

THE ECOLOGY AND BEHAVIOUR OF CHITAL (*Axis axis*)
IN THE ROYAL CHITWAN NATIONAL PARK, NEPAL

(with comparative studies of hog deer (*Axis porcinus*), sambar (*Cervus unicolor*) and Barking deer (*Muntiacus muntjak*)).

by

HEMANTA RAJ MISHRA

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Philosophy.

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University of Edinburgh,
Department of Forestry and Natural Resources,
King's Buildings,
EDINBURGH, EH9 3JU
U.K.



I hereby declare that this dissertation is the result of my own work and the data presented here are my own. No part of this dissertation has been submitted to this or any other University for any degree or diploma. The work described here were carried out from the Department of Forestry and Natural Resources under the supervision of Dr. I. R. Taylor.

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ABBREVIATIONS

Apart from standard abbreviations, I have used the following notations on some of the tables.

1. Sex/Age Class

AM = Adult Male

AF = Adult FEmale

YRM = Yearling Male

YRF = Yearling Female

JV = Juvenile

Fn = Fawn

2. Habitat

RBK = River Bank Kans

RF = Riverine forest

SD = Savannah Dhaddi

OVJ = Old Village Sites

Sal = Sal Forests

3. Others

HMG = His Majesty's Government of Nepal

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ABSTRACT

The Royal Chitwan National Park in southern Nepal is one of the few areas left where 4 species of deer, the Chital, Hog deer, Sambar and the Barking deer co-exist. The objective of this study was to investigate the habitat utilisation, breeding seasons and social organisation of these 4 sympatric species of cervids with particular emphasis on the chital. Detailed information is also given on the daily, seasonal and annual home range behaviour of chital based on the use of radio-telemetry. Data are presented on the annual mortality of chital, the importance of each deer species in the diet of Tiger and Leopard and the antipredator behaviour of the 4 species of deer. Future research priorities and management options for the future of Chitwan National Park are appraised.

CHAPTER 1

1.

INTRODUCTION

1.1 Rationale:

Throughout the Indian sub-continent many animal species that were once widespread have now become greatly reduced in number and distribution as a result of human expansion. The trend has been most noticeable amongst the large mammals and many of these are now severely threatened. (Gee 1959 and 1963; Spillet and Tamang 1966; Schaller 1967; Berwick 1974; Mishra 1974). At present they are mostly restricted to national parks and reserves and their future in areas outside these sanctuaries is at best uncertain. Their future depends mainly on the success of attempts to maintain small, more or less isolated populations in national parks and reserves (Fig. 1.1). To manage these areas properly and so conserve the animal species a profound understanding will be needed of how the populations and the ecosystems in which they live function and of how human activities affect the systems.

The Royal Chitwan National Park in southern Nepal (Fig. 1.2) was set up originally to protect and conserve one such large mammal species: the Great Indian One Horned Rhinoceros (*Rhinoceros unicornis*) since it was one of only two last strongholds of this species in the world (Talbot 1959; Bolton 1975; Laurie 1978). However, the park contained many other endangered species, notably the tiger (*Panthera tigris*), leopard (*Panthera pardus*), gaur (*Bos gaurus*), the Gangetic dolphin (*Platanista gangetica*); gharial (*Gavialis gangeticus*); Great Indian Bustard (*Chloriotis nigriceps*) and a number of ungulates including the chital or axis deer (*Axis axis*).

In 1973, a programme of research was initiated by His Majesty's Government of Nepal (HMG), the Smithsonian Institute (SI), and the

Fig. 1.1: NATIONAL PARKS AND RESERVES MENTIONED IN THE TEXT.



World Wildlife Fund (WWF) aimed at understanding the basic ecology and behaviour of the population of Tiger within the park (Sunquist 1981; Smith and Mishra 1981). This study is a part of that research project and its primary objective was to initiate research into the ecology and behaviour of the prey species upon which the tiger relies (Seidersticker 1976; Tamang 1979; Sunquist 1981). The study concentrated on the main prey species, the chital (McDougal 1977; Schaller 1967; Dinerstein 1980) and gives comparative information, *albeit* in less depth, on a further three species, the hog deer (*Axis porcinus*), the sambar (*Cervus unicolor*) and the barking deer (*Muntiacus muntjak*). All of these deer are themselves becoming more dependent upon national parks for their survival since there is very little suitable habitat outside such reserved areas. So as well as providing information for tiger conservation it is hoped that this study will provide the base of knowledge that will be needed to protect the deer. The main emphasis of this study is to produce part of the scientific base for conservation of deer and tiger in Royal Chitwan National Park. It is hoped that the results will be relevant to other areas.

The study is at the same time of general ecological interest. There have been many studies of deer in various parts of the world (Darling 1937; Flerov 1952; Linsdale and Tommich 1953; Taylor 1956; Dasmann and Taber 1956; Anderson 1961; Eygenraam 1963; Cumming 1966; Lowe 1969; Mitchell 1968; Prior 1968; Kirsch and Geer 1968; Colquhoun 1971; Craighead *et al* 1973; Staines 1974; Clutton-Brock and Guinness 1975; Mutch *et al* 1976; Mitchell *et al* 1977; McCullough 1979). The large mammals of the Indian sub-continent were mentioned in the Vedas as early as 2000 - 1500 B.C. (Rao 1957) and the Mogul rulers of India (13th - 16th century) were famous hunters (Ali 1927). With the advent of the British "Raj" in India, the chital and other

deer were described in journals and books published since the last century (Hodgson 1847; Blandford 1888; Kinloch 1892; Inverarity 1895; Lydekker 1924; Smythies 1942), but most of them provide only interesting historical records and some useful summaries on distribution, weights, and body or antler size. There have been only 3 major studies of these species in the region (Schaller 1967; Eisenberg and Lockhart 1972; Berwick 1974) and these were conducted a decade ago in severely man-altered environments where the forests were constantly disturbed by human activity and large predators were reduced in numbers. Thus this is the first detailed study within the region in an area of maximum diversity of deer species and the full complement of predators and competitors and it is hoped that it will give some insight into how populations of deer operate in such conditions.

This study focuses on the chital (*Axis axis*), the most important of the tiger prey species and provides parallel comparison with three other species of deer (*Axis porcinus*, *Cervus unicolor* and *Muntiacus muntjak*) that share the national park with the chital and that are also preyed upon by the tiger.

Field work started in Chitwan in late May, 1978 and ended at the beginning of October, 1981. This report is based upon 40 months of field study concentrated in the Saurah sector (Fig. 2.1) of the national park.

In this respect this study is analogous to the studies that have been done of ungulates in the savannah areas of east Africa (Grizmek and Grizmek 1960; Darling 1960; Lamprey 1964; Walther 1966; Gwynne and Bell 1968; Jarman 1974; Geist and Walther 1974; Sinclair 1977; Leuthold 1977; Sinclair and Norton-Griffiths 1979) and there is an opportunity to draw useful comparisons with these studies.

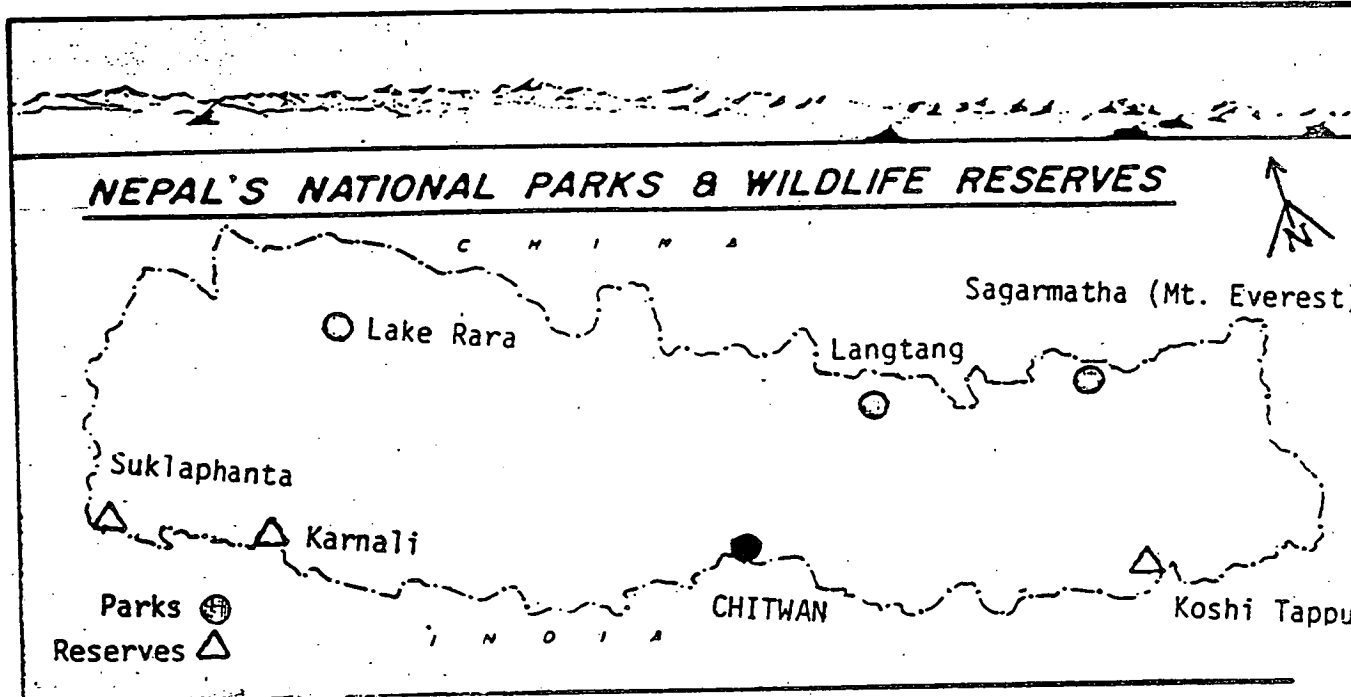
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1.2 Objectives:

The following were the specific objectives of the study:-

1. To describe the patterns of habitat utilisation.
2. To describe the seasonal patterns of reproductive activity.
3. To describe the patterns of social organisation.
4. To investigate in detail the movements and home range behaviour of one species, the chital (*Axis axis*).
5. To investigate predation especially by the Tiger.

Fig. 1.2:





CHAPTER 2

2.

THE ROYAL CHITWAN NATIONAL PARK

2.1 History of the National Park:

The history of the national park is parallel to the history of the great one horned Indian rhinoceros (*Rhinoceros unicornis*) in Nepal. In 1846, Jung Bahadur, the first Rana prime minister declared the rhinoceros a "Royal Animal". Since then the animal and its habitat have received some protection primarily in the Rapti and Reu valleys of Chitwan (Caughley and Mishra 1968). With the collapse of the Rana regime in 1951 much of the wildlife and habitat in Chitwan suffered heavy destruction (Talbot 1959; Gee 1959; Spillet and Tamang 1966). A malaria eradication programme introduced by the United States Agency for International Development in 1954 was followed by a large programme to settle people in Chitwan. By 1959 the whole length of the valley from Hetura to Naryanghat was settled. The human population of the area rose from a few thousand in 1950 to about 10,000 in 1960 (Caughley 1969). The fifties were also a period of political unrest in Nepal and the government was unstable. With the return of a stable government in 1961, a special armed guard unit under the name of Wildlife Management Division was established in Tikoli. In 1964, the late King Mahendra created a "rhino sanctuary" in the area and more than 22,000 people were resettled outside the present park boundaries. In 1973, the present King of Nepal, His Majesty King Birendra Bir Bikram Shah Deva formally declared the area the country's first national park.



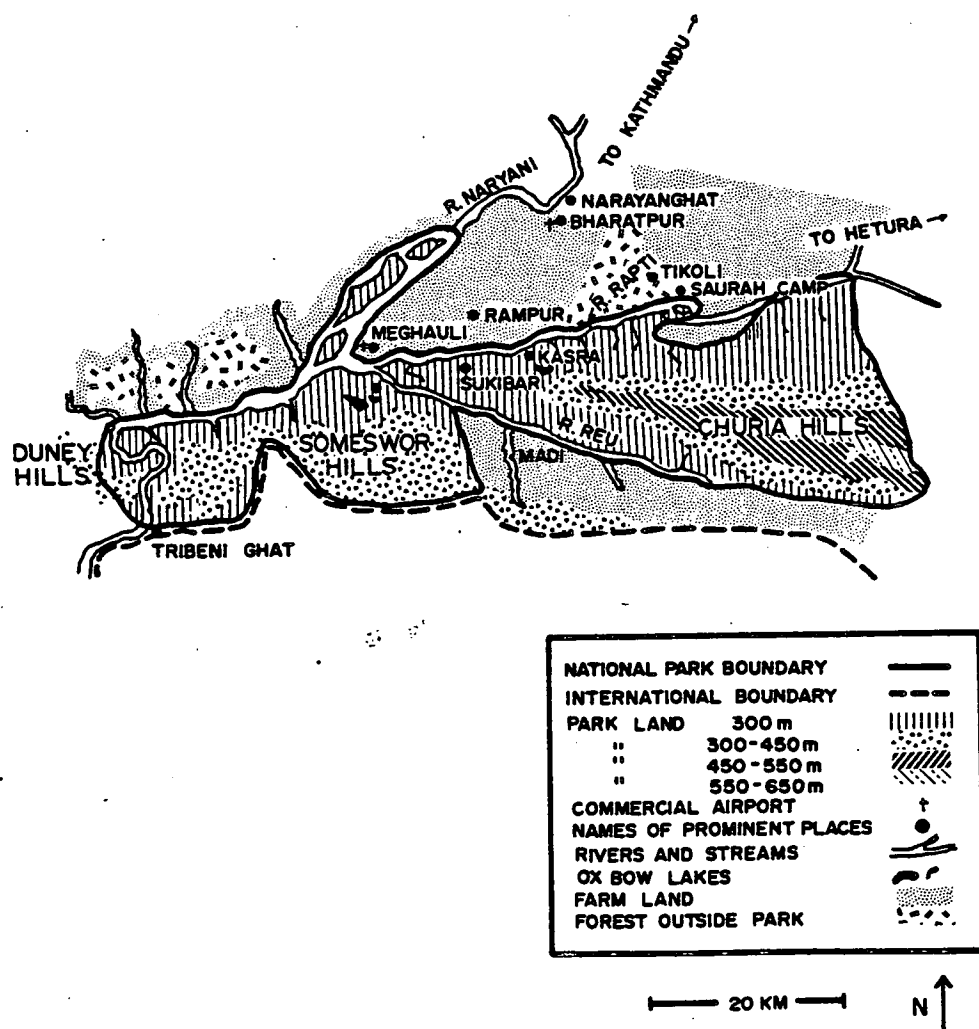
The Rhinoceros (*Rhinoceros unicornis*)
is mainly restricted to the Riverine
forest/grassland habitat

Chitwan has always been famous for its wildlife and forests. The area once formed the hunting preserve of the ruling Rana families with most state guests being taken there for hunting. On such occasions hundreds of elephants were used to pursue tiger, deer, rhinoceros and other big game. Smythies (1942) described the great hunts in Chitwan and provided records of animals shot. Even in modern times state guests ranging from the deposed King of Afganistan to the reigning sovereign of Great Britain, Her Majesty Queen Elizabeth have hunted in Chitwan before the area was declared a national park. However, since hunts were infrequent and the habitat was protected the animal population suffered little despite the large numbers bagged in these hunts.

Oldfield (1880) and Burkhill (1910) stated that the government of Nepal deliberately decided to keep cultivation out of Chitwan at the beginning of the 19th century to form a buffer of malarial forests as a defence from invading armies. Human disturbance of the area was slight, since the few settlements mainly consisted of small patches of jungle cleared by the Tharu people, the oldest inhabitants of Chitwan, who are believed to have developed some degree of tolerance to malaria (Philips 1925).

The area of the national park when first gazetted was 544 sq. km. This area was further extended to 894 sq. km. in 1978.

Fig. 2.1: ROYAL CHITWAN NATIONAL PARK



2.2 Location and boundaries:

The National Park lies in the Chitwan district of the Narayani Zone of Nepal. It is situated in the vicinity of Latitude 27.30 degrees north & Longitude of 84.20 degrees east. The river Rapti demarcates the northern boundary of the park from a densely cultivated area while the southern boundary extends from the Nepal-India border to the east along the Reu river. Its western boundary is delineated by the Narayani River and on the east the park is bounded by forests and farmland (Fig. 2.1). The exact and legal description of the park is provided in the Nepal Gazette (1974).

2.3 Administrative and Legal status:

The entire park is public land under the jurisdiction of the Ministry of Forests of His Majesty's Government of Nepal (HMG). The area is administered by a "Warden" under the provision of the Royal Chitwan National Park Regulations (1974). A team deputed by the Royal Nepal Army is responsible for park protection and anti-poaching activities. The park headquarters is located at Kasra and at present there are 35 armed guard posts distributed throughout the area.

2.4 Access and communication:

The national park is approximately 90 km. by air from Kathmandu. Two commercial airports, one at Bharatpur, and the other at Meghuli service the area. It can be approached overland through the Mugling-Naryan Ghat highway and through the East-West highway from Hetauda. A seasonally motorable road runs through the park. Electricity and telephones do not exist inside the park, though there is a wireless radio at Kasra which is used to contact Kathmandu daily.

2.5 Topography, Drainage and Hydrology:

The park is situated in a river valley basin along the flood plains of Rapti, Reu and Naryani rivers in the inner Terai of Nepal. The Someswar ridge and the Duney hills form the southern catchment and both drain into the Naryani. The Churia hills bisect the park with its northern face draining into the Rapti, the southern aspect forms the catchment of the Reu river. The Rapti basin which is also called the Dun is bounded by the Mahabharata range of mountains on the north. Both the Rapti and Reu flow westwards and converge at Khorla Mohan near Tiger Tops from where they drain into the Naryani. The Naryani then meanders southwards through a narrow gorge between the Someswar hills and the Duney hills for about 25 km. until it reaches the Nepal-India border where it is dammed near Tribenighat. The Naryani is also called the Gandaki and is the third largest river in Nepal. It originates in the high Himalayas and finally drains into the Bay of Bengal after joining the Ganges in India. The Churia, Someswar and the Duney hills are a range of Siwalik hills with rugged and steep southern aspects. The northern slope is dissected by numerous rivulets, streams and nalas some of which carry water throughout the year. The highest point in the park is about 800 meters along the Churia ridge; the lowest point is about 200 meters along the bank of the Naryani near Tribeni Ghat.

The flood plains along the northern sector of the park in the Rapti valley are interspersed with a few tals (oxbow lakes) and ghols (swamps) which contain water even during the dry season. The Rapti and Reu can be crossed by foot or four-wheeled vehicles during the dry season, whereas during the monsoon these rivers rise several times their normal flow making it difficult to cross even by boats or elephants. In this season the rivers are heavy with silt washed down from higher slopes.



The Marsh mugger (*Crocodilus palustris*) in one of tals (Oxbow lakes) in the National Park.

The riverine forests and grasslands along the flood plains remain waterlogged during the monsoon and the ground remains soggy for 2 - 3 months after the rains making movement through the park possible only by elephants or on foot.

2.6 Geology and Soils:

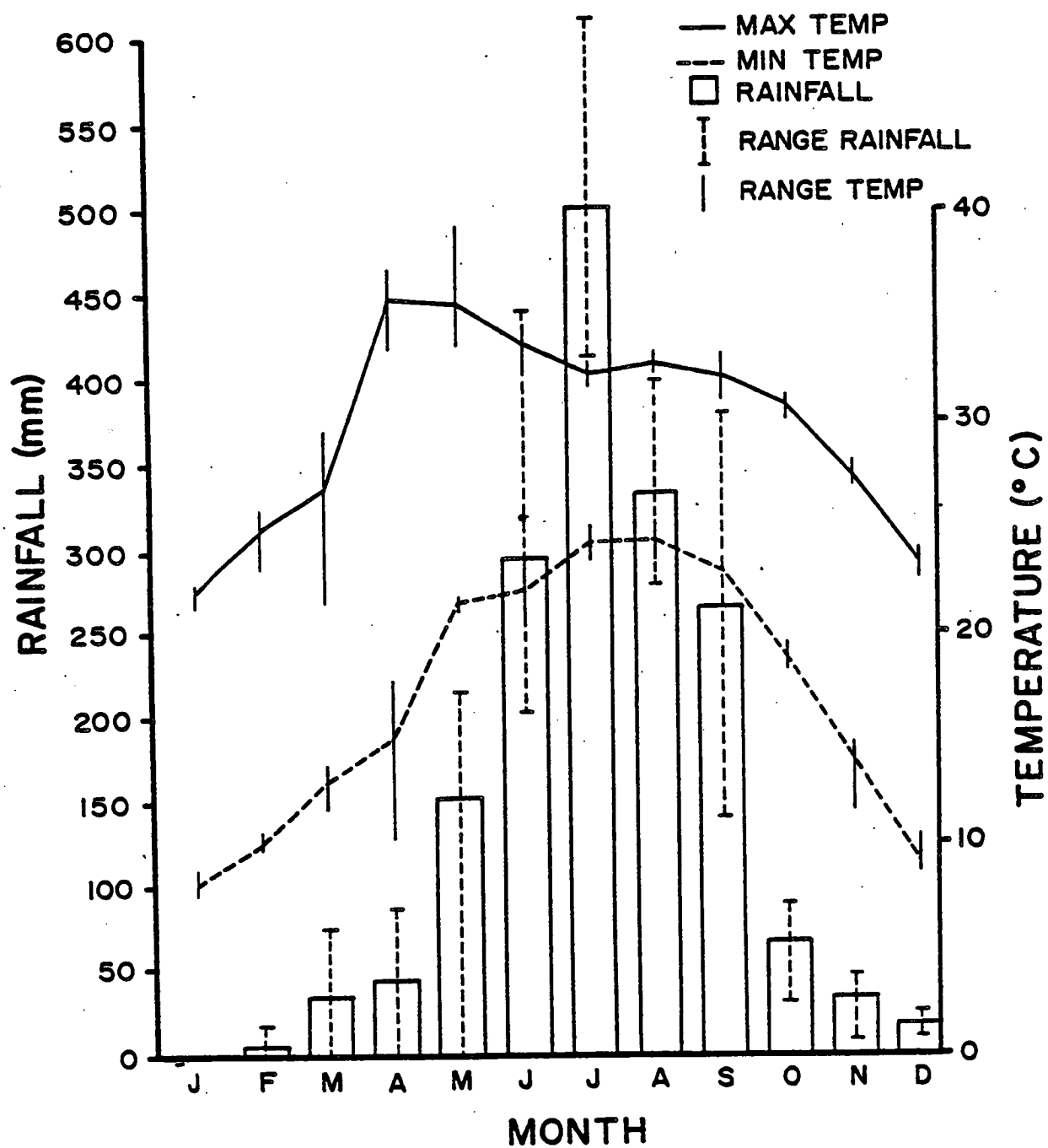
HMG (1968), Hagen (1969) and Berry *et al* (1974) have described the geology and soils of the area. The Mahabharat range of mountains that form the northern catchment of the Rapti valley consists of heavily eroded pre-Siwalik quartzites, phyllites and sandstones. The Churia is a range of Siwalik hills that extend almost throughout the length of the country and are characterized by outwash deposits from the north. All rocks are of Pliocene or Pleistocene origin and consist mainly of sandstones, conglomerates, quartzites, shales and micaceous sandstone (HMG 1968; Hagen 1969). The Siwaliks also show distinctive fault patterns resulting in steeper valleys with poorer vegetation cover on the southern aspect than that of the north.

