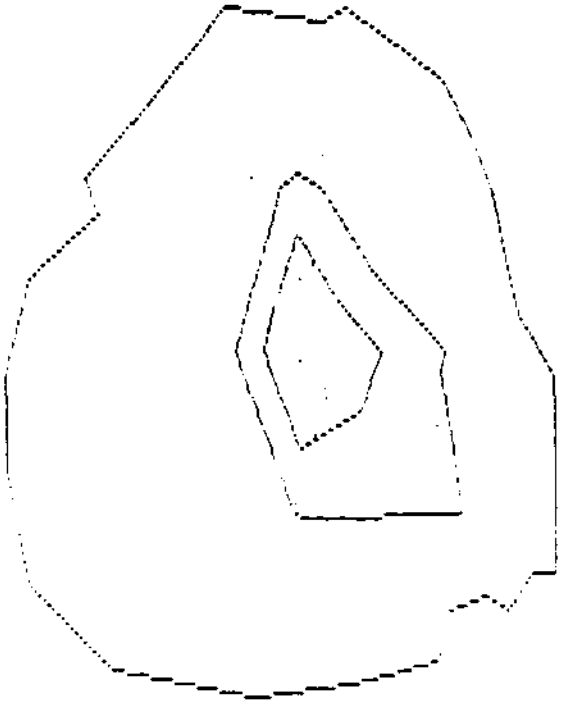

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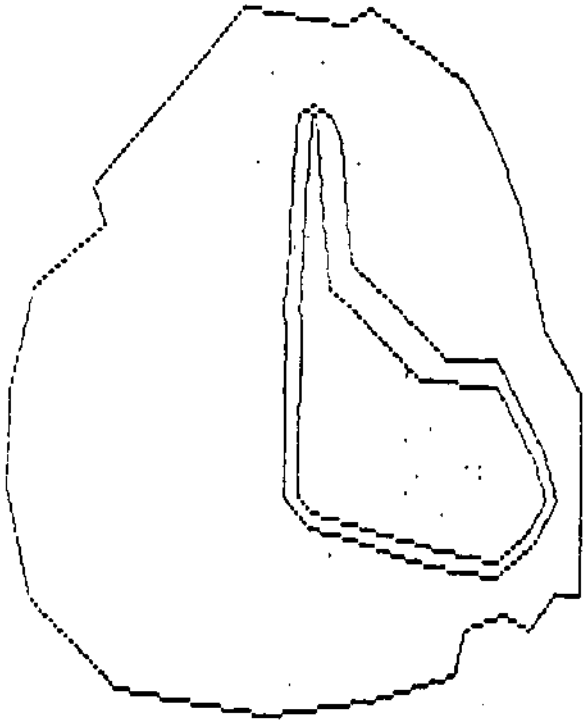

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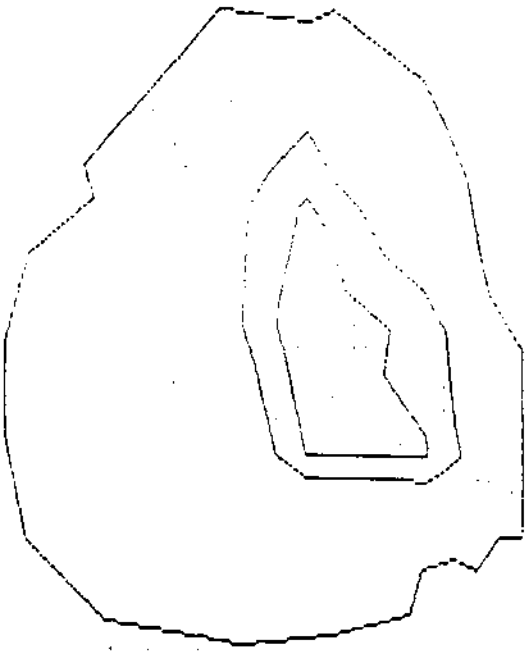