The flood plains form a series of alluvial terraces laid down by rivers and subsequently raised by the Himalayan uplift (Berry *et al* 1974). These terraces are composed of boulders and gravels set in a fine silty matrix. The soil is brown or grey in colour; the texture sandy loam to silty loam. On higher ground the soil is much darker in colour and is sandy or gravely in texture. The outcrop of the parent material occupies much of the surface of the steeper part of the land surface.

2.7 Climate:

The climate is subtropical with the south-east monsoon the dominant factor. There are three main climatic seasons (Fig. 2.2).

Fig. 2.2 Rainfall and Temperature



- (1) The pre-monsoon season: The pre-monsoon season extending from late February to May is the hot and dry period of the year. The winds are south-westerly with the daytime temperature averaging around 36°C . The relative humidity is lowest in March. From April onwards sporadic storms occur with strong winds blowing sand, hail and rain. By the end of May a few intense showers signal the forthcoming monsoon (Fig.2.2).
- (2) The monsoon season: The hot and humid monsoon season extends from June to September. The south-easterly winds bring heavy rainfall causing heavy flooding of rivers and streams. The average daytime temperature when it is not raining is about 33°C , and minimum temperature of about 20°C . By the end of September the frequency of showers decreases and the temperature also begins to decline.
- (3) The post-monsoon season: The post-monsoon is a cool season extending from October to January with the northerly winds from the Great Himalayas and the Tibetan plateau reducing the average daytime temperature to 25°C with the night time temperature occasionally falling as low as 7°C . The nights are damp and cold with heavy fog during the early hours of morning. Frost is occasionally recorded in December and early January. There is little precipitation in form of rain during this season.

Some local variations in rainfall, temperature and humidity have been reported within the Chitwan valley presumably arising from differences in terrain or vegetation.



River Rapti during the dry season



River Rapti just after the monsoon

2.8 The Vegetation:

The following is a brief description of three major vegetation types that can be broadly distinguished in the Royal Chitwan National Park. The classification and nomenclature used follow those of Brandis (1906), Stainton (1972) Hara *et al* (1978) and Bolton (1975).

(1) Sal Forest:

The vegetation is predominated by almost monotypic stands of sal (*Shorea robusta*) which occupies 70 % of the park area. This straight boled deciduous Dipterocarp occupies most of the Churia ridges and well drained parts of the national park. The sal forest of Chitwan is almost a homogeneous community with relatively few associated tree species. The purest stands occur on lower ground between Jarneli and Sukhibar. On higher slopes a few other tree species are scattered within the sal stands. It is intermingled with chir pine (*Pinus roxburghii*) along the southern face of the Churia with the latter forming almost pure stands along the top of the ridge. On the northern slopes a few other tree species such as *Terminalia bellirica*, *Dalbergia latifolia*, *Anogeissus latifolia*, *Dillenia indica* and *Garuga pinnata* are commonly seen growing amongst sal stands. The shrub and herb undergrowth is scant with the exception grass *Themeda caudata*, a grass that grows prolifically on the forest floor forming a dense layer that can reach a height of 5 - 7 metres. Two creepers, *Bauhinia vahilli* and *Spatholobus parviflorus* are common in the sal forest.

(2) Riverine forest:

This forest type extends along river banks, water courses and islands in both the Naryani and Rapti rivers and occupies 7 % of the park area. Four types are distinguished in Chitwan.



The Sal (*Shorea robusta*) forest

(i) Khair - Sisoo (*Accacia catechu* - *Dalbergia sissoo*) are the first tree species to colonize and stabilise the river banks of recent alluvial deposits. This association occurs commonly along the banks of the Rapti, Reu and Naryani. The Island of Shandarjhulla in the Naryani is an especially good example of this type of colonization. The Khair (*Accacia catechu*) is a middle sized thorny tree; whereas the sissoo (*Dalbergia sissoo*) is a much larger tree with vivid green leaves growing to 15 - 20 meters and both of these legumes are important commercial species in Nepal. Khair is more common in the drier part: sissoo grows more readily in damp areas. Tall *Saccharum* grass is often found on wet ground adjacent to the forest strip while the understory consists of *Pogostemon plectroides* and other small herbs and grasses.

(ii) Semal-Vhellar (*Bombax ceiba* - *Trewia nudiflora*) is similar to the tropical deciduous riverine forest described by Stainton (1972). It forms a distinct second stage in the succession between the Khair-Sisoo and Sal forest. The semal (*Bombax ceiba*) is a large tree growing up to 30 - 35 metres and is very much in demand by the match industry. This tree has thorny bark when young and forms a wide crown with large protruding buttresses at its base when it grows older. The vellar (*Trewia nudiflora*) is a much smaller tree with little commercial value. Several other tree species are associated with the forest type including *Butea monosperma*, *Bauhinia malabarica*, *Carea arborea*, *Ekretia laevis*, *Litsea monopetala*, and *Mallotus philippinensis*. Under storey shrubs include *Clerodendrum vicosum*, *Callicarpa macrophylla*, and *Zizyphus jujuba* and occur in areas where forest cover is discontinuous. Forest edges and clearings have tall grasses (*Saccharum munja*, *Saccharum spontaneum* and *Vetiveria zizanoides*) and shorter species such as



The Riverine forest (*Bombax ceiba* - *Trewia nudiflora* type).

Cynodon dactylon, *Chrysopogon aciculatus*, *Digitaria setigera*, *Paspalum flavidum* and *Setaria pallidogusca*.

Two other types of Riverine forest as described by Stainton (1972) occur in areas outside the present park boundaries. Tropical deciduous riverine forests occur on the west bank of Naryani in patches of almost pure stands of Jamun (*Eugenia jambolona*). A few patches of tropical evergreen forest with species like *Albizia Sp.*, *Litsea monopetala*, *Mangifera indica* etc occur in the Bodreni forest adjacent to the park boundary.

(3) Grasslands:

The grasslands in the park form diverse and complex communities of several species and occupy about 20 % of the park area.

Laurie (1978) reported over 40 species of grass from the Saurah area alone. Since grasslands formed one of the main habitats in my intensively studied area, they were described in detail in the next chapter. In addition to Saurah, other area with large patch of grassland occur around Tiger Tops.

2.9 The Fauna

Nepal lies at the junction of the Palaearctic and Oriental zones resulting in great faunal diversity in the country. Over half the total number of bird species found in South and South-East Asia are recorded in Nepal (Fleming *et al* 1976), 350 of which have been recorded in Chitwan. However the mammalian fauna is restricted to the Oriental species of the sub-tropical region of the Indian sub-continent.

A check list of birds, mammals and reptiles is given in Bolton (1975) and the Aberdeen University Expedition Report (1980) provides a detailed list of fish in the park. Thus I have only provided a summary of the main species. The scientific nomenclature, common

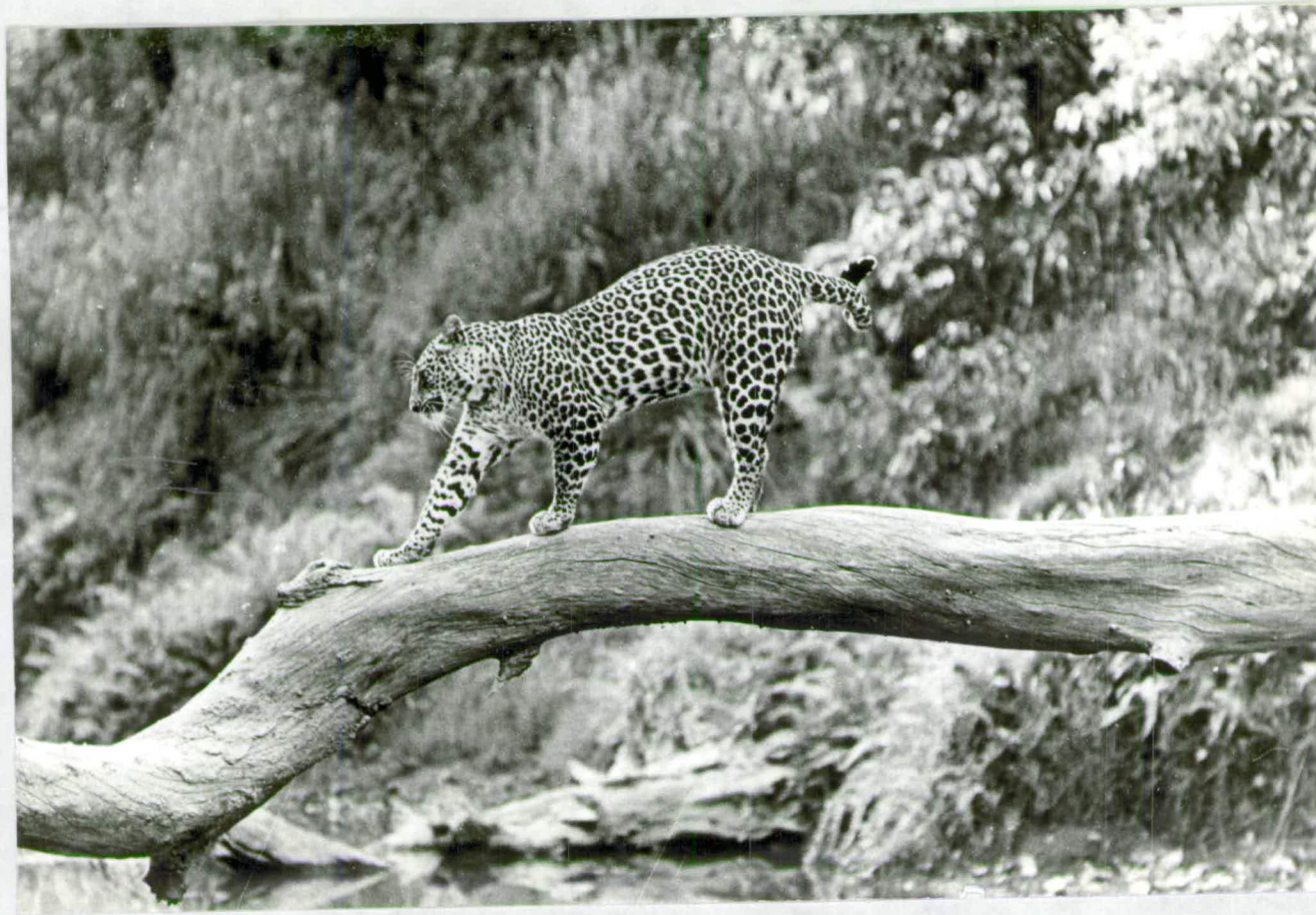


The omnivorous sloth bear (*Melursus ursinus*) is distributed throughout the park.

English name and Nepali name are according to Ellerman and Morrison-Scott (1964), Prater (1965), Mishra and Miesow (1974) and Majpuria (1981).

The national park contains the second largest population of the great one Horned Indian rhinoceros (*Rhinoceros unicornis*) in the world after Kaziranga National Park in India. The estimated population in Chitwan is about 300 individuals (Laurie, 1978). The park is also one of the strongholds of the tiger (*Panthera tigris*); its current population is estimated to be about sixty (Smith and Mishra, 1981). Other carnivores include the leopard (*Panthera pardus*), wild dog (*Cuon alpinus*), jackal (*Canis lupus*) and fox (*Vulpus bengalensis*). The omnivorous sloth bear (*Melursus ursinus*) is also common in the park. The ungulate species include the gaur (*Bos gaurus*), wild swine (*Sus scrofa*) and four species of deer which are described in more detail in the following chapters. The Swamp deer (*Cervus duvauceli*) were present in marshy areas until the 1960's but are now extinct in Chitwan. Smythies (1942) reported wild Asiatic buffalo (*Bubalus bubalis*) in Chitwan, but these are also extinct. Wild Asiatic elephants (*Elaphus maximus*) have formerly occurred in the Chitwan (Spillet and Tamang 1966) valley but at present only one group consisting of 10-12 animals has been reported in the south-eastern corner of the park on the other side of the Churia hills (Mishra 1980). However domestic elephants are commonly seen in Chitwan. At present there are 42 animals in areas adjacent to the park, over half of which are owned by the Government and used for park related activities.

Aquatic vertebrates include the rare Gangetic dolphin or Saus (*Platanista gangetica*), the mugger or marsh crocodile (*Crocodylus palustris*) and the endangered gharial (*Gavialis gangeticus*). Gharials are presently being bred in captivity and released in the wild (Mishra



The Leopard (*Panthera pardus*) is distributed along the edge of the park

and Maskey, 1982).

Smaller mammals include two species of monkey (*Macaca mulatta* and *Presbytis entellus*), porcupine, martens, civets, voles, rats, hares, otters, mongoose and others about which very little is known.

2.10 Land use around the Park:

The Tharus are the only indigenous people in the area and little is known about their origin in Chitwan. Their way of life differs from that of the more recent settlers from the hills. Although people of all castes and from all parts of Nepal are found in Chitwan, Tamangs form the majority.

The agriculture and land use pattern in the Chitwan valley is similar to most of the inner Terai. Berry *et al* (1974) described the traditional system of farming in the adjacent Nawalpur district and recently Milton and Binney (1980) described the seasonal cycles of planting and harvesting in areas adjacent to my study site. As in most of Southern Nepal, rice (*Oryza sativa*) is the main crop. Normally it is planted in June - July and harvested in November - December, however in areas with a permanent water source it can be planted and harvested earlier. On such land dal (pulses) are planted after the rice harvest. Maize (*Zea mays*) is planted before the monsoon in the drier and sloping ground and is harvested in August - September. The major winter crops are wheat (*Triticum arvense*) and mustard (*Brassica* sp). These are planted after the rice harvest and are harvested four to five months later. Domestic cattle are often allowed to graze on recently harvested land and their dung is left in the field, thus providing fertilizer for the next crop.

Barley (*Hordeum vulgare*) and millet (*Paspalum scrobiculatum*) are planted in some wetter areas. Chillies (*Capsicum annum*) and tobacco



Grass cutting commences around the middle of January
when over 100,000 people harvest the tall grasses.

(*Nicotiniana tabaccum*) along with some fruits such as banana (*Musa balbisiana*) and mangoes (*Mangifera indica*) are planted near villages.

Farming techniques are primitive compared with those of the economically developed countries. Ploughing is done with bullocks. Irrigation channels are dug annually leading from major water sources. Stock include domestic cattle and water buffaloes which provide both milk and bullocks for ploughing and pulling carts. Goats and sheep are kept; the male offspring of the former are often castrated and provide meat.

The human ecology and socio-political features in the National Park are described by Milton and Binney (1980) and Mishra (1982). The description of the people and their culture is given in Bista (1967).

2.11 Factors affecting the Ecosystem of the Park:

(1) Grass cutting:

Since 1978 local villagers have been permitted to enter the park to collect grass for building materials. Most houses in Chitwan are roofed with thatch grass, and canes of tall elephant grass have been traditionally used to construct walls and partitions. The park is the only area where these materials are available. Consequently villagers come to the park from up to 50 kilometers away and every year over 100,000 people enter the park and harvest the grasses. The grass cutting season starts during the second half of January and lasts for a period of 15 days. It is estimated that over 66,800 tons of grass is removed annually from the park area (Mishra 1982).

(2) Burning:

Annual burning in the Chitwan valley is an ancient human practice (Bolton 1975; Laurie 1978). The grassland and the surface litter of the sal forests are burnt between January and April. Early fires are



Fire starts during the grass cutting and
continues until the beginning of monsoon.

32

made by villagers after the thatch grass harvest. The fire burns the leaves and young dry shoots of dense grasses, leaving the stems and reeds clear which are then cut. Late fires during the dry, windy period from March to May are also induced by humans, but can also be caused by lightning (Wharton 1968). Annual fires seem to maintain the grasslands and a few species of shrub. Semal (*Bombax ceiba*) is the only fire resistant tree and is encroaching the grassland (Troth 1976). Regrowth of grasses after burning is rapid and they often reach 2 - 3 metres in height before the first monsoon shower.

(3) Tourism:

The Royal Chitwan National Park is a popular destination for overseas tourists visiting Nepal. The Tiger Tops and the Saurah sectors are the two main destinations. Every year over 8000 tourists visit Chitwan with an average stay of 2 nights in the park. Government restrictions of tourist concessionaires and control of the use of domestic elephants used by visitors has kept the effect of tourism to a low level. Furthermore high costs and lack of proper facilities have helped to keep the number of visitors to a manageable level.

(4) Other human disturbance:

The National Park and its concessionaires employ over 500 people who dwell inside the park. There is very little other human disturbance in the National Park and this is also limited to the fringes. Poaching of large mammals is negligible though thatch grass, bamboo and fuel wood are occasionally stolen. Some grazing encroachment occurs; it is restricted to isolated areas along the fringes. However, the rivers are heavily fished mainly by the Bote people who depend upon fish for their livelihood. The domestic elephants are regularly grazed inside the park area and several species of trees are lopped to provide fodder. However their impact on the vegetation of the park has not yet been studied.



The Tharus are the only indigenous people in Chitwan

CHAPTER 3

3. THE MAIN STUDY AREA

3.1 Introduction:

The study was concentrated on the north-eastern sector of the park, in the Saurah area. The study area covered approximately 35 sq. km. and enclosed all the main habitats of the National Park. On the east the area is surrounded by the village lands of Bhimpur Panchyat while on the west it is bounded by Sal forest and grasslands. The Rapti River demarcated the study site on the north and sal forest of the Churia slopes formed the southern boundary. The study area also included a small island (Itcharni) on the Rapti river at Saurah (Fig. 3.1). The Rapti river was only crossable by jeep at Saurah during the dry season. However, it could be crossed throughout the year by dugout canoes or on the back of domestic elephant.

The geology, soil and climate of the area is similar to that described previously (Chapter 2). However, the vegetation, particularly the grass lands, were distinct and more diverse than in most of the other areas of the national park. In the study area I recognised 5 main types of habitat. For convenience, I selected to use the local vernacular names in describing each of these habitat types:

3.2 The Sal Forest:

Approximately 39 % of the area was covered with sal forest and the vegetation type is similar to subtropical deciduous sal forests (Stainton 1972) that has been described previously (Chapter 2).