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Fig.6 *SNF6*

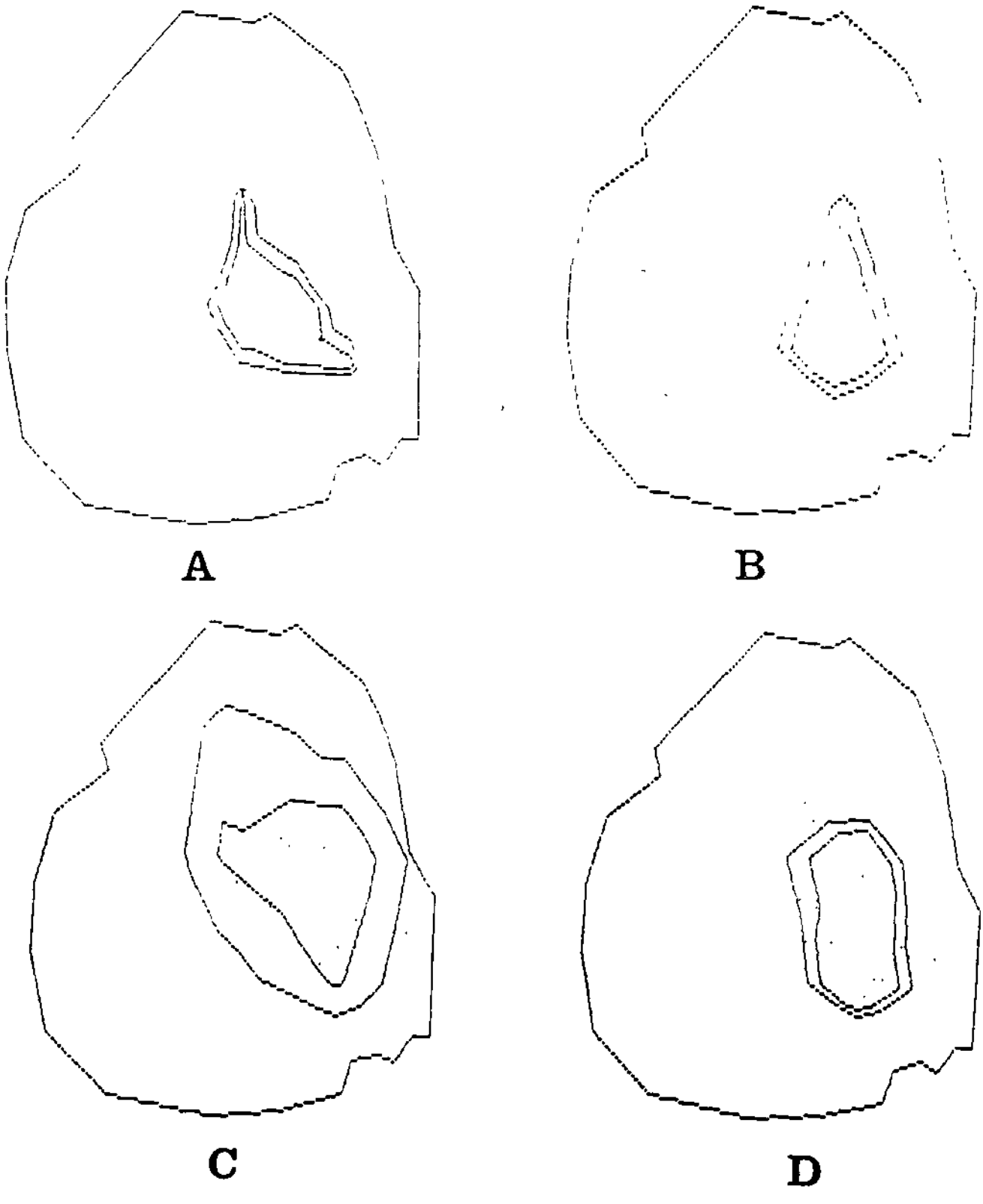