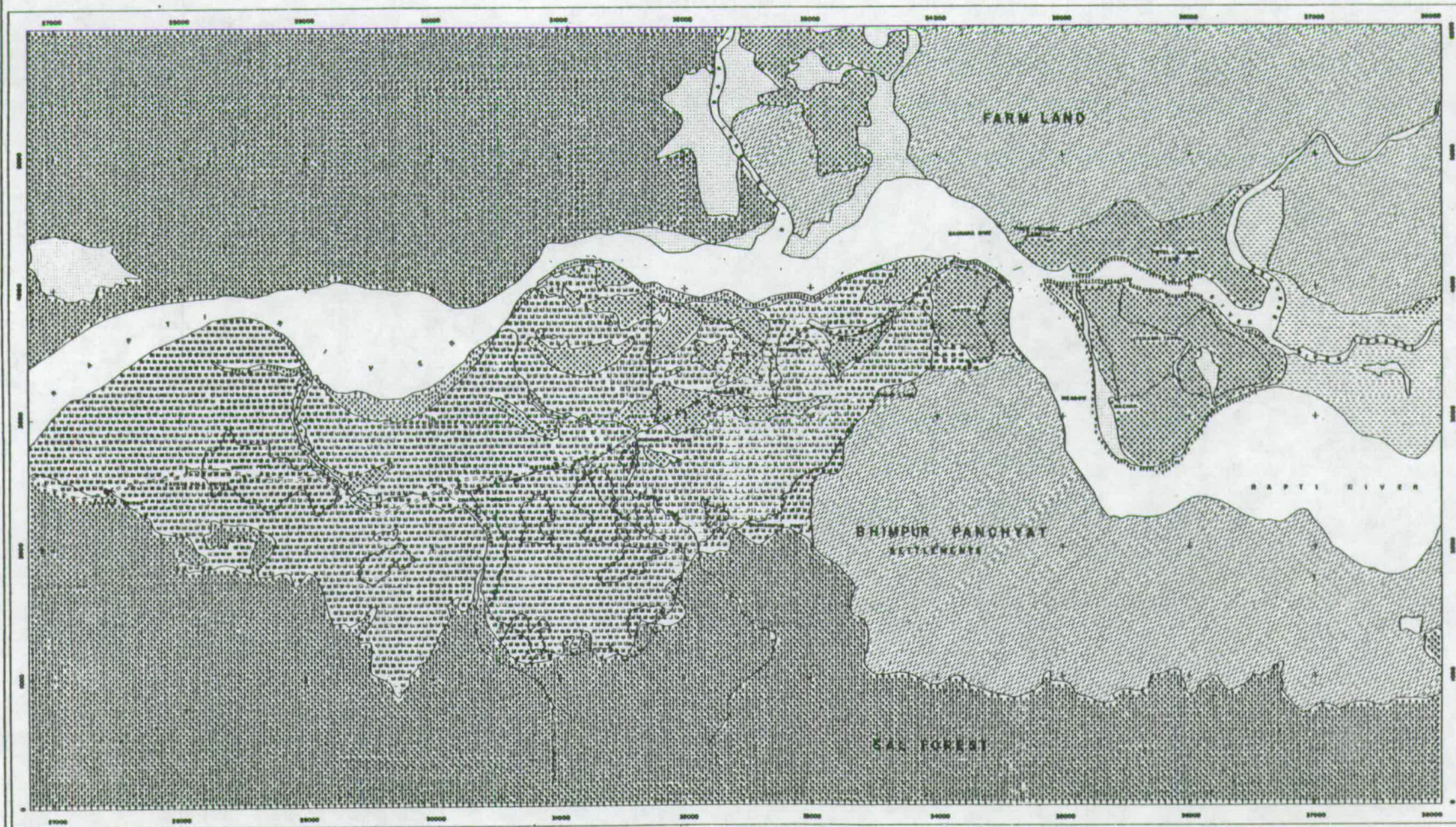
3.3 The Riverine Forest:

Of the main types of Riverine forest described previously, only the Semal-Vhellar (*Bombax ceiba-Trewia nudiflora*) were found in the study area. Except for a large patch covering approximately 2 sq.km.

FIG 3.1

TIGER ECOLOGY PROJECT

INTENSIVE STUDY AREA VEGETATION MAP AXIS DEER STUDY

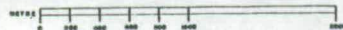


LEGEND

- OLD VILLAGE SITES
- MEADOWS
- FARM LAND
- SAL FOREST
- SALVING FOREST
- SAVANNA (SHADI TALL GRASS LAND)



SCALE





The old village sites mainly consist of the **thatch**
grass (*Imperata cylindrica*)

at Itcharni Island, most of the riverine forest was distributed in small patches. The vegetation is similar to the Tropical Deciduous Riverine Forest (Stainton 1972) described in the previous section. The Riverine forests occupied approximately 21 % of the main study area.

3.4 The Grasslands:

I have distinguished 3 main types of grasslands.

1. The Savannah-Dhaddi:

Dhaddi is local general term for tall and dense patches of grassland referred to as "Elephant grass". Approximately, 19% of the study area was under this type of habitat. This tall grass association can be further sub-divided into 3 categories (Laurie 1978):

- (i) The *Themeda villosa* forms dense and tall stands of over 6 metres in height in openings in the Sal forest;
- (ii) The *Saccharum* - *Narenga* association grows to a height of 8 metres as mixed stands with other grasses or as pure pockets. Younger trees of *Bombax ceiba*, *Trewia nudiflora* and *Bauhinia* spp are often scattered throughout the grassland as a woodland Savannah.
- (iii) The *Arundo* - *Phragmites* spp associated with *Saccharum* spp, *Typha elephantina* and *Cyperus* spp form a dense cover of grassland over 7 metres in height around lakes, nalas and old stream beds.

2. The Old Village Khar-Jhaksi:

This type of grassland is mainly restricted to old village sites that were abandoned in 1964, when people living inside the present park boundary were resettled outside. This type of grassland mainly consists of *Imperata cylindrica* or "thatch grass" occurring in almost pure



The River Bank kans (*Saccharum spontaneum*)
stretches along the southern bank of the Rapti.

patches with *Saccharum* spp clustered sparsely. Grass in this type of habitat is shorter than that described previously and heights vary from 1 to 2 metres. *Imperata cylindrica* is greatly in demand as roofing material in the whole district and consequently this type of grassland is the first to be harvested and burned during the grass cutting season (Chapter 2). Old village sites were scattered on approximately 15 % of the study area.

3. The River Bank Kans:

Kans (*Saccharum spontaneum*) is the first species to colonize dry river beds and it forms almost a homogeneous patch along the southern bank of the Rapti river. On elevated ground *Saccharum spontaneum* is interspersed with *Saccharum munja*, *Eranthus ravennae* and *Narenga* spp. which represents a later stage of plant succession. Bor (1960) stated that *Saccharum spontaneum* is replaced by *Narenga* spp. and other species of grasses if the area is repeatedly burnt. Approximately 6 % of the study area was occupied by this type of vegetation.

There are permanent sources of water throughout the study area. The eastern part of the study area particularly around Itcharni Island is one of the main tourist destinations since it has a high density of rhinoceros (Laurie 1978). The grasslands particularly the Savannah Dhaddi and the old village sites were the principal sites where the local people obtained thatch and other grasses during the grass cutting season.

CHAPTER 4

4.

THE STUDY SPECIES

4.1 Introduction:

The Royal Chitwan National Park is one of the few remaining areas in Asia where 4 species of deer, the Chital, hog deer, sambar and the barking deer co-exist in the same environment. A fifth species, the swamp deer (*Cervus duvauceli*) was present in marshland north of the Rapti river until the early sixties, but has now disappeared as these areas came under cultivation. There is a specimen of the tiny mouse-deer or Indian Chevrotan (*Tragulus meminna*) in the National Museum in Kathmandu, which is reported to have been collected from Chitwan nearly five decades ago, but at present there is no evidence of its occurrence in Chitwan. The 4 species presently common in Chitwan are briefly described below.

4.2 The Chital or Axis deer or Spotted deer (*Axis axis*) Erxleben:

1. Nomenclature: The chital belongs to the genus *Axis* with 3 other species (Walker 1964). The hog deer (*Axis porcinus*) is described below, Calamian deer (*Axis calamianensis*) occurs only in the Calamian Island of the Philippines, and the Bawean deer (*Axis kuhli*) is only found in Bawean Island in Indonesia. There is some confusion on the exact nomenclature of this genus. Lydekker (1898) regarded the Axis as a sub-genus of *Cervus*. However, Simpson (1945) and Ellerman and Morrison-Scott (1964) recognise it as a separate genus with the Sri Lanka chital as a sub-species (*Axis axis ceylonensis*) separate from those of India and Nepal (*Axis axis axis*). More recently, Koopman (1967) and Lekagul and McNeely (1977) have also grouped them under the genus *Cervus*. Flerov (1952) considered the Axis to be among the most primitive of the true Cervids having been present during the Pliocene



The chital (*Axis axis*) is only indigenous to the Indian sub-continent.

and Pleistocene in Europe and Asia. The earliest description of this animal is found in the religious books of Hindu mythology, the Ramayana, Mahabharata and the Vedas (2000 - 1500 B.C.).

2. Distribution: The chital is only indigenous to Sri Lanka, India, Bangla Desh and Nepal. The Gir forest of Gujrat, India forms the western limit to its distribution, from where it extends eastwards through most northern provinces of India except the Punjab (Russell 1900). Assam (India) forms its eastern limit.

In Nepal, it is distributed throughout the Terai with major concentrations in parks and reserves of the southern region (Fig. 1.2). They are also found in the Nagurjun and Gokarna forests of Kathmandu.

Eight chital were introduced to the Hawaiian Islands of Molka and Lanai in 1868 and the population now numbers about 5000 to 6000 (Graf and Nichols 1966). The chital were also introduced in Texas around 1932 and appear to be thriving well (Ables, 1974). Whitehead (1972) reports that they have also been introduced into parts of Australia, Argentina and Brazil.

3. Size: Adult males ~~captured in~~ Chitwan measured about 90 cm at shoulder height and weighed 71 kg on average. Females measured about 75 cm at shoulder height and weighed 50 kg on average.

4. Distinctive characters: The chital has a clean, well groomed coat which is bright rufous in colour, and profusely marked with distinctive white spots. These spots are retained from birth to death, a characteristic not found in other Cervidae. A dark strip runs down the spine from the nape to the tip of the tail. The abdomen, rump, throat, and the insides of ears, legs and tail are white. There is no seasonal difference in the colour or pattern of the coat. Albinism

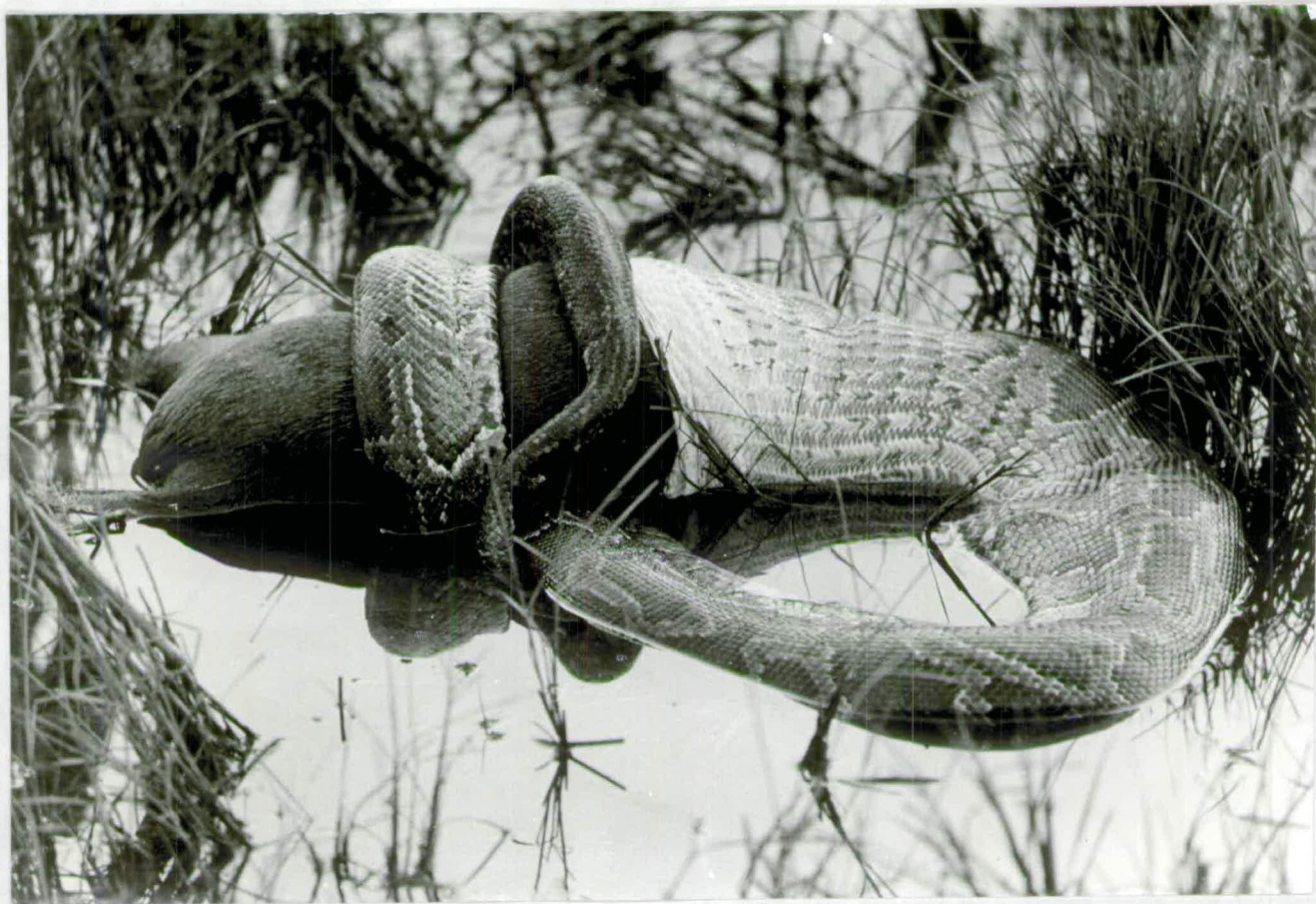
has been known to occur but melanism is rare (Bahadur 1942; Graf and Nichols 1966). The hair of the coat is soft, shiny and kept constantly clean by regular licking. Sebaceous and apocrine glands located at the base of the hair shaft exude an oily liquid and this gives the coat a glossy appearance (Graf and Nicholls 1966). However the coat of the fawn is longish, slightly shabby and less glossy. The infra-orbital gland located below the corner of the eye produces a secretion with a characteristic mild smell. The upper jaw contains no incisors nor canines but carries 3 premolars and 3 molars on each side. The lower jaw has 3 pairs of incisors, 1 pair of canine (often not noticeable in adults), 3 pairs of pre-molars and 3 pairs of molars.

Antlers rise from bony pedicles about 2 cm long and have a distinct burr at the base. Adults have three-tiered antlers with a brow tine growing almost at right angles to the main beam. The beam forks near the top with a longer outer tine forming a continuation of the main beam. A frontal view of well formed antlers gives a harp like appearance. Antlers are brownish in colour with ivory like tips. The longest beam length of antler recorded is 101.1 cm (Ward 1922).

4.3 The hog deer (*Axis porcinus*) Zimmerman:

1. Nomenclature: The hog deer belongs to the same genus as the chital and two sub-species are recognized (Whitehead 1972). The hog deer of Nepal, India, Sri Lanka and Burma (*Axis axis porcinus*) is distinguished from a slightly larger race (*Axis axis annamiticus*) of southern Thailand, Indio-China and Malaya.

2. Distribution: The hog deer has a much wider distribution than the chital. It is distributed throughout the alluvial grasslands of northern India, extending eastwards to southern Nepal, Burma, Thailand and Indo-



One hog deer (*Axis porcinus*) is swallowed by the Indian Python(*Python molurus*) in the study area.

China (Prater 1965; Lekagul and McNeely 1977). It does not occur in central or peninsular India (Schaller 1967) but is found in Sri Lanka, where, it is believed to have been introduced by the Dutch during the 16th century (Whitehead 1972). They were introduced in Australia around 1970 but very little is known about their status in exotic environments (Whitehead 1972).

Since most of the grassland habitat has been lost to agriculture, hog deer at present are restricted to a few pockets in the Indian Sub-Continent. In Nepal, hog deer are mainly concentrated in Chitwan, Karnali Bardia and Suklaphanta.

3. Size: Adults stand 60 to 75 cms high and weigh 30 to 45 kg, with males slightly bigger than females (Prater 1965).

4. Distinctive characters: The hog deer gets its name by its squat pig-like appearance particularly during movement. Though belonging to the same genus as the chital, an adult hog deer does not have distinctive white spots on its greyish coat. Antlers consist of a short brow tine and a straight beam with a fork at the top.

Hog deer have been known to interbreed with chital in captivity (Crandall 1964). In Chitwan, on two occasions, I came across deer that had chital like bodies but hog deer like antlers. Hybrids can be seen at the Gokarna forest in Kathmandu.

4.4 The Sambar (*Cervus unicolor*) Kerr

1. Nomenclature: The sambar (*Cervus unicolor*) is not only the largest deer of southern Asia but also the most widespread in distribution. A total of 16 sub-species have been recognized of which the Sri Lanka sambar (*Cervus unicolor unicolor*) is distinguished from that of Nepal

and India (*Cervus unicolor niger*).

2. Distribution: The sambar is distributed from the dry thorn forest of Western India to the tropical rain forest of Thailand, Burma, Malaysia and in the Islands of Indonesia, Philippines and Formosa. It is found from sea level to almost 3000 metres in the pine and oak forest of Bhutan. This deer has also been introduced in Australia and New Zealand where they are reported to be thriving well (Whitehead 1972).

In Nepal they are distributed throughout the terai and in the forest of Nagurjun and Gokarna around Kathmandu.

3. Size: Males average about 140 cm at shoulder height and females are slightly smaller. Weight of adult males in Nepal varied from 200 to 300 kg while females scaled between 150 to 200 kg (DNPCO records 1980).

4. Distinctive characters: Sambars have a coarse brownish grey coat with pale under parts. Mature stags have a mane around the throat and are slightly darker in colour than hinds. Antlers are stout, rugged and bigger than any of the other deer in Chitwan. They measured 90 to 100 cm and have a brow tine set at an acute angle to the beam. The beam forks into almost equal tines at the top.

4.5 The barking deer or Indian muntjak (*Muntiacus muntjak*) Zimmerman.

1. Nomenclature: There are five species and about 15 sub-species of this genus in southern Asia. The Indian muntjak or barking deer (*Muntiacus muntiacus vaginalis*) of Nepal, Northern India, and Bhutan is distinguished as a separate race from that (*M. m. aureus*) of central India. The barking deer of southern India and Sri Lanka is also



The Sambar (*Cervus unicolor*) is the largest of all the deer of Asia.

regarded as a separate race (*M. m. malabaricus*).

2. Distribution: The barking deer is distributed throughout Asia from sea level to 3000 metres in the Himalayas. It has also been introduced to private parks and gardens in Europe.

3. Size: The barking deer is the smallest deer of Chitwan. Adult males stand about 50 - 60 cm at shoulder and scale about 20 to 25 kg. Females are slightly smaller (Prater 1965).

4. Distinctive characters: The animal takes its name from its call which is a dog-like bark. The antlers are set on prominent, long, hair-covered pedicles and consist of a short brow tine and an unbranched beam. The upper canines in males are well developed and are used in self defence (Prater 1965). Both males and females have a rust coloured coat with pale underparts.

The most peculiar fact about this species is that it has the lowest number of diploid chromosomes (7 in male and 6 in female) yet described in any mammal (Wurster and Bernischke 1970). It is also the most primitive species of its order and is also regarded to be the ancestor of the living families of artiodactyls (Colbert 1969; Dubost 1971; Godina *et al* 1962; Barrette 1977).

CHAPTER 5

5.

MATERIALS AND METHODS

5.1 Introduction;

Two major difficulties are encountered when field research is conducted in Chitwan National Park. Firstly the vegetation especially the grass ~~is~~ amongst the most dense and tall to be found anywhere. To preserve the natural qualities of the area, the road network has been kept to the minimum. Thus mobility is a very severe problem. Secondly, there are many potentially dangerous animals especially rhinoceros, sloth bear, leopard and tiger. The use of domestic elephants is thus essential for mobility and safety and my field methods were largely dependent on the use of trained elephants and the personnel attached to them.

In this section I describe the general methods used in the study, equipment, material and techniques used for catching deer and radio telemetry methods. Description of methods associated with specific aspects of the study are given in relevant chapters.

5.2 Direct Observation:

Direct observation was used extensively to investigate habitat utilization, social structure and breeding seasons. Water supplies and suitable feeding areas are not highly localized in Chitwan as they are in many other areas in the Indian sub-continent such as Khana National Park, India. This combined with the dense vegetation and movement of predators makes observation from fixed points relatively unprofitable. A better strategy is to go out and search for the animals. Thus my observations were made by traversing quietly through the forest on the back of an elephant along a grid, 1 metre wide cut specifically for the study. The grid line was marked at regular intervals to

estimate the proportion of each habitat.

The total length of the transect was 52.4 km of which 25.0 km was in the Sal forest, 9.9 km in the Riverine forest, 9.1 km in Savannah Dhaddi, 4.6 km in Old village and 3.8 km in River Bank kans. Sightings were recorded on a predesigned card with one card per sighting; the format was consistent for all species at all times. Date, time, species and the activity first sighted were recorded on the card. The total number of the group and numbers in different sex and age classes (Chapter 8) were also noted. The state of antlers in the males (Chapter 7) and notes on behaviour were also made. In addition to the ungulates, I kept records of the sightings of other large mammals such as the sloth bear, wild dogs, leopard and tiger (Table 5.1) to provide records for future reference by the national park staff.

During the period of 3 years from June 1978 to May 1981, a total of 6506 groups consisting of 27,319 individuals were sighted. Among these, the ungulates comprised 6,358 sightings consisting of a total of 27,107 individuals. (Table 5.1 and 5.2). Most animals were sighted between-06.00 hours,-10.00 hours and 15.00 hours - 19.00 hours with only a few sightings during the middle of the day (Table 5.4). The sighting frequencies were highest during the pre-monsoon months of February to May, when it was dry and hot. Most of the area is burnt during this season following a harvest of grasses in January; thus the visibility was better than at other times of the year.

5.3 Capture Techniques:

There is very little information on the techniques used to capture Asiatic ungulates in the wild and there was no information or reliable methods to capture wild chital for scientific study. Thus I had to experiment with techniques, which are described below.

TABLE 5.1: Sighting frequencies of groups by month.

ROYAL CHITWAN NATIONAL PARK, 1978-1981

Month	Chital	Hog deer	Sambar	Barking deer	Wild Boar	Rhino	Gaur	Sloth bear	Leopard	Tiger	Wild dog
Jan.	116	24	69	24	15	46	-	4	7	3	-
Feb.	313	116	114	24	27	51	3	16	5	1	1
Mar.	419	213	147	52	65	137	14	25	4	-	2
Apr.	320	186	100	64	98	111	15	14	2	6	-
May	379	77	122	99	62	98	9	15	6	1	-
June	152	46	59	41	53	101	-	3	2	1	-
July	125	16	45	26	17	94	-	-	1	1	-
Aug.	183	28	79	45	14	98	-	2	1	1	-
Sept.	185	52	76	32	9	73	-	1	2	-	-
Oct.	164	36	21	32	16	32	-	3	1	-	-
Nov.	129	20	25	36	8	41	-	1	3	-	-
Dec.	201	29	60	59	32	39	-	6	4	2	1
Total	2686	843	917	534	416	921	41	90	38	16	4



TABLE 5.2: Number tallied/Month

ROYAL CHITWAN NATIONAL PARK, 1978-1981

Month	Chital	Hog deer	Sambar	Barking Deer	Wild boar	Rhino	Gaur	Sloth Bear	Leopard	Tiger	Wild dog
Jan.	584	54	113	25	43	66	-	5	10	3	-
Feb.	2800	258	196	29	70	82	10	18	6	1	3
Mar.	4163	441	245	59	131	233	100	36	4	-	13
Apr.	2882	421	176	71	193	182	95	22	2	6	-
May	2455	146	230	121	145	189	185	18	6	1	-
June	995	150	121	49	149	179	-	4	2	1	-
July	724	46	75	27	34	191	-	-	1	2	-
Aug.	1588	49	126	60	28	170	-	6	1	1	-
Sept.	1447	194	121	37	24	149	-	3	2	-	-
Oct.	858	73	25	38	32	51	-	7	1	-	-
Nov.	649	25	33	39	16	62	-	1	3	-	-
Dec.	970	39	91	75	46	59	-	9	7	2	5
Total	20115	1896	1552	630	911	1613	390	129	45	17	21

TABLE 5.3: Sighting Frequencies of groups by Time (Nepal Standard Time: NST)

Time (NST)	Chital		Hog deer		Sambar		Barking deer		Wild boar		Rhino		Gaur		Sloth bear		Tiger		Leopard		Wild dog	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Before 06.00 hr.	136	5.1	37	4.4	47	5.1	29	5.4	30	7.2	86	9.3	2	4.9	1	1.1	3	18.8	2	5.3	-	-
06.00-06.59	349	13.0	114	13.5	112	12.2	103	19.3	72	17.3	124	13.5	10	24.4	8	8.9	2	12.5	3	7.9	1	25.0
07.00-07.59	329	12.2	116	13.7	108	11.8	88	16.5	30	7.2	108	11.7	14	34.1	4	4.4	-	-	2	5.3	-	-
08.00-08.59	330	12.3	74	8.8	99	10.8	64	12.0	29	7.0	61	6.6	5	12.2	7	7.8	1	6.2	5	13.2	-	-
09.00-09.59	188	7.0	54	6.4	40	4.5	26	4.9	15	3.6	32	3.5	-	-	5	5.6	-	-	1	2.6	-	-
10.00-10.59	81	3.0	20	2.4	22	2.4	18	3.4	8	1.9	11	1.2	-	-	2	2.2	-	-	-	-	-	-
11.00-11.59	51	2.0	16	2.0	14	1.5	6	1.1	5	1.2	10	1.1	-	-	2	2.2	-	-	1	2.6	-	-
12.00-12.59	59	2.2	11	1.3	18	1.9	8	1.5	4	1.0	5	0.5	-	-	6	6.7	-	-	-	-	-	-
13.00-13.59	61	2.3	12	1.4	19	2.1	3	0.6	4	1.0	10	1.1	-	-	3	3.7	-	-	-	-	-	-
14.00-14.59	66	2.4	15	1.8	23	2.5	4	0.7	4	1.0	9	1.0	-	-	4	4.4	-	-	-	-	-	-
15.00-15.59	108	4.0	33	3.9	48	5.2	23	4.3	8	1.9	33	3.6	-	-	6	6.7	-	-	3	7.9	-	-
16.00-16.59	317	11.8	71	8.4	129	14.1	63	11.8	48	11.5	149	16.2	3	7.3	11	12.2	-	-	7	18.4	1	25.0
17.00-17.59	405	15.1	160	19.0	153	16.7	64	12.0	93	22.3	167	18.1	4	9.8	15	16.7	5	31.3	8	21.0	1	25.0
18.00-18.59	175	6.5	95	11.2	69	7.5	31	5.8	59	14.2	89	9.7	2	4.9	14	15.6	1	6.2	5	13.2	1	25.0
After 19.00	31	1.1	15	1.8	16	1.7	4	0.7	7	1.7	27	2.9	1	2.4	2	2.2	4	25.0	1	2.6	-	-
Total	2686	100	843	100	917	100	534	100	416	100	921	100	41	100	90	100	16	100	38	100	4	100

1. Drive Technique: This method consisted of driving chital into a concealed net using elephants and the Whit cloth. The latter is a local vernacular term to describe 10 to 15 sections of white cloth of about 3 x 40 metre, which was hung in such a way that it formed a funnel to drive animals towards a fixed point. A camouflaged net measuring 2 x 14 metre was loosely stretched across the deer trail so that it collapsed and entangled the animal as soon as it hit the net. Domestic elephants were used to drive the wild animal towards the net and an observer hiding in a tree close to the net administered an immobilizing drug on any entangled deer. Different doses of the drug (Rompun or Xylazine) were used depending upon an estimate of the animal's weight.

The Whit cloth technique was invented in Nepal during the early part of the last century and was the standard method of tiger hunts of bygone days. Though this technique worked well in driving tigers, I observed some sambar jumping over the cloth. If the beat was noisy, the chital also sometimes crashed through the cloth. The success of capture of chital by this technique was very low. Approximately 15 attempts were required to catch one deer. One of the main reasons for the failure of this technique for catching chital was that other species also got caught or dropped the net before the chital was driven into it. In addition to the cervids, animals such as the tiger, sloth bear, leopard, rhinoceros and the wild boar got entangled in the net. Fortunately the net was not strong enough to hold all the animals for a long time with the exception of two wild boars, which had to be tranquilized before release. One sambar died as a result of breaking its back and two chital in velvet broke their antlers after they crashed into the net. Thus this method is not advisable for areas like Chitwan which harbour many different species even though the technique is relatively

TABLE 5.4: CAPTURE METHODS, DRUG DOSES AND EFFECTS OF ROMPUN (XYLAZINE) AND OTHER DRUGS ON WILD CHITAL :
ROYAL CHITWAN NATIONAL PARK

No.	Method Capture	Sex/age Class	Wt (Kg)	Drug	Dose (Ml)	Dose Mg/Kg	Duration Sedated (Minutes)	Effects Sedation	Remarks
1	Drive	Yr.M	38	Rompun	0.5	1.3	40	Slight	
2	Drive	Adult.F	55	Rompun	1.5	2.7	27	Slight	
3	Drive	Adult.M	65	Rompun	1.5	2.3	71	Deep	
4	Drive	Adult.F	52	Rompun	1.5	2.9	112	Deep	
5	Darting	Adult.F	56	Rompun	0.5	1.9			
				M.99	1.0	0.22	90	Deep	
				Acp.	0.5	0.09			Acp = Acepromazine
*	Darting	Adult.F	53	Rompun	1.0	1.9			*= No number assigned
				M.99	1.0	0.02	105	Deep	Animal died within 2 hours
									Deer not captured
*	Darting	Adult.M	NA	Rompun	2.0	NA	NA	NA	
6	Can.Net	Adult.F	45	Rompun	1.0	2.2	40	Medium	
7	Drive	Adult.M	49	Rompun	0.7	1.4	83	Deep	
8	Drive	Adult.M	58	Rompun	1.5	2.6	30	Slight	
9	Drive	Adult.M	85	Rompun	1.6	1.9	55	Deep	
10	Drive	Adult.M	60	Rompun	1.0	1.9	20	Slight	
11	Drive	Adult.M	70	Rompun	1.0	1.4	35	Medium	
12	Drive	Adult.F	40	Rompun	1.0	2.5	50	Medium	Found dead in 12 hours
13	Can.Net	Adult.F	45	Rompun	1.5	3.3	125	Deep	
14	Can.Net	Adult.F	54	Rompun	2.0	3.7	440	Deep	Longest Sedated Chital
15	Can.Net	Adult.F	50	Rompun	2.0	4.0	17	Slight	Found dead in 15 hours
16	Can.Net	Adult.F	58	Rompun	2.0	3.4	385	Deep	Second longest Sedation
17	Can.Net	Adult.M	80	Rompun	1.0	1.3	53	Deep	
18	Can.Net	Adult.M	75	Rompun	1.0	1.3	22	Medium	
19	Can.Net	Adult.M	63	Rompun	1.0	1.6	75	Deep	
20	Can.Net	Adult.F	NA		NA	NA	NA	NA	No drug Used
21	Can.Net	Adult.M	82	Rompun	1.0	1.2	45	Medium	
22	Can.Net	Yr.F	20	Rompun	0.5	2.5	44	Deep	
23	Can.Net	Adult.F	NA		NA	NA	NA	NA	No drug used
24	Can.Net	Yr.F	32	Rompun	0.5	1.6	155	Deep	
25	Can.Net	Adult.F	NA		NA	NA	NA	NA	No drug used
26	Can.Net	Adult.F	NA		NA	NA	NA	NA	No drug used
27	Can.Net	Adult.M	75	Rompun	1.0	1.3			
				Ketamine	0.5	0.7	55	Deep	Found dead in 24 hours
28	Can.Net	Yr.M	40	Rompun	0.5	1.3			
				Ketamine	0.5	1.3	13	Slight	
29	Can.Net	Yr.M	20	Rompun	0.5	2.5	50	Deep	
30	Can.Net	Yr.F	NA		NA	NA	NA	NA	No drug used
31	Can.Net	Yr.M	35	Rompun	1.0	2.9	45	Deep	Found dead in 24 hours
32	Can.Net	Yr.F	NA		NA	NA	NA	NA	No drug used
33	Can.Net	Adult.M	NA		NA	NA	NA	NA	No drug used
34	Can.Net	Adult.M	NA		NA	NA	NA	NA	No drug used
35	Can.Net	Adult.F	NA		NA	NA	NA	NA	No drug used
36	Can.Net	Adult.F	51	Rompun	1.0	2.3	57	Deep	
37	Can.Net	Yr.M	43	Rompun	1.0	2.3	135	Deep	
38	Can.Net	Yr.F	25	Rompun	0.5	2.0	163	Deep	

easy and economical in areas where labour is cheap and domestic elephants are readily available.

2. Darting: This technique consisted of the use of chemical drugs in a projectile syringe that was fired from a rifle at a free ranging chital. The equipment used was a Palmer "Capchur Gun" (USA) and is described by Young (1973). This technique had to be abandoned after only three attempts. In all three it took 30 minutes to one hour to find the tranquilized deer. On two occasions I used darts with radio transmitters but both times darts were dropped as the animal rushed through dense thickets: I ended up finding the dart first. One immobilized deer that was found lying in the sun after about one hour of darting died within the next hour. Though this technique caused the least amount of disturbance and trauma to the animal, it had to be abandoned since the chance of finding a drugged animal was low and the darting operation was too time consuming.

3. Cannon Net: This system consisted of four metal projectiles that carried a net when fired by the use of powered charges (explosives). The net would fly over deer that had been baited to a specific site and entangle them. A detailed description of the system is given in Giles (1969) and the cannon net used was obtained from Wildlife Materials, USA. This method requires some preliminary knowledge of the movement of deer and needs a relatively open site. Salt dissolved in water was poured at a site of the net. In Chitwan it usually took 1 to 3 days for the chital to be attracted to the salt lick. Four "cannons" attached to the net were covered by leaves and shrubs. An electrical wire ran between the net and a machan (tree hide) about 50 metres from the site. When the deer approached the front of the net, the rockets were fired by connecting the electrical wire to a car

TABLE 5.5: Drug dose (Rompun) Xylazine by weight class Chitals

DOSE		NUMBERS IN DIFFERENT WEIGHT (Kg) CLASS							
Mg/Kg	N	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90
1.0 - 1.5	6	-	-	1	1	-	1	2	1
1.6 - 2.0	6	-	1	1	-	2	1	-	1
2.1 - 2.5	6	2	-	1*	2	-	1	-	-
2.6 - 3.0	4	-	-	1*	-	3	-	-	-
3.1 - 3.5	2	-	-	-	1	1	-	-	-
3.6 - 4.0	2	-	-	-	1*	1	-	-	-
TOTAL	26	2	1	4	5	7	3	2	2

Rompun Mixed with Other Drugs

Rompun 0.9										
M.99 0.02	1	-	-	-	-	-	1	-	-	-
Acepromazine 0.05										
Rompun 1.9							1*	-	-	-
M.99 0.02	1	-	-	-	-	-	-	-	-	-
Rompun 1.3							-	-	1*	-
Ketamine 0.7	1	-	-	-	-	-	-	-	-	-
Rompun 1.3							-	-	-	-
Ketamine 1.3	1	-	-	-	1	-	-	-	-	-

* Animal died within 24 hours

battery. Deer trapped in the net were immobilized by an intramuscular injection of a drug. Despite an ear shattering noise this method was successful and most of the chital in this study were captured by this technique (Table 5.4). The salt bait also attracted other animals such as sambar, hog deer, rhinoceros, gaur and wild swine. One chital fawn died after being hit by the projectile, but other than this there were no incidents.

5.4 Drugs, Doses and their effects on Chital:

Drugs were administered to 31 chital of different sex/age classes and the effects of sedation were recorded (Table 5.4). Drugged animals were weighed to estimate the dose in Mg/Kg of body weight (Table 5.6). Rompun (*Xylazine*) solution (100 Mg/ML) was the main drug used either alone or mixed with other drugs (Table 5.5).

One attempt to immobilize an adult male by darting with 2.0 ML of Rompun did not result in the successful capture of the animal. Although the unsteady movements indicated the animal was under the influence of the drug, it was not possible to capture it. Another darting attempt using a mixture of Rompun (1.9 mg/kg) and Etrophine (0.02 mg/kg) resulted in the death of a doe within 2 hours. This drugged animal was found in the sun 45 minutes after darting, it died within the next hour. Etrophine is reported to raise the body temperature (Young 1973) hence over heating by the drug could have been the cause of death. However, one darting attempt was successful using a mixture of Rompun (0.9 mg/kg), Etrophine (0.02 mg/kg) and Acepromazine (0.09 mg/kg) to capture a doe that weighed 56 Kg. This deer was in a deep sedation for about 90 minutes after which it came out without use of the antidote (M 50:50). Mixture of Etrophine has also resulted in successful immobilization of the rhinoceros in Chitwan



Field Methods largely depended upon the use of trained domestic elephants.

Two attempts to immobilize chital were made by using a mixture of Ketaset (*Ketamine*) and Rompun. One sub-adult male weighing 40 Kg was administered 1.3 Mg/Kg of the former and the same dose of Rompun. The deer was sedated for only 13 minutes and the effects were only slight as the animal made several attempts to run away. Another male weighing 75 Kg that was administered a mixture containing the same dose of Rompun and 0.7 Mg/kg of Ketamine was found dead the next day within 500 metres of the capture site. This animal was under deep sedation for 55 minutes and ran away after giving the appearance of normal movement.

Rompun alone was administered to 26 deer that were caught by the drive technique or the cannon net (Table 5.4). Among these, 3 were found dead within the next 12 - 24 hours. All these animals were under sedation for less than an hour (Table 5.4) and their movements had appeared normal when they ran away. One of the dead does weighed 40 Kg and was injected with a dose of 2.5 Mg/Kg of Rompun. The other was a sub-adult male weighing 35 Kg and was given 2.9 Mg/Kg of Rompun. The third deer that died was an adult weighing 50 Kg and was administered 4.0 Mg/Kg of Rompun.

However, two young chital weighing 25 kg each were administered with a dose of 2.5 Mg/kg of Rompun and both survived after being in deep sedation of 44-50 minutes.

One doe weighing 54 kg was in deep sedation for 7 hours and 20 minutes on a dose of 3.7 Mg/kg and another doe that weighed 58 kg was in a deep sedation for 6 hours and 25 minutes on a dose of 3.4 Mg/kg of Rompun. However both recovered afterwards and lived. None of the deer that were sedated for over an hour died when Rompun was used alone



Captured Chital were immobilized

(Table 5.5), suggesting the importance of getting the animal deeply sedated so that it can wear off the effects of drug while asleep.

Many of the drugged animals, particularly those in a medium and slight sedation, reacted to the noise of elephants and people nearby and seemed to be stimulated by noises from the forest.

Despite 3 casualties, Rompun was found to be a safe drug for use on wild chital even though the deer captured by both the drive and the cannot net technique were subjected to some stressful conditions. The drug has an analgesic effect and is reported to depress the central nervous system (Sagner and Haas 1968; Clarke and Hall 1969; Hime and Jones 1970). The manufacturer of the drug (Chemagro Corp., USA) prescribes a dose of 2.2 Mg/kg, but, Hime and Jones (1970) have safely used almost double that dosage on a captive female chital in England. Young (1973) gave a figure of 8 Mg/kg as the maximum tolerable dose for African ungulates. Based on 26 samples from Chitwan, a list of Rompun dosages in Mg/kg on different weight class is provided (Table 5.5) and it appears that less than 3 Mg/kg may be the safest margin. The mixing of Rompun with other drugs was found to be risky as 2 out of 4 chital died by such a mixture.

The manufacturers of Rompun recommend that the drug should not be used on animals with a full stomach. Since it is not possible to observe this recommendation in the wild, it could have been the cause of death of some of the deer as autopsy indicated their stomachs to be full of plant material. Nine deer were collared without the administration of any drug (Table 5.4). Although it is possible to bring a deer entangled in a net under control with two to four people without the use of a drug; experiences from Chitwan illustrated that the animal was subjected to less stress if it was sedated by the use of Rompun.

5.5 Radio Tracking;

1) Equipment; The captured deer were fitted with a radio collar. The radio tracking equipment was supplied by the University of Minnesota, Bio-electronics Laboratory, Cedar Creek in the U.S.A. The radio collar had a two-stage transmitter and emitted pulse signals at the rate of 65-80 pulses per minute (Sunquist 1981). Each collar transmitted at a different frequency within the band of 164.000 to 165.000 MHz. Power was provided by two 2.8 v lithium batteries.

The receiver weighed about 1.8 kg and had a frequency control synthesiser in 1 KHz increments over 1 MHz band. Power to the receivers was provided by 12 internal 1.5 volt cells. A telex model 610-2000 headphone was used with the receiver. A directional hand held yagi antenna cut and tuned to 164.000 MHz was used.

2) Procedure: Reference points along the study area were marked at a regular interval of 100 metres with numbered metal plates. Prominent points such as roads, bridges and other topographic features also provided specific reference points. The study area was scanned daily by traversing along the marked and numbered trail cut through the forest. When a signal was received the position of the animal was determined by circling the animal at a close range of about 100 metres and by triangulation from marked reference points as described by Heezen and Tester (1967). The direction to the tagged deer was determined by rotating the antenna in an arc and finally zeroing it to a point where a maximum aural signal was heard at the minimum sound volume level of the receiver. A bearing of azimuth was taken using Sunnto (Finland) hand compass. A second bearing was taken from another known location about 100 to 300 metres apart. During radio tracking many reference points were available, but the position that was closest

to the animal was used to maximize the right angle intersection between the bearings and thus increase the accuracy of the location. The fixes or locations were plotted on enlarged maps (Scale 1.5 cm = 200 metres).

Radio tracking was done mostly from elephant back and occasionally by foot or motor vehicle. Time, date and notes about the habitat, locations, and where the reading was taken were recorded. The collared deer were sighted at times and their herd composition and notes on their behaviour were recorded. However, no attempts were made to pursue visual observations with the aid of radio to avoid disturbing the animal or shifting its position. If any animal transmitted from the same area continuously for a few days, attempts were made to sight the animal. In most of these cases the animals were found to have been killed by a predator. Among the 34 deer that survived, 5 were fitted with ordinary visual collars without radio transmitters. These animals were sighted less than 5 times indicating the difficulties of locating non-radio collared animals in Chitwan.

Some animals were lost due to predation (Chapter 10). Despite uniform effort throughout the study area, some animals were located more than others. Some radios stopped transmitting within a year while others transmitted for nearly 3 years. The frequencies of transmitters were not consistent in 4 of the receivers used often shifting to higher or lower values than suggested by the manufacturer. This frequency drift was more noticeable during the monsoon and the cold season.

Because of these variations I had to radio collar a large number of deer to ensure that the animals were not lost by predation or by transmitter failures.



Captured chital were fitted with a radio collar

CHAPTER 6

6.

HABITAT UTILISATION

6.1 Introduction;

The habitat in Chitwan is a complex mosaic of different plant communities (Chapter 3). Climatically, 3 seasons are distinct in Chitwan (Chapter 2). The pre-monsoon period between February to May is dry and hot with most of the grassland and undergrowth in Sal forest burnt. This is followed by a monsoon season when the tall grasses are in full growth and the climate is wet and warm. The post-monsoon period between October - January is cold and frosty. The relationship between habitat structure and its utilisation by different herbivores has been illustrated in the Serengeti Plains of Africa (Lamprey 1963; Bell 1970; Sinclair and Norton-Griffiths 1979) but such parallel examples are lacking in Nepal. The ungulates of Chitwan live in a seasonally changing environment. Presumably their pattern of habitat utilisation reflects an adaptation to these seasonal changes. The social organisation of the deer in Chitwan is discussed later (Chapter 8) and the objective of this section is to provide an insight into the seasonal variations in habitat utilisation by chital and to compare it with the other deer of Chitwan.