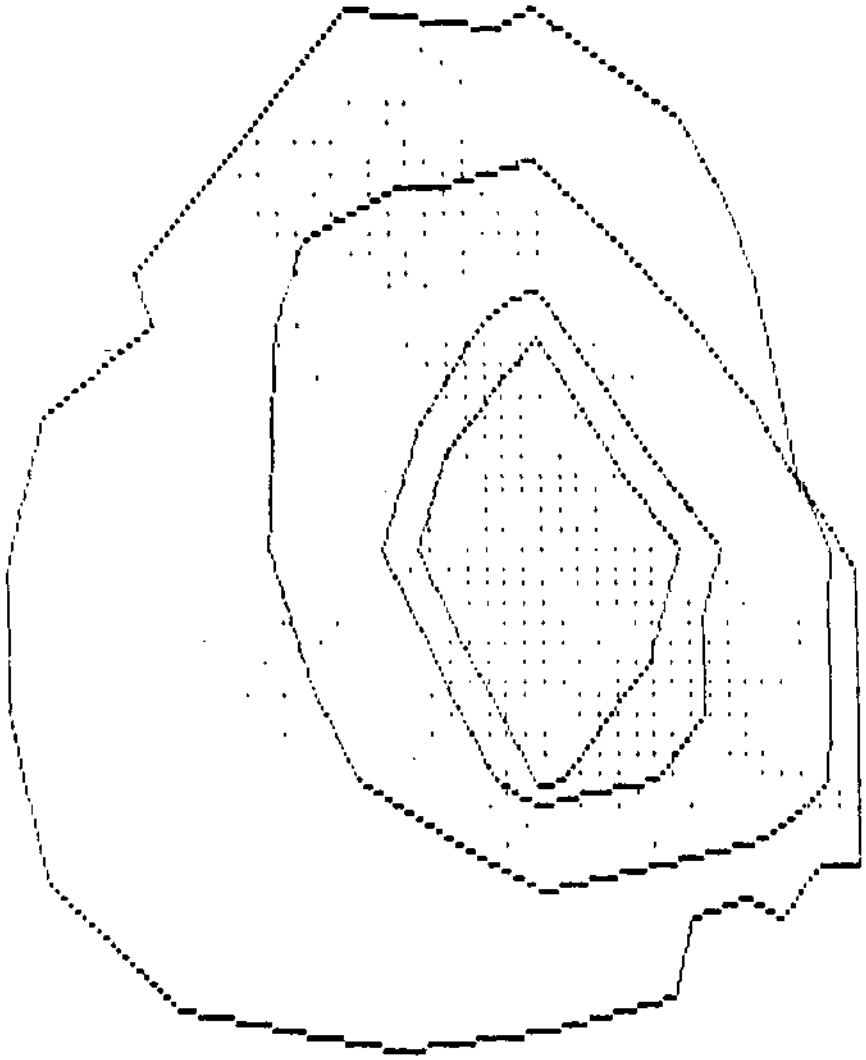
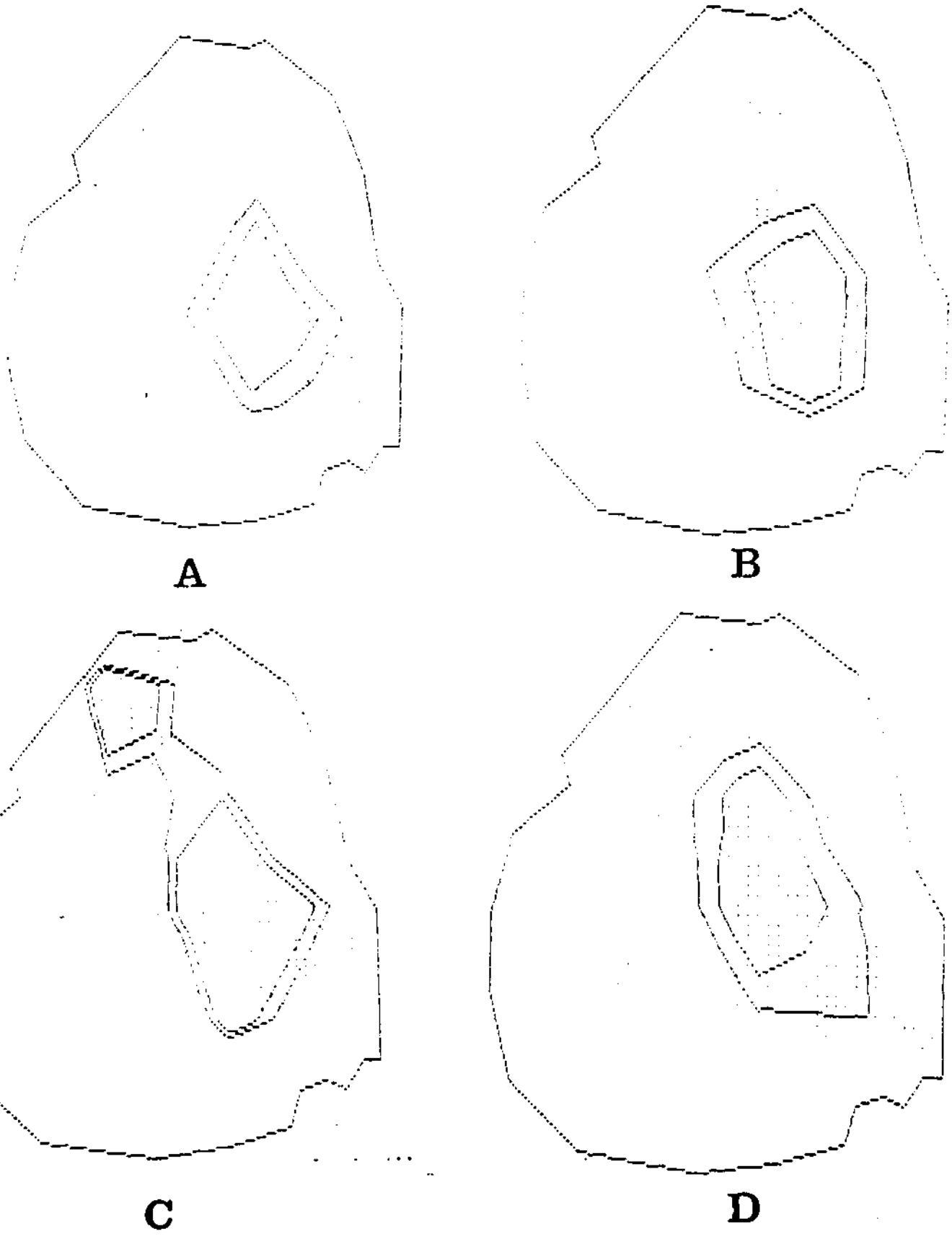