6.2 Methods:

The Riverine forest, Sal forest and grasslands are the 3 main types of habitats that have been recognised in Chitwan (Chapter 3). The grasslands were further distinguished into the River Bank Kans, Savannah Dhaddi and the Old Village sites (Chapter 4).

My methods consisted of observation from elephant back by traversing along set transects that passed through all habitats and has been described previously (Chapter 5). The proportion of transect in each habitat type was not equal. Of the total of 52.4 Km of transect, 3.8 Km

(7.3 %) were in the River Bank Kans; 9.9 Km (18.9 %) were in Riverine forest; 9.1 km (17.4 %) were in Savannah Dhaddi; 4.6 Km (8.8 %) were in Old Village sites and 25.0 Km (47.7 %) were in the Sal forest. Thus I computed a habitat preference rating index (HPI) by dividing the percentage of animals observed in each month in each habitat type by the percentage of transect traversed in each habitat (Hess & Swartz 1940; Piennar 1969; Petrides 1975).

METHODS (contd.)

The transects were covered in a systematic fashion so that the same total length was covered each month. In any one day only about one quarter of the whole transect system could be covered so that four days were needed to cover all the transect length.

The use of counts along transects to compare habitats and also seasonal changes within habitats carry the risk that the data obtained reflect changes in visibility rather than abundance of animals. Seasonal visibility changes in riverine forest and sal were not so great so it is unlikely that there were major errors in these habitats. However visibility changes in grassland were substantial so some testing on the validity of the method was necessary. Initially I planned to use estimates of the density of droppings. However it was found impossible to distinguish between species with certainty because of sex and age variation. The method could not be used. Instead I decided to use the data from radio-telemetry locations as a test. These data are presented after the data on transects and the results from the two methods will be shown to be in agreement.

TABLE 6.1 : CHITAL : Habitat Preference Index (HPI)

		River Bank Kans					Riverine Forest					Savannah Dhaddi					Old Village Sites					Sal Forest											
Month	Total	Number		Transect		HPI	Number		Transect		HPI	Number		Transect		HPI	Number		Transect		HPI	Number		Transect		HPI							
		N	%	L	%	x/y	N	%	L	%	x/y	N	%	L	%	x/y	N	%	L	%	x/y	N	%	L	%	x/y							
		(x)	(km)	(y)						(x)	(km)	(y)						(x)	(km)	(y)						(x)	(km)	(y)					
June	995	97	9.7	3.8	7.3	1.32	698	70.2	9.9	18.9	3.71	29	2.9	9.1	17.4	0.16	17	1.7	4.6	8.8	0.19	154	15.5	25.0	47.7	0.32							
July	724	58	8.0	3.8	7.3	1.09	619	85.5	9.9	18.9	4.52	4	0.6	9.1	17.4	0.03	2	0.3	4.6	8.8	0.03	41	5.7	25.0	47.7	0.11							
August	1588	161	10.1	3.8	7.3	1.38	1369	86.2	9.9	18.9	4.52	31	2.0	9.1	17.4	0.11	8	0.5	4.6	8.8	0.05	19	1.2	25.0	47.7	0.03							
Sept.	1447	128	8.8	3.8	7.3	1.20	1185	81.9	9.9	18.9	4.33	3	0.2	9.1	17.4	0.01	0	0.0	4.6	8.8	0.00	131	9.1	25.0	47.7	0.19							
Oct.	858	128	14.9	3.8	7.3	2.04	683	79.6	9.9	18.9	4.21	0	0.0	9.1	17.4	0.0	0	0.0	4.6	8.8	0.00	47	5.5	25.0	47.7	0.11							
Nov.	649	130	20.0	3.8	7.3	2.73	439	67.6	9.9	18.9	3.57	51	7.9	9.1	17.4	0.45	0	0.0	4.6	8.8	0.00	29	4.5	25.0	47.7	0.09							
Dec.	970	139	14.3	3.8	7.3	1.95	660	68.0	9.9	18.9	3.59	85	8.8	9.1	17.4	0.50	31	3.2	4.6	8.8	0.36	55	5.7	25.0	47.7	0.11							
Jan.	584	92	15.8	3.8	7.3	2.16	320	54.8	9.9	18.9	2.89	42	7.2	9.1	17.4	0.41	103	17.6	4.6	8.8	2.00	27	4.6	25.0	47.7	0.09							
Feb.	2800	93	3.3	3.8	7.3	0.45	640	22.9	9.9	18.9	1.21	431	15.4	9.1	17.4	0.88	1556	55.6	4.6	8.8	6.31	80	2.9	25.0	47.7	0.06							
March	4163	92	2.2	3.8	7.3	0.30	1044	25.1	9.9	18.9	1.32	872	20.9	9.1	17.4	1.20	1517	36.4	4.6	8.8	4.13	638	15.3	25.0	47.7	0.32							
April	2882	46	1.6	3.8	7.3	0.21	618	21.4	9.9	18.9	1.13	387	13.4	9.1	17.4	0.77	166	5.8	4.6	8.8	0.65	1665	57.8	25.0	47.7	1.21							
May	2455	123	5.0	3.8	7.3	0.68	1182	48.1	9.9	18.9	2.54	177	7.2	9.1	17.4	0.41	41	1.7	4.6	8.8	0.19	932	38.0	25.0	47.7	0.79							

"U" test (Siegel 1956) was used to compare seasonal differences within each habitat.

(i) The Riverine Forest: The habitat preference index (HPI) in the Riverine forest was consistent during the monsoon and the post-monsoon season (Fig. 6.1). However, the index (HPI) was significantly lower ($p < 0.02$) during the pre-monsoon season than at other times of the year. During this period most of the other habitats are burned and chital forage in large groups in adjacent patches of grassland that were burnt and cut (see below).

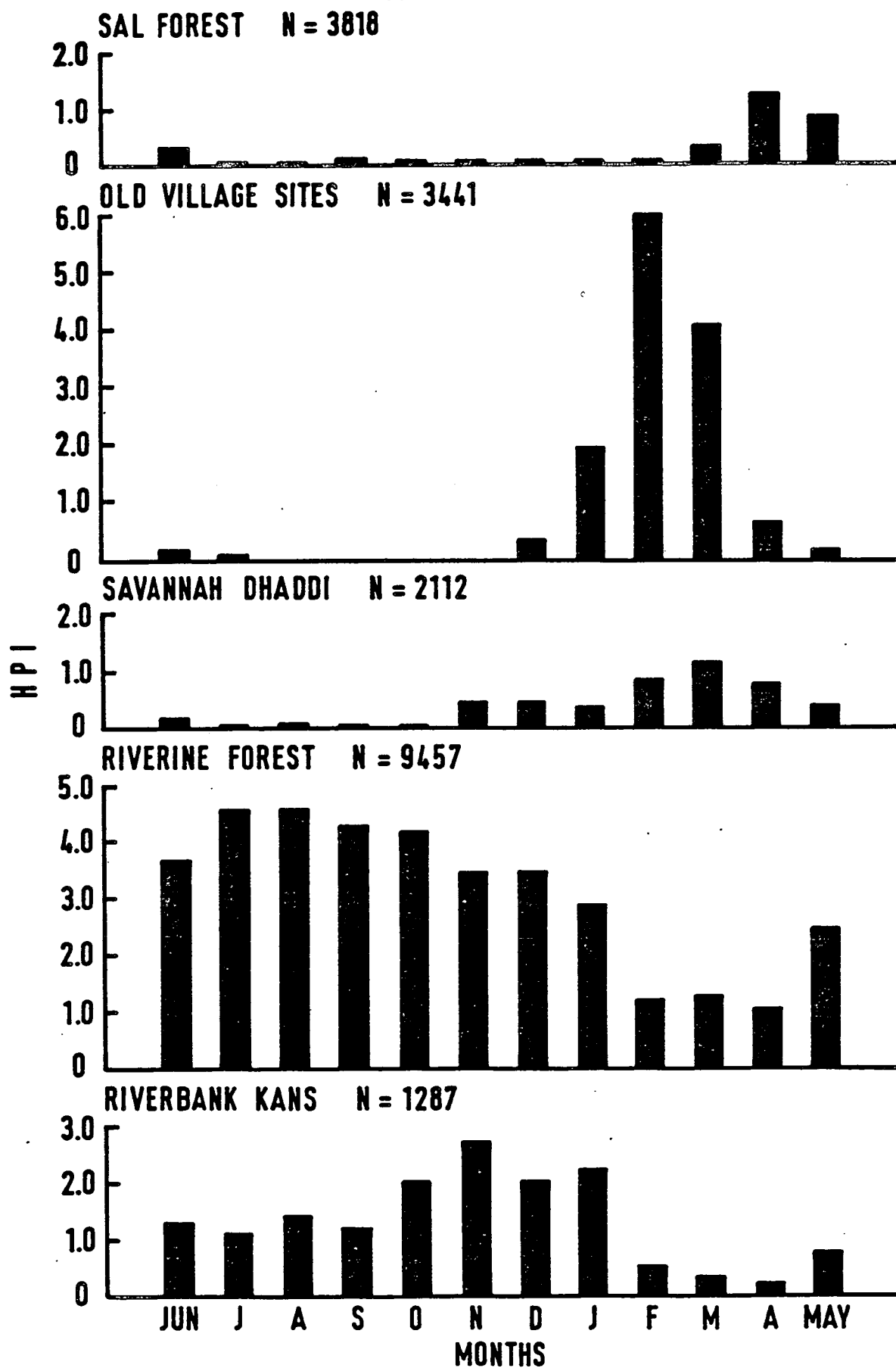
(ii) The Sal Forest: Though chital were seen in the Sal forest throughout the year the habitat preference rating (HPI) index in this habitat was much lower than in the Riverine forest. Here the index (HPI) ranged from 0.03 in August to a maximum of only 1.21 in April (Fig. 6.1). Fire in the Sal forest in Chitwan occurs during the end of the pre-monsoon season than other times of the season, but the difference was not significant ($p = 0.10$).

(iii) The Grasslands: The habitat preference index (HPI) in the 3 grasslands habitats for the whole year was not significantly ($P > .10$) different except for the difference between the Savannah Dhaddi and the River Bank Kans, where the latter was significantly ($p < 0.05$) higher than the Savannah Dhaddi. Here I have examined the seasonal differences in the use of each of the grassland habitats.

(a) The River Bank Kans:

The habitat preference rating index (HPI) in the River Bank Kans ranged from 0.21 in April to 2.73 in November (Table 6.1). This habitat appeared to be used more during the post-monsoon months than

FIG 6.1



CHITAL : HABITAT PREFERENCE INDEX (HPI)

TABLE 6.2: HABITAT USE BY RADIO COLLARED CHITAL IN NUMBER OF LOCATIONS BY HABITAT BY SEASON

Season/Sex	Riverine Forest					Grass Lands					Sal Forest				
	Area		Locations		Index	Area		Locations		Index	Area		Locations		Index
	km ² (approx)	% y	N	% x	x/y	km ² (approx)	% y	N	% x	x/y	km ² (approx)	% y	N	% y	x/y
1. Pre-Monsoon															
Male	7.5	21.3	647	60.1	2.82	14.0	40.1	394	36.6	0.91	13.5	38.6	36	3.3	0.09
Female	7.5	21.3	825	61.5	2.89	14.0	40.1	489	36.5	0.91	13.5	38.6	27	2.0	0.05
Both sex	7.5	21.3	1472	60.9	2.86	14.0	40.1	883	36.5	0.91	13.5	38.6	63	2.6	0.07
2. Monsoon															
Male	7.5	21.3	845	83.3	3.91	14.0	40.1	160	15.8	0.39	13.5	38.6	9	0.9	0.02
Female	7.5	21.3	1012	82.2	3.86	14.0	40.1	198	16.8	0.42	13.5	38.6	21	1.7	0.04
Both sex	7.5	21.3	1857	82.7	3.90	14.0	40.1	358	15.9	0.40	13.5	38.6	30	1.3	0.03
3. Post-Monsoon															
Male	7.5	21.3	806	84.2	3.95	14.0	40.1	151	15.8	0.39	13.5	38.6	7	0.0	0.0
Female	7.5	21.3	716	80.9	3.80	14.0	40.1	146	16.5	0.40	13.5	38.6	23	2.6	0.07
Both sex	7.5	21.3	1522	82.6	3.88	14.0	40.1	297	15.1	0.40	13.5	38.6	23	1.2	0.03
4. Both Sex All seasons Combined	7.5	21.3	4851	74.6	3.50	14.0	40.1	1538	23.6	0.59	13.5	38.6	116	1.8	0.05

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at other times of the year (Fig. 6.1). The index (HPI) was significantly higher ($p < 0.02$) during the post monsoon season than during the pre-monsoon, and the monsoon seasons.

(b) The Old Village Sites:

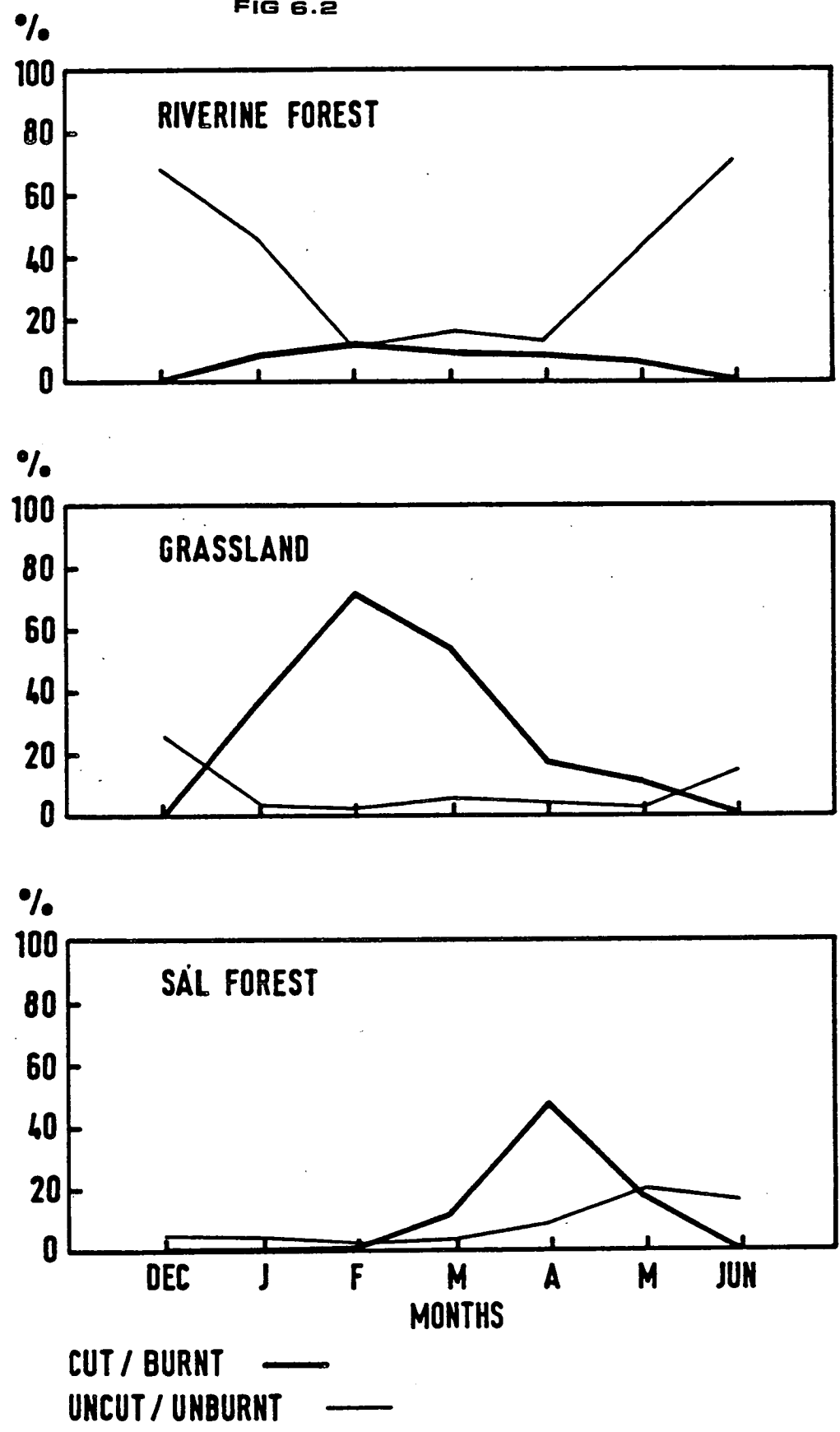
Except for the months of January, February and March; the habitat preference index (HPI) in the Old Village sites was less than 1.00 (Table 6.1). The index (HPI) was significantly higher ($p < .05$) from January to March than other times of the year. The Old Village sites are the areas from where thatch grass is first harvested in January and this habitat is also the area that is first burnt in January/February. The habitat preference index (HPI) increased from 0.36 in December and reached a peak (6.31) in February after which it declined to 0.32 in June (Fig. 6.1).

(c) The Savannah-Dhaddi: The habitat preference index in the Savannah Dhaddi was less than 1.00 throughout the year except in March when it reached 1.2. This habitat is burnt about a month later than the Old Village sites in February/March and chital were seen feeding on young shoots of tall grasses that sprout within a week of burning. The index (HPI) was significantly ($p < .05$) higher during the pre-monsoon season than other times of the year.

(2) Effects of grass cutting and burning on habitat utilisation trends:

Grass cutting starts around the middle of January and lasts for two weeks. The area is also burnt during this time beginning in the Old Village sites. Next the Savannah Dhaddi is burnt and burning continues into the Sal forest at the end of the dry season. Here, I have compared the use of cut and burnt areas with those that were neither cut nor burnt.

FIG 6.2



(i) The Riverine Forest: Since there is no grass cutting nor fire in the Riverine forest except the fringes, most of the deer in this habitat were in areas that were neither cut nor burnt (Fig. 6.2).

(ii) The grasslands: In December, a month before grasscutting commenced 26.3 % of the chital were in the grasslands. There were no cut or burnt patches at that time so all the animals seen were in uncut and unburned grassland. In January 40.5 % of all the deer tallied were in grasslands of which 36.6 % were in patches that were cut/burnt and only 4.1 % were in patches that were neither cut nor burnt. In February, 74.2 % of all the chital observed were in grasslands out of which 72.4 % were in burnt/cut patches. In March, the numbers observed in cut/burnt patches declined to 53.9 % and declined further to 10.9 % in May, by which time most grasses had grown over a metre high. Of all the animals tallied in grasslands between January and May less than 6 % were in patches that were neither burnt nor cut (Fig. 6.2).

(iii) The Sal forest: Fire in the Sal forest occurs at the end of the dry season. The number of chital observed in patches that were burnt increased from 1.0 % in February when fire is restricted to the fringes to 47.9 % in May when most Sal forest is burnt (Fig. 6.2).

(3) A comparison with radio collared chital:

Since I had plotted the radio locations of 27 ~~27~~ collared chital for the estimation of home range sizes (Chapter 9), I compared the use of Riverine forest, Grasslands and Sal forest habitats of radio marked animals with those observed by transect count methods. Of the total 6505 radio locations, 74.6 % were in the Riverine forest, 23.1 % in the

grasslands and only 1.8 % in the Sal forest (Table 6.2).

A habitat preference index was also computed by dividing the percentage of locations by the percentage of area under each habitat type indicated. The index (HPI) was higher in the Riverine forest for both males and females throughout the year (Table 6.2). During the pre-monsoon season in the Grasslands the index (HPI) was more than double than the monsoon and post-monsoon (Table 6.2). The index (HPI) indicated that the use of Sal forest by marked deer was not significant. This is similar to the observation of the transect count methods. A Spearman's correlation coefficient (Siegal 1956) indicated the number of radio locations in the 3 different seasons in the Riverine forests, grasslands and Sal forest were similar ($r_s > 0.73$; $p < 0.03$) to the number of chital observed by transect count in the 3 main types of habitat in the three different seasons.