Fig.7 RNF7

APPENDIX II
Utilization distribution of all seven reintroduced rhinos of DNP. Isopleths (90%,70% & 50%) are generated by Harmonic Mean Transformation of the Mcpaal program.

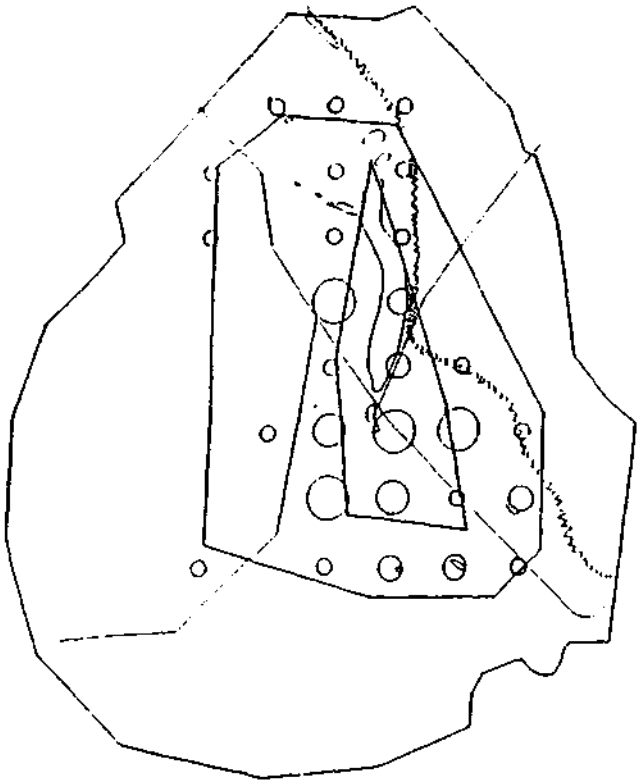


APPENDIX III
Utilization Distribution of all seven Rhinos in each season Isopleths (70% & 50%) are generated by Harmonic Mean Transformation of the Mcpaal Program. (A-winter87;B-summer87;C-monsoon87;D-winter88)

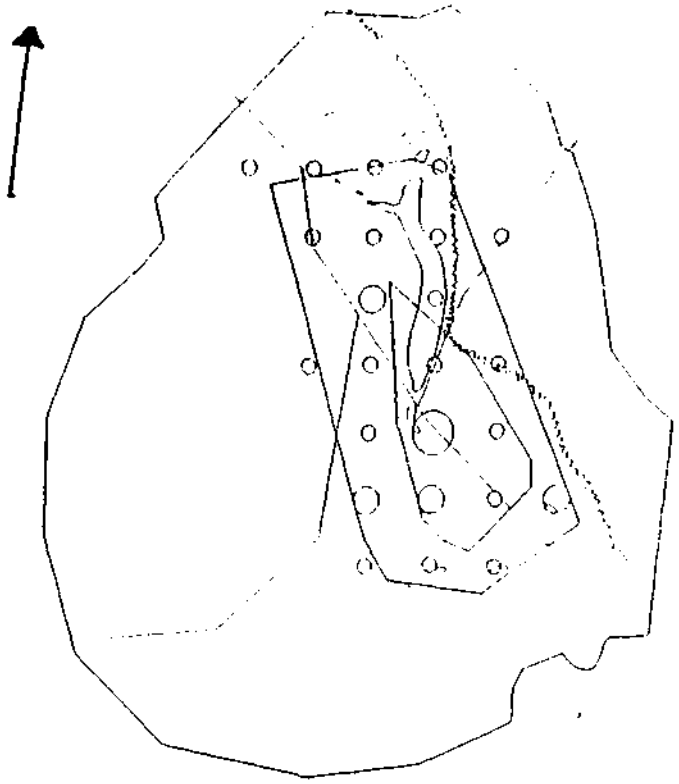


APPENDIX IV

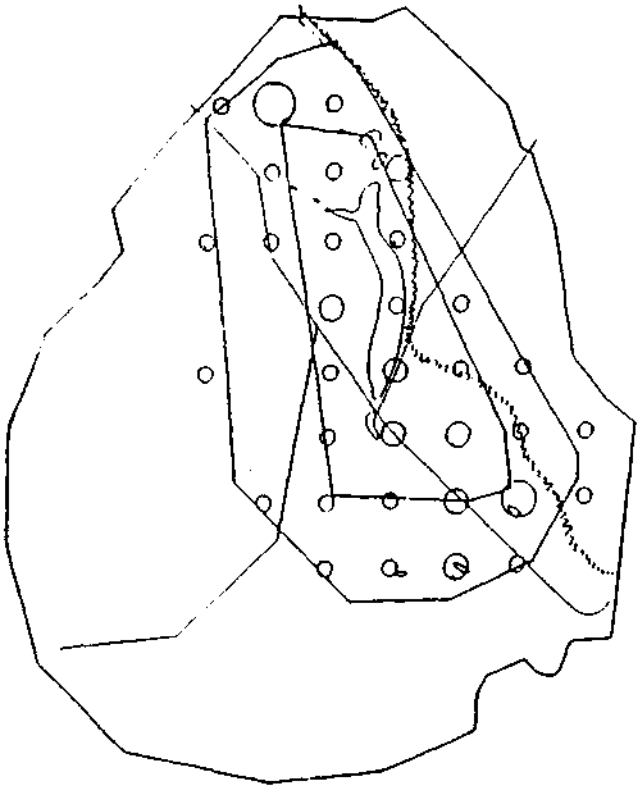
Distribution of Rhino locations. Large circles represent higher number of sightings. The outer polygon, generated by joining outermost locations, represents UD in each season.The inner polygon is the overlap in UD of all seven rhinos.