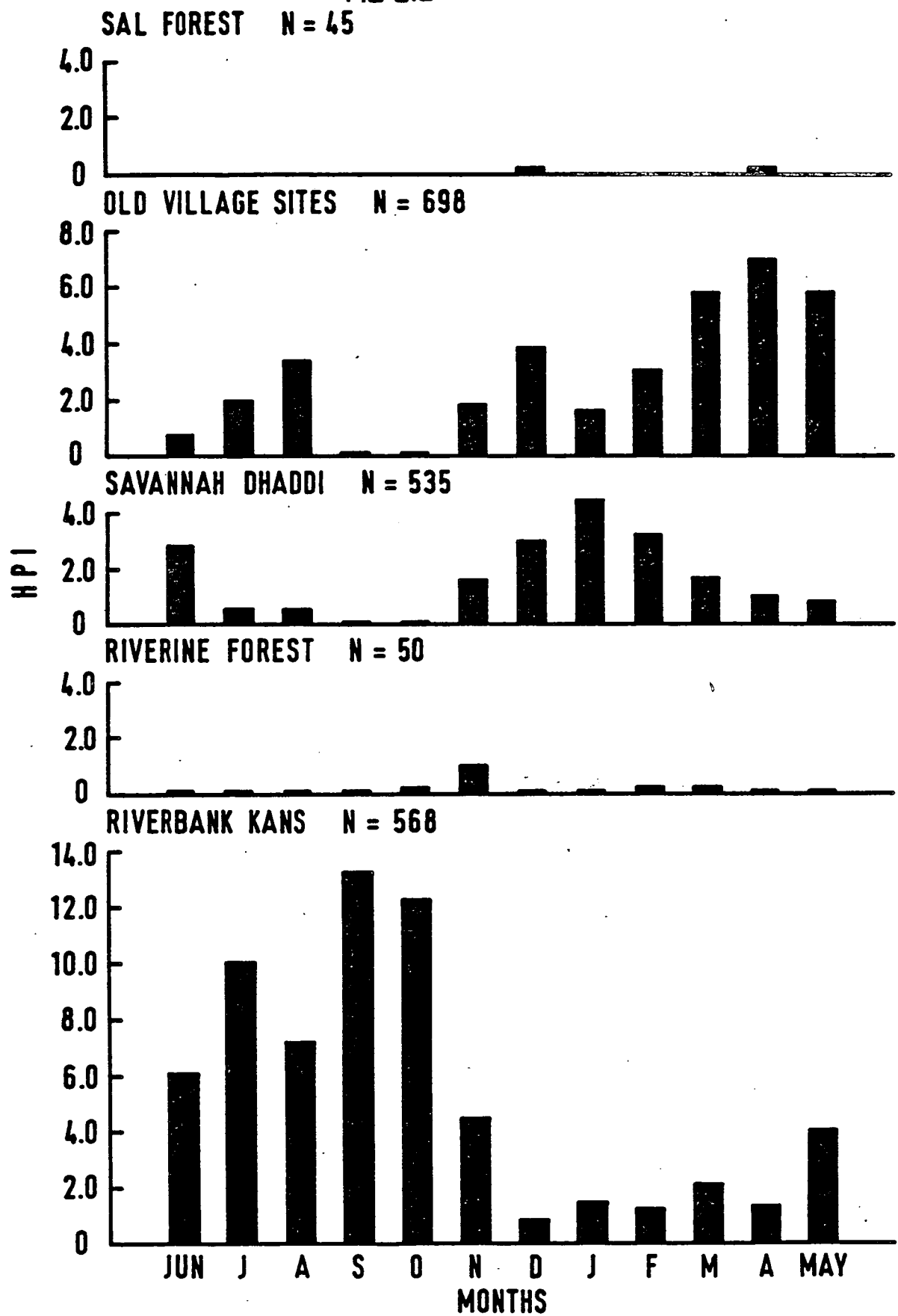
6.4 A Comparison with other deer:

(1) The Hog deer: Of the total of 1896 observations of hog deer 94.6 % were in the grasslands and only 3.1 % in the Riverine forest and 2.4 % in the Sal forest (Table 6.3). The habitat preference rating index (HPI) for hog deer is distinctly higher in the grasslands than forest habitat (Fig. 6.3). In the grassland habitats the preference rating index (HPI) for the whole year was significantly higher ($p < 0.05$) in the River Bank Kans than the Savannah Dhaddi but was not significantly different ($p = 0.20$) between the Old Village sites and the River Bank Kans. The index (HPI) was not significantly different ($p = 0.14$) between the Old Village sites and the Savannah Dhaddi for the whole year. Here I have examined the seasonal differences in the use of each of the 3 grassland habitats by the hog deer.

TABLE 6.3: HOG DEER HABITAT PREFERENCE INDEX (HPI)

Month	Total	River Bank Kans					Riverine Forest					Savannah Dhatti					Old Village Sites					Sal Forest				
		Number		Transect		HPI	Number		Transect		HPI	Number		Transect		HPI	Number		Transect		HPI	Number		Transect		HPI
		N	%	L	%	x/y	N	%	L	%	x/y	N	%	L	%	x/y	N	%	L	%	x/y	N	%	L	%	x/y
		(x)		(km)	(y)		(x)		(km)	(y)		(x)		(km)	(y)		(x)		(km)	(y)		(x)		(km)	(y)	
June	150	66	44.0	3.8	7.3	6.02	0	0.0	9.9	18.9	0.0	74	49.3	9.1	17.4	2.83	10	6.7	4.6	8.8	0.76	0	0.0	25.0	47.7	0.0
July	46	34	73.9	3.8	7.3	10.12	0	0.0	9.9	18.9	0.0	4	8.7	9.1	17.4	0.50	8	17.4	4.6	8.8	1.97	0	0.0	25.0	47.7	0.0
August	49	26	53.1	3.8	7.3	7.27	1	2.0	9.9	18.9	0.10	5	10.2	9.1	17.4	0.58	15	30.6	4.6	8.8	3.47	2	4.1	25.0	47.7	0.08
Sept.	194	187	96.4	3.8	7.3	13.20	2	1.0	9.9	18.9	0.05	1	0.5	9.1	17.4	0.02	2	1.0	4.6	8.8	0.11	2	1.0	25.0	47.7	0.02
Oct.	73	65	89.0	3.8	7.3	12.19	4	5.5	9.9	18.9	0.29	4	5.5	9.1	17.4	0.31	0	0.0	4.6	8.8	0.0	0	0.0	25.0	47.7	0.0
Nov.	25	8	32.0	3.8	7.3	4.38	5	20.0	9.9	18.9	1.05	7	28.0	9.1	17.4	1.60	4	16.0	4.6	8.8	1.81	1	4.0	25.0	47.7	0.08
Dec.	39	2	5.1	3.8	7.3	0.69	1	2.6	9.9	18.9	0.13	20	51.3	9.1	17.4	2.94	13	33.3	4.6	8.8	3.78	3	7.7	25.0	47.7	0.16
Jan.	54	6	11.1	3.8	7.3	1.52	0	0.0	9.9	18.9	0.0	41	75.9	9.1	17.4	4.36	7	13.0	4.6	8.8	1.47	0	0.0	25.0	47.7	0.0
Feb.	258	24	9.3	3.8	7.3	1.27	14	5.4	9.9	18.9	0.28	149	57.8	9.1	17.4	3.32	69	26.7	4.6	8.8	3.03	2	0.8	25.0	47.7	0.01
Mar.	441	67	15.2	3.8	7.3	2.08	14	3.2	9.9	18.9	0.16	127	28.8	9.1	17.4	1.65	223	50.6	4.6	8.8	5.75	10	2.3	25.0	47.7	0.04
April	421	40	9.5	3.8	7.3	1.30	5	1.2	9.9	18.9	0.06	79	18.8	9.1	17.4	1.08	272	64.6	4.6	8.8	7.34	25	5.9	25.0	47.7	0.12
May	146	43	29.5	3.8	7.3	4.04	4	2.7	9.9	18.9	0.14	24	16.4	9.1	17.4	0.94	75	51.4	4.6	8.8	5.84	0	0.0	25.0	47.7	0.0

FIG 6.3



HOG DEER : HABITAT PREFERENCE INDEX (H P I)

(i) The River Bank Kans; In the River Bank Kans, the habitat preference index (HPI) ranged from 0.69 in December to 13.20 in September (Table 6.3). Though the index (HPI) did not differ significantly between the pre-monsoon and the post-monsoon, it was significantly ($p < 0.05$) higher in the pre-monsoon than the former two seasons.

(ii) The Savannah Dhatti: In the Savannah Dhatti, the habitat preference index (HPI) ranged from 0.2 in September to 4.36 in January (Fig. 6.3). However there were no significant seasonal differences between the pre-monsoon, post-monsoon and monsoon seasons.

(iii) The Old Village Sites: In the Old Village sites, habitat preference rating index (HPI) reached a peak of 7.3 in April (Fig. 6.3). In contrast to the River Bank Kans the index (HPI) was significantly higher ($p < 0.03$) during the pre-monsoon season than the other two seasons. There was no significant difference in the index (HPI) between the monsoon and post-monsoon seasons in this habitat.

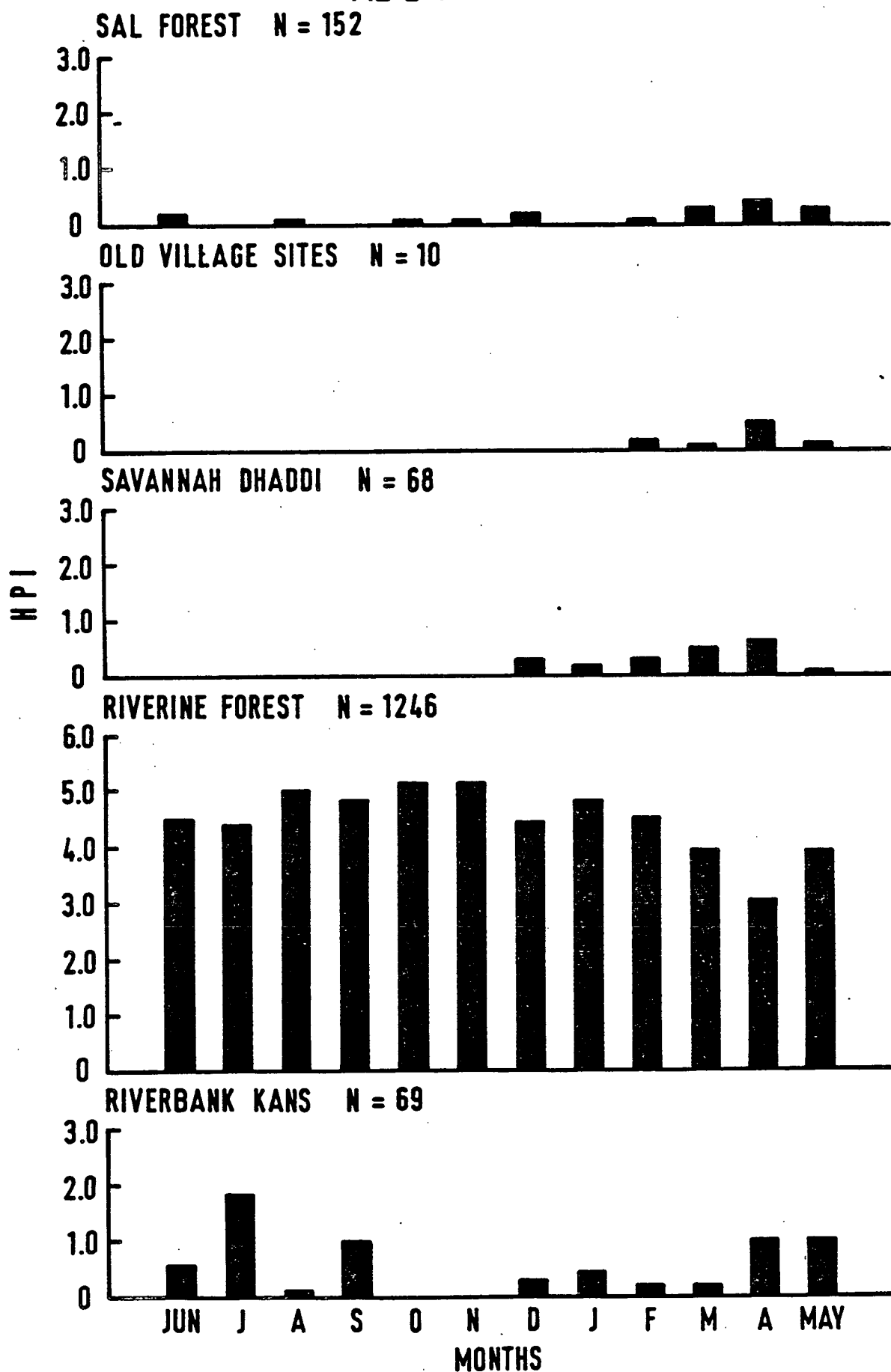
Though there were seasonal differences on the habitat preference indices (HPI) in the 3 grassland habitats, the hog deer was mainly a species with distinct preference for the grasslands. Unlike the chital, it did not demonstrate seasonal shifts between forests and grasslands.

(2) The Sambar: In contrast to the hog deer 80.3 % of the 1552 observations of sambar were in the Riverine forest and 9.8 % in the Sal forest (Table 6.4). The grasslands comprised 9.9 % with 4.5 % in the River Bank Kans, 4.4 % in the Savannah Dhatti and only 1.0 % in the Old Village sites. The habitat preference rating index (HPI) for the whole year was significantly higher ($p < 0.001$) in the Riverine forest than any other habitat throughout the year. Unlike the chital,

TABLE 6.4: SAMBAR HABITAT PREFERENCE INDEX (HPI)

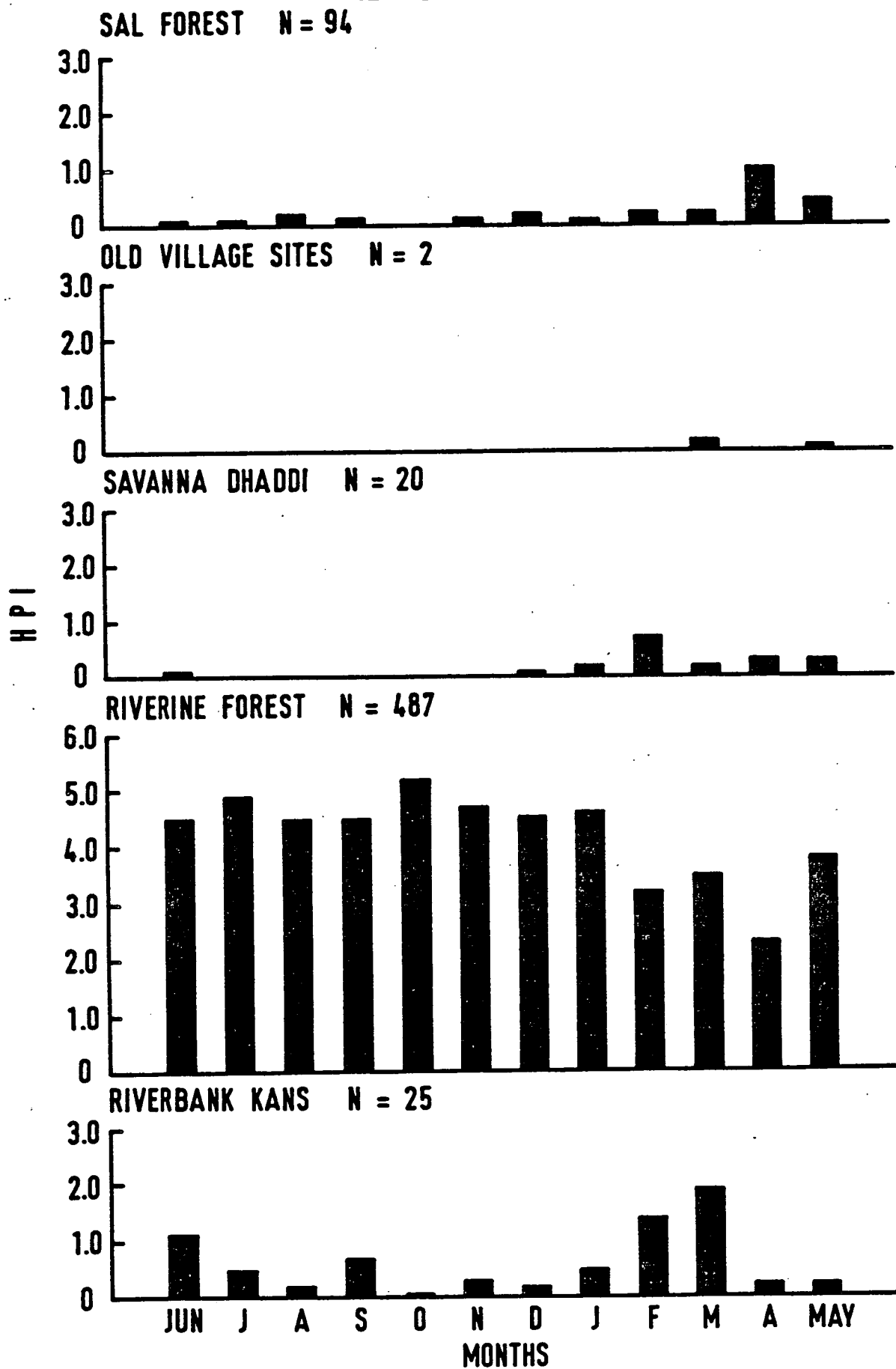
Month	Total	River Bank Kans					Riverine Forest					Savannah Dhaddi					Old Village Sites					Sal Forest				
		Number		Transect HPI			Number		Transect HPI			Number		Transect HPI			Number		Transect HPI			Number		Transect HPI		
		N	%	L	%	x/y	N	%	L	%	x/y	N	%	L	%	x/y	N	%	L	%	x/y	N	%	L	%	x/y
		(x)	(km)	(y)			(x)	(km)	(y)			(x)	(km)	(y)			(x)	(km)	(y)			(x)	(km)	(y)		
June	121	5	4.1	3.8	7.3	0.56	103	85.1	9.9	18.9	4.50	0	0.0	9.1	17.4	0.0	0	0.0	4.6	8.8	0.0	13	10.7	25.0	47.7	0.22
July	75	10	13.3	3.8	7.3	1.82	63	84.0	9.9	18.9	4.44	1	1.3	9.1	17.4	0.07	0	0.0	4.6	8.8	0.0	1	1.3	25.0	47.7	0.02
August	126	1	0.8	3.8	7.3	0.10	118	93.7	9.9	18.9	4.95	1	0.8	9.1	17.4	0.04	0	0.0	4.6	8.8	0.0	6	4.8	25.0	47.7	0.10
Sept.	121	9	7.4	3.8	7.3	1.01	109	90.1	9.9	18.9	4.76	1	0.8	9.1	17.4	0.04	0	0.0	4.6	8.8	0.0	2	1.7	25.0	47.7	0.03
Oct.	25	0	0.0	3.8	7.3	0.0	24	96.0	9.9	18.9	5.07	0	0.0	9.1	17.4	0.0	0	0.0	4.6	8.8	0.0	1	4.0	25.0	47.7	0.08
Nov.	33	0	0.0	3.8	7.3	0.0	32	97.0	9.9	18.9	5.13	0	0.0	9.1	17.4	0.0	0	0.0	4.6	8.8	0.0	1	3.0	25.0	47.7	0.06
Dec.	91	2	2.2	3.8	7.3	0.30	75	82.4	9.9	18.9	4.35	5	5.5	9.1	17.4	0.31	0	0.0	4.6	8.8	0.0	9	9.9	25.0	47.7	0.20
Jan.	113	4	3.5	3.8	7.3	0.47	103	91.1	9.9	18.9	4.82	4	3.5	9.1	17.4	0.20	0	0.0	4.6	8.8	0.0	2	1.8	25.0	47.7	0.03
Feb.	196	3	1.5	3.8	7.3	0.20	170	86.7	9.9	18.9	4.58	10	5.1	9.1	17.4	0.29	3	1.5	4.6	8.8	0.17	10	5.1	25.0	47.7	0.10
March	245	4	1.6	3.8	7.3	0.21	182	74.3	9.9	18.9	3.93	23	9.4	9.1	17.4	0.54	2	0.8	4.6	8.8	0.09	34	13.9	25.0	47.7	0.29
April	176	14	8.0	3.8	7.3	1.09	100	56.8	9.9	18.9	3.00	17	9.6	9.1	17.4	0.55	8	4.5	4.6	8.8	0.51	37	21.0	25.0	47.7	0.44
May	230	17	7.4	3.8	7.3	1.01	168	73.0	9.9	18.9	3.86	6	2.6	9.1	17.4	0.14	3	1.3	4.6	8.8	0.14	36	15.6	25.0	47.7	0.32

FIG 6.4



SAMBAR : HABITAT PREFERENCE INDEX (H P I)

FIG 6.5



the habitat preference index (HPI) did not show any significant seasonal shifts and most sambar were restricted to the riverine forests for all months of the year (Fig. 6.4).

(3) The Barking deer: Of the total of 630 barking deer observations, 77.6 % were in the Riverine forest, 14.9 % in the Sal forest and only 7.5 % in the grasslands (Table 6.5). Like the sambar, the habitat preference rating index was significantly ($p < 0.001$) higher in the Riverine forest than other habitats. The index (HPI) in the barking deer indicate that most of the animals are restricted to the riverine forest without any significant seasonal shifts in habitat utilisation (Fig. 6.5).

6.5 Discussion:

The foregoing results demonstrate the seasonal trends of habitat utilisation of the 4 species of deer that share the national park and are based on day time observations in the main study area. The seasonal trends in group formation and social systems in relation to habitat structure are discussed later (Chapter 8).

Based on their use of habitat, the deer species of Chitwan can be divided into 3 main groups. The hog deer is a species of grassland. In contrast the sambar and barking deer have a distinct preference for forest habitat. On the other hand, the chital fits between these extremes using both the forest and grassland habitat.