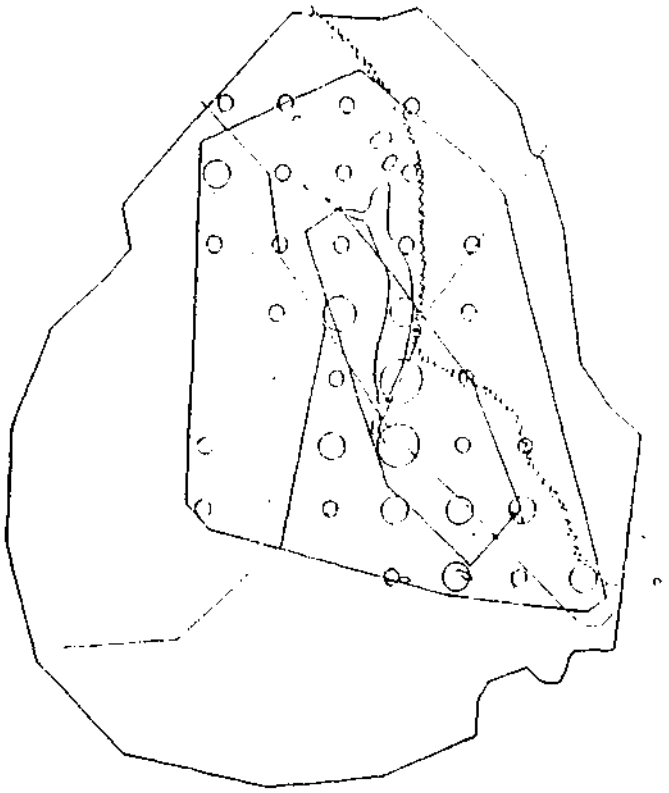
Winter 87



Summer 87



Monsoon 87



Winter 88

APPENDIX V

PRIMATA

The Rhesus Monkey	Macaca mulatta
The Common Langur	Presbytis entellus

CARNIVOREA

FAMILY FALIDAE

The Tiger	Panthera tigris
The Panther	Panthera pardus
The Jungle Cat	Felis chaus
The Leopard Cat	Felis bengalensis
The Fishing Cat	Felis viverrina

FAMILY VIVERRIDAE

Small Indian Civet	Viverricula indica

FAMILY UPSIDAE

The Sloth Bear	Melursus ursinus

FAMILY CANIDAE

The Wolf	Canis lupus
The Jackal	Canis aureus
The Indian Fox	Vulpes bengalensis

FAMILY HYAENADAS

The Hyena	Hyaena hyaena

FAMILY HERPESTIDAE

The Common Mongoose	Herpestes edwardsi
The Small Indian Mongoose	Herpestes auropunctatus

FAMILY ANTILOPINAE

The Blue Bull	Boselaphus tragocamelus
The Black Buck or The Indian Antelope	Antilope cervicapra

FAMILY CERVIDAE

The Spotted Deer	Axis axis
The Barking Deer	Muntiacus muntjak
The Hog Deer	Axis porcinus
The Sambhar	Cervus unicolor
Swamp Deer	Cervus duvauceli duvauceli

FAMILY SUIDAE

The Wild Boar	Sus scorfa

RODENTIA

The Porcupine	Hystrix indica
The Common Rat	Rattus rattus
Indian Male Rat	Bandicota bengalensis
Long Tailed Tree Mouse	Vandelcuria oleracea
House Mouse	Mus musculus
Five Stripped Squirrel	Funambulus pennati
Red Flying Squirrel	Petaurista petaurista albiventer

PROBOSCIDAE

The Indian Elephant	Elephas maximus

LAGOMORPHA

The Indian Hare	Lepus nigricollis
The Hispid Hare	Caprolagus hispidus