In the Dry Tropical Forest of Gir (North West India), Berwick (1974) classified the chital as primarily a browser particularly during the dry season. In the moist semi-evergreen tropical forest of Kanha (Central India), the Chital mostly utilized open meadows grazing on short grasses (Schaller, 1967). In Sri Lanka, on its southern-most range, it used

TABLE 6.5: BARKING DEER HABITAT PREFERENCE INDEX (HPI)

Month	Total	River Bank Kans					Riverine Forest					Savannah Dhaddi					Old Village Sites					Sal Forest				
		Number		Transect		HPI	Number		Transect		HPI	Number		Transect		HPI	Number		Transect		HPI	Number		Transect		HPI
		N	% (x)	L (km)	% (y)	x/y	N	% (x)	L (km)	% (y)	x/y	N	% (x)	L (km)	% (y)	x/y	N	% (x)	L (km)	% (y)	x/y	N	% (x)	L (km)	% (y)	x/y
June	49	4	8.2	3.8	7.3	1.12	42	85.7	9.9	18.9	4.53	1	2.0	9.1	17.4	0.11	0	0.0	4.6	8.8	0.0	2	4.1	25.0	47.7	0.88
July	27	1	3.7	3.8	7.3	0.50	25	92.6	9.9	18.9	4.89	0	0.0	9.1	17.4	0.0	0	0.0	4.6	8.8	0.0	1	3.7	25.0	47.7	0.07
August	60	1	1.7	3.8	7.3	0.23	52	86.7	9.9	18.9	4.58	0	0.0	9.1	17.4	0.0	0	0.0	4.6	8.8	0.0	7	11.7	25.0	47.7	0.24
Sept.	37	2	5.4	3.8	7.3	0.73	32	86.5	9.9	18.9	4.57	0	0.0	9.1	17.4	0.0	0	0.0	4.6	8.8	0.0	3	8.1	25.0	47.7	0.16
Oct.	38	0	0.0	3.8	7.3	0.0	38	100.0	9.9	18.9	5.29	0	0.0	9.1	17.4	0.0	0	0.0	4.6	8.8	0.0	0	0.0	25.0	47.7	0.0
Nov.	39	1	2.6	3.8	7.3	0.35	35	89.7	9.9	18.9	4.74	0	0.0	9.1	17.4	0.0	0	0.0	4.6	8.8	0.0	3	7.7	25.0	47.7	0.16
Dec.	75	1	1.3	3.8	7.3	0.17	65	86.7	9.9	18.9	4.58	1	1.3	9.1	17.4	0.07	0	0.0	4.6	8.8	0.0	8	10.7	25.0	47.7	0.22
Jan.	25	1	4.0	3.8	7.3	0.54	22	88.0	9.9	18.9	4.65	1	4.0	9.1	17.4	0.22	0	0.0	4.6	8.8	0.0	1	4.0	25.0	47.7	0.08
Feb.	29	3	10.3	3.8	7.3	1.41	18	62.1	9.9	18.9	3.28	4	13.8	9.1	17.4	0.79	0	0.0	4.6	8.8	0.0	4	13.8	25.0	47.7	0.28
March	59	8	13.6	3.8	7.3	1.86	40	67.8	9.9	18.9	3.58	2	3.4	9.1	17.4	0.19	1	1.7	4.6	8.8	0.19	8	13.6	25.0	47.7	0.28
April	71	1	1.4	3.8	7.3	0.19	32	45.1	9.9	18.9	2.38	4	5.6	9.1	17.4	0.32	0	0.0	4.6	8.8	0.0	34	47.9	25.0	47.7	1.00
May	121	2	1.7	3.8	7.3	0.23	88	72.7	9.9	18.9	3.84	7	5.8	9.1	17.4	0.33	1	0.8	4.6	8.8	0.09	23	19.0	25.0	47.7	0.39

grasslands and the scrub-grassland interface in the semi-dry deciduous forest of Wilpattu National Park (Eisenberg and Lockhart 1972]. Based on observations in Sri-Lanka, Eisenberg and Lockhart (1972) concluded that the chital's ability to use forest depends upon the maturity of stands since it can not reach above 1.5 metres. Though the study of food and feeding habits of chital was beyond the scope of this study, it is doubtful if the height of leaves and branches can be the main criterion for habitat use. In Chitwan, the chital were often seen feeding on leaves, flowers and fruits that drop on the ground.

They were often sighted under trees where monkeys, both rhesus (*Macaca mulatta*) and Langur (*Presbytis entellus*) were feeding on leaves, fruits and flowers some of which drop to the ground as a result of the activities of the monkeys on tree tops. In my study area the Chital appears to be an animal of the Riverine forests where it spends most of its time and uses adjacent patches of other habitat when forage there becomes abundant. Though the Riverine forest comprised only about 21 % of my study area, movement of radio collared deer indicated that the chital spend over 60 % of their time in this habitat throughout the year. Though low in proportion, the Riverine forest forms a mosaic of small patches with cover from predators and shelter from extreme heat or rain, and is in close proximity to other habitats.

The seasonal monsoon recharges the annual production of grasses. The annual harvest of grasslands and seasonal fire maintain a diversification in habitat structure. The chital is an animal that has been reported to favour habitats where forest patches are broken by glades, meadows, grasslands and other features both in its indigenous and exotic environment (Schaller 1967; Eisenberg and Lockhart 1972;

Dinerstein 1980; Berwick 1974; Graf and Nichols 1966; Ables 1974). Leopold's (1933) "Laws of dispersion" state that the distribution of "game" is directly proportional to the amount of "edge" in any area. Dasman (1948) indicated that it is not the quantity of any habitat component but the degree of interspersation among habitat types that limits the distribution and density of animals. The vegetation in my study area, particularly as a result of changes brought about both by man and nature appears to provide a good habitat for the chital. It seems to be a species of the ecotone in contrast to the three other species which favoured only one specific type of habitat.

The hog deer is a species of grasslands. In Chitwan, the seasonal shifts in habitat use were restricted between 3 main grassland habitats. In the pre-monsoon, when the grasses are cut and burnt it used the Old Village sites while during most of the year particularly the monsoon, the river-bank kans seemed to be the preferred habitat. Throughout its range in the Indian sub-continent the hog deer are threatened. Most ~~the~~ grassland habitat have been farmed as they are fertile with alluvial deposits and easy to cultivate.

The sambar and barking deer are forest species. Because of its size the sambar must need substantial quantities of food compared to any of the other 3 species of deer. Like the chital, they were often seen feeding on leaves that have fallen on the ground. The Riverine forest contains more species of shrubs and trees particularly deciduous species than the Sal forest or grassland. Thus it seemed to be the preferred habitat. It also provides cover for more or less solitary living animals like the sambar and barking deer. A study of plant phenology and the seasonal use of fallen fruits and leaves as a source of food will provide more knowledge on the seasonal differences in

habitat use by the 4 species of deer of the Royal Chitwan National Park.

Studies conducted in the Serengeti plains of East Africa have demonstrated that all areas are not equally used by different species of herbivores (Grizmek and Grizmek 1960; Lamprey 1963). There it has been illustrated that species living in the same area must depend upon different use of resources in either use of different plant species or same plant species at different times (Jarman and Sinclair 1979). The habitat utilisation of the four species of deer in Chitwan follows this pattern since they maintain an ecological separation in their choice of habitat.

CHAPTER 7

7.

BREEDING SEASONS

7.1 Introduction:

Most cervids that have been studied in Europe and America exhibit distinct breeding cycles (e.g. **Severinghaus and Cheatum** 1956; **Linsdale and Tommich** 1953; **Verme** 1965; **Guinness et al** 1971; **Chapman and Chapman** 1975; **Kucera** 1978; **McCullough** 1979). In the temperate region most deer rut in autumn and fawns are born in the spring. This cycle has obvious survival benefits as environmental factors, particularly weather, are extreme between seasons (**Sadleir** 1969). In contrast to the deer of Europe and America very little is known about the breeding cycles of deer in Southern Asia. The limited published information available suggests that breeding seasons are not consistent throughout the range of individual species. Regional differences in climate and vegetation are believed to have resulted in these variations (**Krishnan** 1959; **Prater** 1965; **Berwick** 1974). **Eisenberg and Lockhart** (1972) suggested that in Sri Lanka breeding is synchronized to seasons of drought and rainfall and consequently to the availability of forage. Some confusion in the literature appears to have resulted from observations of captive Asian deer in zoological parks particularly in Europe and America, where most have been reported to breed throughout the year (**Bedford and Marshall** 1942; **Jarvis and Morris** 1962; **Asdell** 1964; **Crandall** 1964; **Schaller** 1967; **Miller** 1975). However, this study seems to be the first long-term attempt to monitor the breeding cycles, extending through all seasons for the 4 species of deer in their indigenous environment. In this section I shall be concerned with answering the following main questions:

1. What is the seasonal pattern of reproductive activity in males ?
2. What is the seasonal pattern of reproductive activity in females ?

3. What is the adaptive significance of the observed patterns ?

Again the study was concentrated on the chital but comparative data on the hog deer, sambar and the barking deer were also obtained.

7.2 Methods:

(1) Seasonal patterns of reproductive activity in males:

In cervids there are two major components in the reproductive activity of the males : male-male interactions involved in the establishment of territory or dominance hierarchy and male-female interactions leading to copulation and fertilisation. Male-male interactions will normally peak before the male female interactions (Lincoln 1972). The seasonal pattern of male-male interactions can be defined by quantifying two parameters; antler development and bellowing (see below). The pattern of male-female interactions was more difficult to define. In the whole study period of 3 years copulation was observed only twice. Attempts were made to define the seasonality of male-female interactions by quantifying other behaviour which is normally linked to copulation- flehmen, approach, chase or tending postures and mounting attempts. Flehmen or "lip curl" (Alteri and Muller-Schwarze 1980) is a term first used by Walther (1958) to describe a characteristic behaviour of male deer. Males sniff or lick urine from females and raise their head with an upcurled lip. The male is apparently able by sniffing to assess the state of reproductive receptivity of the females (Estes 1976; Smith 1977). If the female is in heat the male will approach her with his neck and snout stretched almost parallel to his body. If the female moves the male chases her to a distance of 20 - 30 metres, and after one or two chases the male sniffs the anal region of the female. This behaviour has been termed "tending" (McHugh 1958). Mounts or attempts

to mount are self explanatory.

A. Male-male interactions:

(a) Antler development: Antlers are used in male-male competition in the establishment of a social order in breeding males of many cervids (Bubenik 1968; Espmark 1964; Lincoln 1971; Lincoln and Guinness 1973; Clutton-Brock *et al* 1979). Detailed studies of various species of deer have shown that full antler development coincides with the onset of the rut period (Taylor 1956; Schaller 1967; Eisenberg and Lockhart 1972; Miura 1981; Sharatchandra and Gadgil 1981). Severinghaus and Cheatum (1956) have reported that the weight of testes in white tailed deer (*Odocoileus virginianus*) reaches a maximum during rut. The output of testosterone increases with the maturity of antlers and there is an increase in aggressive and sexual activities during the rut (Lincoln 1981). It has been demonstrated that the seasonal changes in testicular activity dictates the annual cycle of casting and antler growth (Goss 1969 a and b; Lincoln *et al* 1970; Lincoln 1981). Ables (1974) interpreted the presence of abundant sperm in the epididymus of testes of chital as being indicative of breeding capability and concluded that it is the maturation of hard antlers that will determine whether a male will breed. Thus the annual cycle of antler development is assumed to be indicative of mating seasons.

During the standard series of transects (Chapter 3) all male deer seen were initially grouped into 3 categories: shed antlers; velvet antlers and hard antlers. The chital antlers were further classified according to an estimate of their size (Schaller 1967; Sharatchandra and Gadgil 1981; Miura 1981) and the number of branches (Ables 1974). Hard antlers were distinguished as spike, when it was unbranched and short (<10 cm). Branched antlers estimated to be less than 30 cm were classified as the next smallest class. The third

class comprised antlers estimated to be more than 30 cm but less than 60 cm. The biggest antler class recognized were those estimated to be more than 60 cm long.

Shed antlered males were distinguished by the raw scar visible on the top of their pedicles. New antler growth proceeds immediately and in the early stage of development is noticeable as a bulb-like bifurcation. Antlers in this category were termed as "first fork antlers". Like-wise antlers with a second bifurcation were termed "second fork" and those with both brow and upper tines well developed but still in velvet were classified as "fully developed" velvet antlers. Young bucks with spike velvet antlers were grouped as such.

(b) Bellowing: During the rut male chital emit a characteristic and distinctive bellow (Graf and Nicholls 1966; Schaller 1967; Ables 1974). Lydekker (1901) described it as 'peculiar moan', while Graf and Nichols (1966) described it as sounding "yo-o-o-w-w" or h-h-o-u-u-h". I would describe it as a shrill, choked blast suddenly forced out as if the animal was running out of breath. Nevertheless, it is very distinctive and is analogous to the "roaring" described in the red deer stag (*Cervus elaphus*) and in reindeer (*Rangifer tarandus* L.) and is used likewise in male-male competition during the rut (Espmark 1964). The frequency of bellowing can be used more precisely than antler development to record the seasonal pattern of male-male interactions.

The records of bellows were enumerated from fixed "listening sites". Between 05:00 hours and 21:00 hours on a total of seven days each month records were kept of date, time, number of bouts of bellowing and number of elements (bellows) per bout. The number of hours (16 hours) and number of days (7 days) were kept constant for all the months so that the data

could be compared. The total number of bouts of bellows heard were grouped by time (Nepal standard time) and months.

B. Male-female interactions:

Flehmen, tending, mounting or attempts to mount were recorded as and when sighted while covering a standard series of transect and were grouped by months. The size and state of antlers of the males involved were also recorded.

C. Seasonal Pattern in Females:

The seasonal variation in the number of newly born fawns was considered to be an index of the breeding cycle in females. The number of adult does and fawns seen along the standardised transects were recorded and grouped by months. The state of the coat and relative height were the main criteria used to distinguish fawns from older juveniles (Chapter 8). This is similar to the methods used in Sri Lanka (Eisenberg and Lockhart 1972). The seasonal pattern of births in females is difficult to determine precisely in the field. Ungulates in general and cervids in particular are known to hide their young immediately after birth (Pruitt 1960; Espmark 1964; McCullough 1971; Lent 1974). In the red deer (*Cervus elaphus*) the hiding phase is reported to be 3-4 days (Bubenik, 1968), while in roe deer (*Capreolus capreolus*) it is 2-3 weeks (Kurt 1968). In the introduced chital in Hawaii, the hiding phase was estimated to be 7-10 days (Graf and Nichols 1966). In captive Reeve's muntjak (*Muntiacus reevesii*), it is estimated to last up to 4 weeks (Yahner 1980). Since it is not known how long most of the deer in Asia hide their young, I assumed it unlikely to last more than 2 weeks. The age of fawns described in this section is estimated to be less than about 30 days in chital, sambar and hog deer (Chapter 8). Since it was difficult to distinguish between newly born

fawns and older juveniles in barking deer, the fawns described here are estimated to be less than 3 months (Eisenberg and Lockhart 1972).

7.3 Results

(1) The Chital

A. Male-male Interactions

(a) Antler Phenology: Between June 1978 and May 1981, a total of 3795 observations of male chital in different stages of antler development were made. The numbers observed in shed, velvet and hard antlers in each month were standardized in percentage of the total seen in any specific month (Table 7.1). In Chitwan, the population of chital started shedding their antlers in August and the last animals had shed by March. Both antlers were dropped more or less simultaneously. I only saw 7 animals carrying one antler on one side of the head. A few of the animals ($n = 47$) appeared to be bleeding at the raw antler scar. Within 2 weeks of shedding a knob-like outgrowth covered with shiny hair was prominent. In the next 15-20 days a bulb like bifurcation developed on the antler surface and by December the second fork had developed in most of the chital (Table 7.2). By February, most deer had developed a distinct brow tine and upper tine (Fig. 7.1). The peak occurrence of velvet antlers was between December to February after which the sightings of velvet antlers started to decline and by May over 95 % of the deer had hard antlers (Fig. 7.2). The peak season in velvet was also the period when the sexes segregated and adult males and females formed their own groups and foraged separately (Chapter 8). It was also the time when most fawning took place. Similarly, the peak period of hard antlers coincided with the peak period when the sexes mixed and there was a strong co-relation between the percentage of males with hard antlers and frequency of mixed groups sighted

TABLE 7.1: CHITAL: ANTLER CYCLE IN SHED, VELVET, HARD ANTLERS OBSERVED BY MONTH

Month	Grand Total	NUMBERS												NUMBERS AS PERCENTAGE TOTAL OF THE MONTHS											
		YEAR 1 (1978-79)				YEAR 2 (1979-80)				YEAR 3 (1980-81)				YEAR 1 (1978-79)				YEAR 2 (1979-80)				YEAR 3 (1980-81)			
		Shed	Vel.	Hard	Total	Shed	Vel.	Hard	Total	Shed	Vel.	Hard	Total	Shed	Vel.	Hard		Shed	Vel.	Hard		Shed	Vel.	Hard	
June	282	0	0	63	63	0	0	150	150	0	0	69	69	0	0	100.0		0	0	100.0		0	0	100.0	
July	134	0	0	45	45	0	0	27	27	0	0	62	62	0	0	100.0		0	0	100.0		0	0	100.0	
Aug	344	10	0	108	118	0	0	14	14	14	11	187	212	8.5	0	91.5		0	0	100.0		6.6	5.2	88.2	
Sept	329	6	16	23	45	2	4	12	18	31	27	208	266	13.3	35.6	51.1		11.1	22.2	66.7		11.7	10.2	78.2	
Oct	193	6	11	16	33	3	14	16	33	26	47	54	127	18.2	33.3	48.5		9.1	42.4	48.5		20.5	37.0	42.5	
Nov	155	17	33	20	70	1	6	2	9	13	41	22	76	24.3	47.1	28.6		11.1	66.7	22.2		17.1	53.9	28.9	
Dec	247	37	101	16	154	2	23	4	29	2	57	5	64	24.0	65.5	10.4		6.9	79.3	13.8		3.1	89.1	7.8	
Jan	127	2	23	9	34	1	27	2	30	2	56	5	63	5.9	67.6	26.5		3.3	90.0	6.7		3.2	88.9	7.9	
Feb	535	5	152	31	188	1	38	10	49	7	223	68	298	2.7	80.9	16.5		2.0	77.6	20.4		2.3	74.8	22.8	
March	618	0	73	69	142	2	125	112	239	4	132	101	237	0	51.4	48.6		0.8	52.3	46.9		1.7	55.7	42.6	
Apr	408	0	29	171	200	0	7	60	67	0	10	131	141	0	14.5	85.5		0	10.4	89.6		0	7.1	92.9	
May	423	0	4	209	213	0	2	90	92	0	2	116	118	0	1.9	98.1		0	2.2	97.8		0	1.7	98.3	

Month	Total Velvet\Shed Classified	Stages of Growth									
		Shed		Spike		1st Fork		2nd Fork		Fully Developed	
		N	%	N	%	N	%	N	%	N	%
June	0	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0
Aug.	25	14	56.0	0	0	10	40.0	1	4.0	0	.0
Sept.	58	31	53.4	3	5.2	24	41.4	0	.0	0	0
Oct.	73	26	35.6	2	2.8	29	39.7	13	17.8	3	4.1
Nov.	54	13	24.1	5	9.3	23	42.5	12	22.2	1	1.9
Dec.	59	2	3.4	9	15.3	11	18.6	31	52.5	6	10.2
Jan.	58	2	3.5	5	8.6	8	13.8	25	43.1	18	31.0
Feb.	230	7	3.0	42	18.3	33	14.3	54	23.5	94	40.9
Mar.	136	4	2.9	16	11.8	14	10.3	21	15.4	81	59.6
Apr.	10	0	0	0	0	0	0	2	20.0	8	80.0
May	2	0	0	0	0	0	0	0	0	2	100

FIGURE 7.1: CHITAL: Stages of Antler development in percent observed by month (1980-1981).

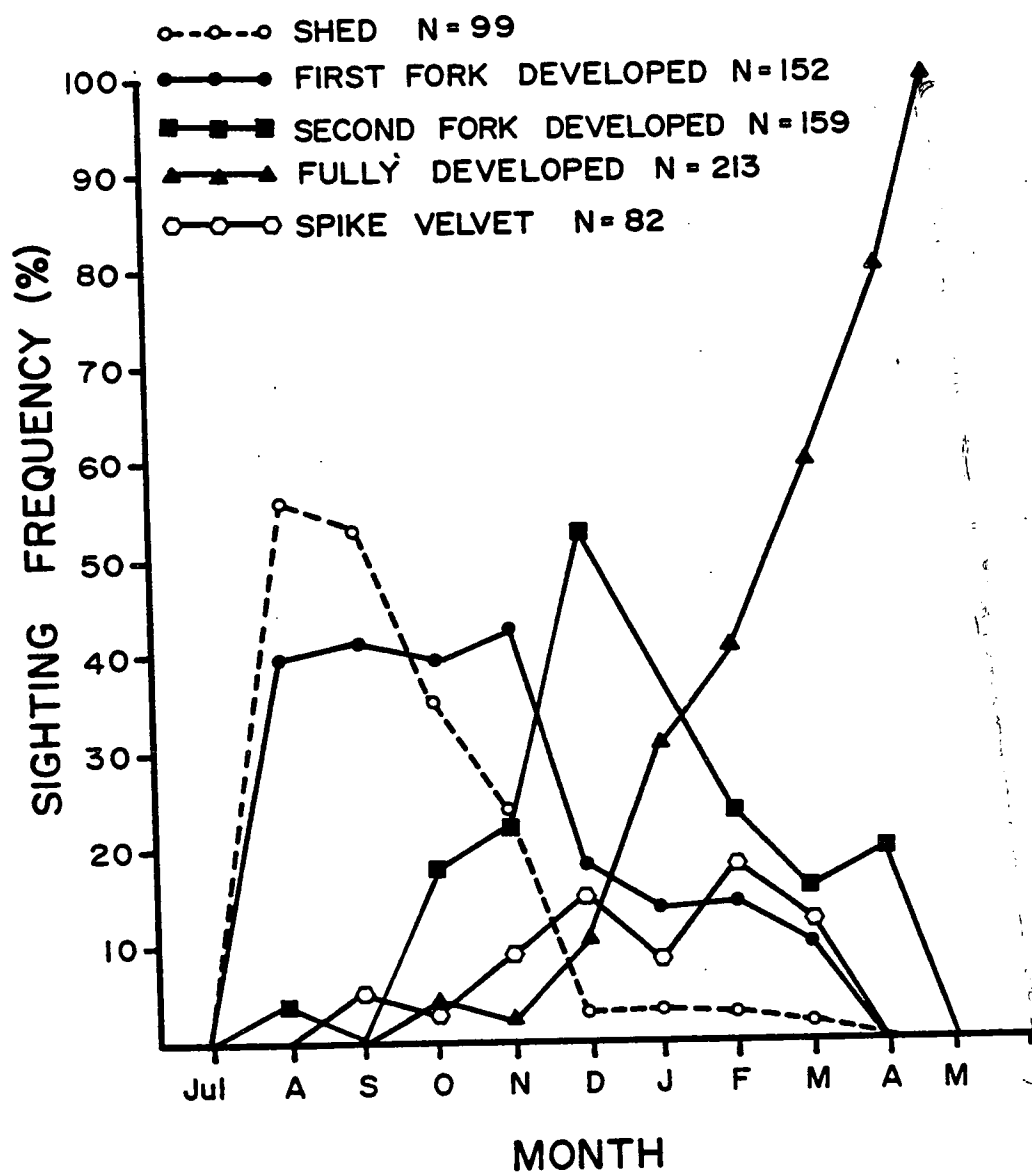


TABLE 7.3: Chital Hard Antlers observed in Different Antler Class 1980 - 1981

Month	Total hard antlers classified 1.	ANTLER CLASS							
		I		II		III		IV	
		Spike	2.	Less than 30 cm.		30 cm - 60 cm		More than 60 cm	
		N	%	N	%	N	%	N	%
June	60	7	11.7	20	33.3	15	25.0	18	30.0
July	56	5	8.9	14	25.0	22	39.3	15	26.8
Aug.	156	23	14.7	42	26.9	35	22.4	56	35.9
Sept.	166	40	24.1	34	20.5	57	34.3	35	21.1
Oct.	49	19	38.7	16	32.6	10	20.4	4	8.2
Nov.	7	3	42.8	3	42.8	1	14.3	0	0
Dec.	5	2	40.0	2	40.0	1	20.0	0	0
Jan.	4	2	50.0	1	25.0	1	25.0	0	0
Feb.	62	18	29.0	23	37.1	14	22.6	7	11.3
Mar.	85	17	20.0	28	32.9	21	24.7	19	22.4
Apr.	118	20	16.9	31	26.3	39	33.1	28	23.7
May	101	11	10.9	27	26.7	32	31.7	31	30.7
Total	869	167	19.2	241	27.7	248	28.6	213	24.5

1. Excluding unclassified hard antlers

2. Antlers without any fork or branches

FIGURE 7.2: CHITAL: Percent shed, velvet, hard antlers observed in each month.

N = 3795

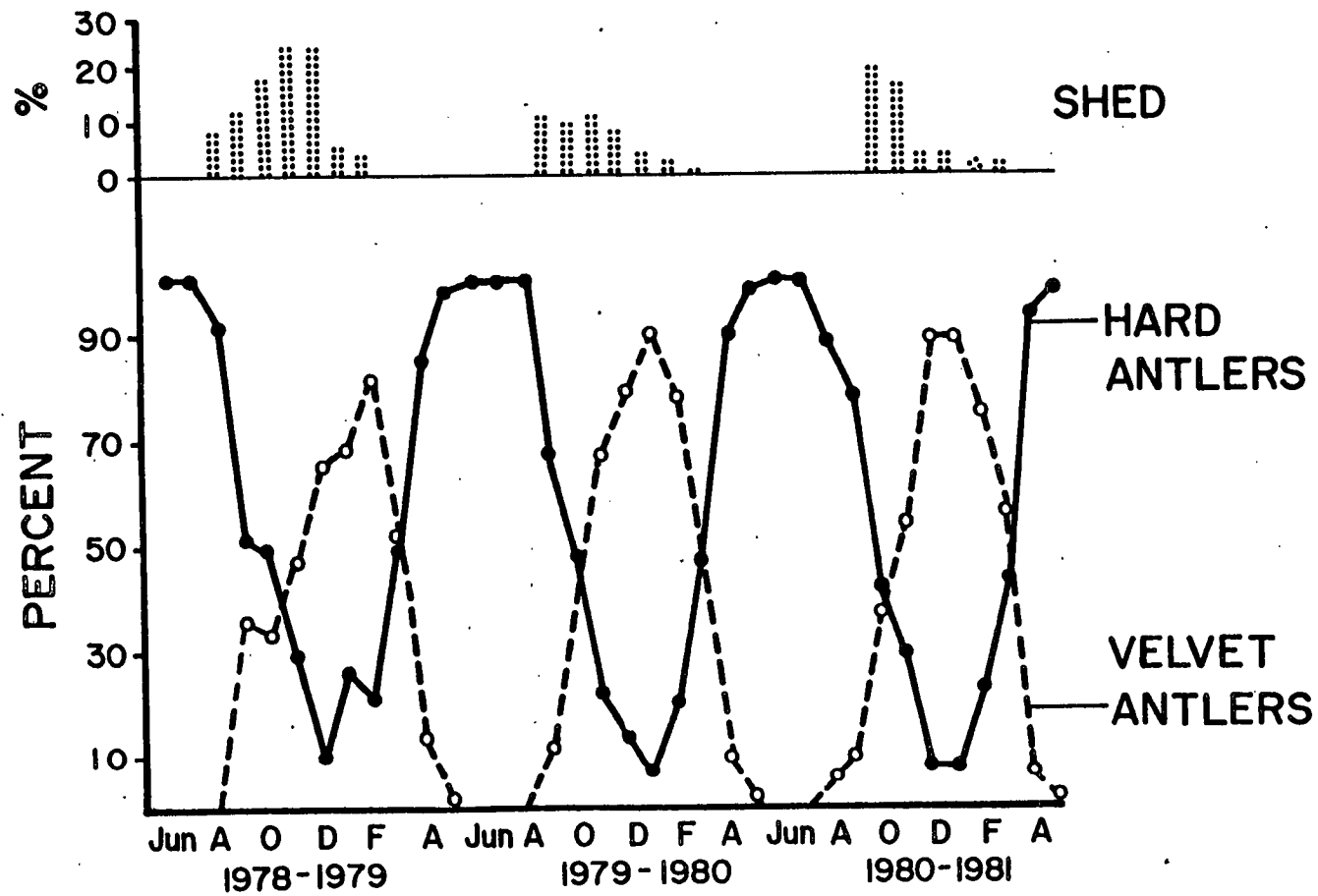


FIGURE 7.3: Chital Frequency of Bellows/Month

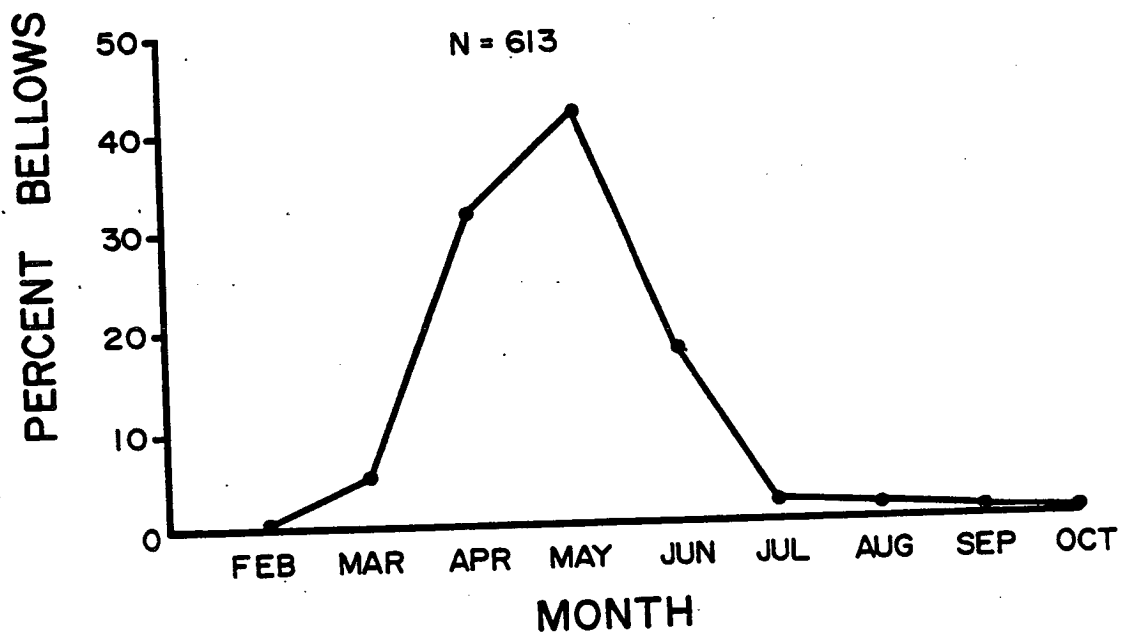


FIGURE 7.4: Chital Frequency Bellows /Time

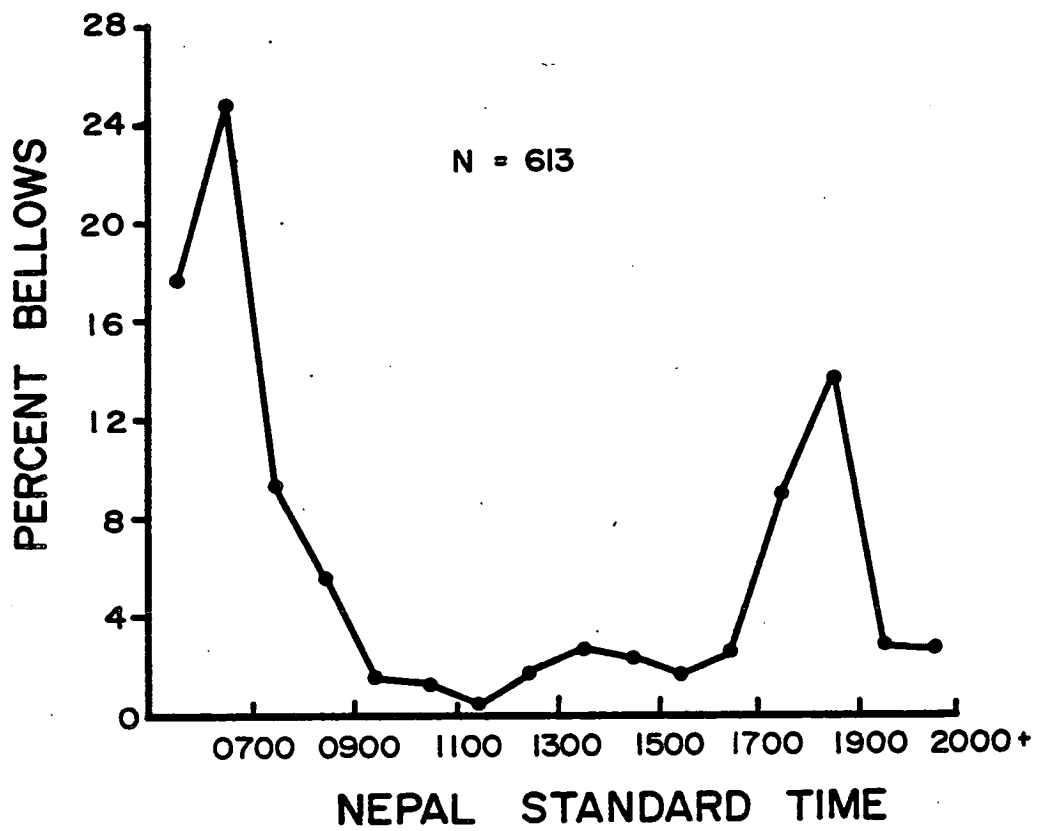
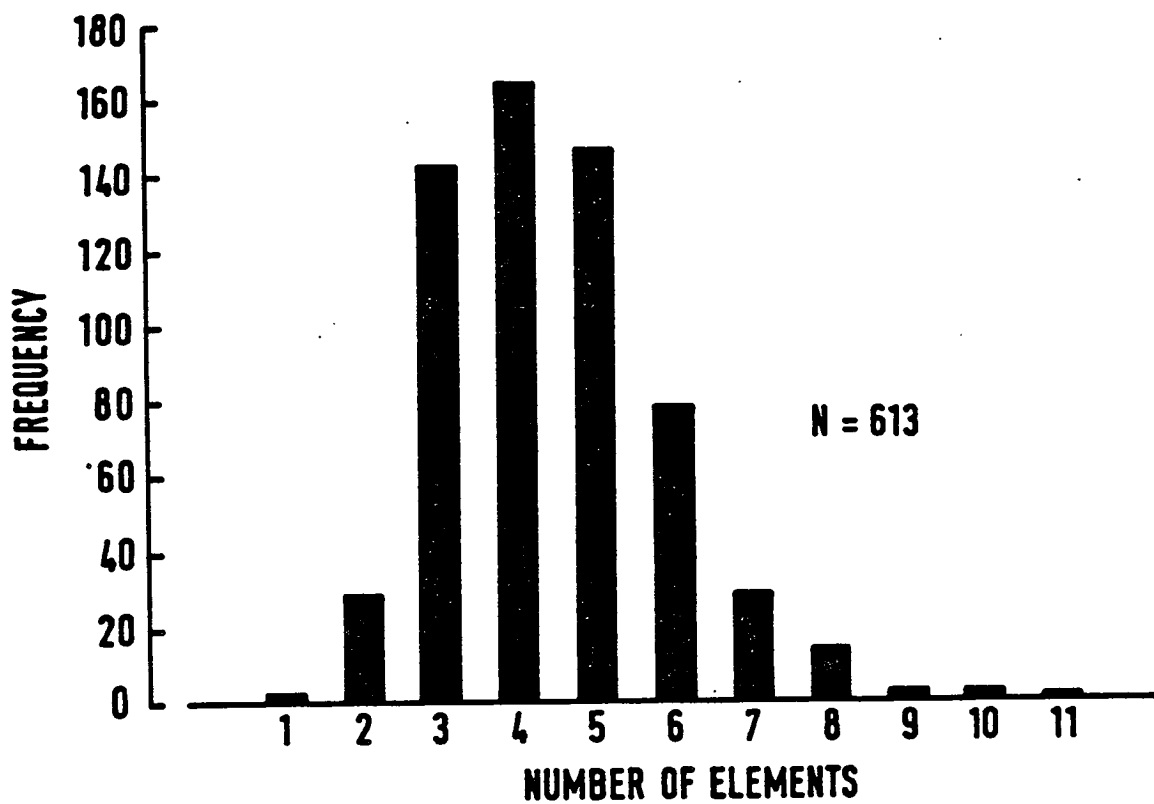


FIG 7.5



CHITAL : NUMBER OF ELEMENTS PER CALL

($r_s = 0.9578$ $p < .001$). Sexes started to mix as the antlers became harder and this is a behaviour common to all cervids. Of a total of 869 hard antlers classified in 1980-1981; 19.2 % were spike antlers; 27.7 % estimated to be less than 30 cm; 28.6 % estimated to be between 30-60 cm and 24.5 % were estimated to measure over 60 cm (Table 7.3).

(b) **Bellowing:** In Chitwan, bellows of rutting males were heard only from February to September. The frequency of bellows heard reached a peak in May after which it declined rapidly and one last bellow was heard in September (Fig. 7.3). This behaviour has a marked diurnal pattern with peaks in early morning and late afternoon (Fig. 7.4). The number of elements or bouts per call ranged from 1 to 11 but most calls consisted of 4 elements (Fig. 7.5). I did not observe any significant seasonal pattern on the number of elements per bellow though the bouts appeared to be more rapid in April and May.

B. Male-female interactions:

A total of 154 male-female interactions comprising of 35 observations of flehmen, 93 "tending" observations; 44 mounts or attempts to mount and 2 copulations.

(a) **Tending:** "Tending" behaviour was observed in all the months except between November to January. Of the total of 93 observations, 79 were between March and June and the peak was reached in May (Table 7.4). Of these observations, 56 (60.2 %) with antlers between 30-60 cm; 7 (7.5 %) with antlers estimated to be less than 30 cm, 5 (5.4 %) young bucks in spike antlers and no chital with velvet antlers were seen in the "tending" postures (Table 7.4).

(b) **Flehmen:** Except for one record in October all the 35 observations were recorded between the months of January and June.

The month when most ($n = 11$) flehmen was observed was in April. Of the total observations, 26 (78.8 %) of males had antlers estimated to be over 60 cm in length; 5 (26.1 %) with antlers estimated to be between 30-60 cm; 2 (6.1 %) with antlers estimated to be less than 30 cm and none with spike or velvet antlers (Table 7.5).

(c) Mounts or attempts to mount: This behaviour was not observed between October and January. The peak month when most males were seen mounting or attempting to mount was in May (Table 7.4). Of the 44 observations recorded 24 (54.5 %) of males had antlers estimated to be over 60 cm, 11 (25.0 %) with antlers estimated to be 30-60 cm, 5 (11.4 %) with less than 30 cm antlers; 3 (6.8 %) with spike antlers and one (2.3 %) with fully developed velvet antlers.

(d) Copulation: Two copulation was recorded both were in May and by males that had antlers estimated to be over 60 cm.

C. Seasonal cycles in females:

Since the sample sizes were not consistent for all the species for each month of the year, the data were standardized to express number of fawns per 100 does recorded by months.

Fawns were sighted in every month of the year. However, the ratio of fawns per 100 adult does increased from the lowest level of 2.8 in June to a peak of 24.9 in December (Table 7.6) and after January it started to decline (Fig. 7.10). Thus despite a certain degree of spread, there was a distinct seasonal pattern of parturition. The main season of births was during the relatively cold and dry post-monsoon season.

TABLE 7.4: Chital Interactions between adult male and adult

Female

Months	Tending	Flehmen	Mount	Copulate
January	0	2	0	0
February	5	1	3	0
March	17	6	5	0
April	25	11	14	0
May	27	9	15	2
June	12	5	4	0
July	1	0	0	0
August	2	0	1	0
September	1	0	2	0
October	3	1	0	0
November	0	0	0	0
December	0	0	0	0
Totals	93	35	44	2

TABLE 7.5: Chital Male/Female Interactions by Antlers Class :

Antler Class	Tending		Flehmen		Mount		Copulate		TOTAL	
	N	%	N	%	N	%	N	%	N	%
IV More than 60 cm	56	60.2	26	78.5	24	54.4	2	100.0	108	62.8
III 30 - 60 cm	25	26.9	5	15.1	11	25.0	0	0.0	41	23.8
II Less than 30 cm	7	7.5	2	6.1	5	11.4	0	0.0	14	8.1
I Spike hard	5	5.4	0	0.0	3	6.8	0	0.0	8	4.7
Velvet	0	0.0	0	0.0	1	2.3	0	0.0	1	0.6
TOTAL	93	54.1	33	19.2	44	25.6	2	1.2	172	100.0

TABLE 7.6: NUMBER OF FAWNS PER 100 DOES

Month	Fawns per 100 Does			
	Chital <30 days	Hog Deer <30 days	Sambar <30 days	Barking Deer <3 Months
June	2.8	0	42.8	0
July	4.0	4.3	37.1	0
August	9.4	0	15.6	7.1
September	9.0	0	3.8	7.7
October	13.7	0	0	0
November	14.9	0	5.3	18.2
December	24.9	0	2.2	14.8
January	21.6	0	6.3	0
February	20.7	8.5	11.8	0
March	17.5	8.3	10.5	4.8
April	12.8	16.4	7.0	6.9
May	8.5	29.8	13.3	14.9

7.4 A comparison with other deer:

The other cervids in Chitwan were seen much less often than the chital and thus the sample sizes for them were smaller. Unlike the chital their calls during the rut could not be distinguished from alarm or other calls. Thus I have only compared the seasonal cycle of antler development and the ratio of fawns to adult does.

(1) The hog deer:

(a) Antler cycle: A total of 398 observations of hog deer bucks were recorded and the percentage of shed, velvet and hard antlers in each month was computed (Table 7.7). Male hog deer were rather elusive and it was generally difficult to observe them clearly enough to see new antler scars. One deer with shed antlers was seen in November and the rest were seen between February and March. Except for 6 animals all those with velvet antlers were sighted between the months of December and May. The peak occurrence of velvet was in April and the peak in hard antlers was reached in ~~Sept~~ - ~~Oct~~ when no deer in velvet were seen (Fig. 7.6). The annual cycle of antler development in hog deer was 2-3 months later than that of chital.

(b) Seasonal cycle of females: A total of 68 fawns were recorded and with the exception of one in July all were seen between February and May. The number of fawns per 100 does increased steadily from February and reached a peak in May after which there was a sharp decline. Fawning in hog deer did not appear to be as wide spread as in the chital and there is about 4 to 5 months difference between the peak period of fawning these two species (Fig. 7.10).

(2) The Sambar:

(a) Antler cycle: A total of 360 sambar observations were

TABLE 7.7: HOG DEER ANTLER CYCLE IN SHED, VELVET, HARD ANTLERS OBSERVED BY MONTH

Month	Total	Number			Percent		
		Shed	Velvet	Hard	Shed	Velvet	Hard
June	26	-	2	24	-	7.7	92.3
July	14	-	1	13	-	7.1	92.9
August	13	-	2	11	-	15.4	84.6
September	34	-	-	34	-	-	100.0
October	10	-	-	10	-	-	100.0
November	6	1	1	4	16.7	16.7	66.6
December	10	-	4	6	-	40.0	60.0
January	8	-	4	4	-	50.0	50.0
February	67	4	25	38	6.0	37.3	56.7
March	110	15	75	20	13.6	68.2	18.2
April	60	-	49	11	-	81.7	18.3
May	40	-	14	26	-	35.0	65.0

FIGURE 7.6: Hog Deer: Antler cycle in percent of shed, velvet and hard antlers observed in each month

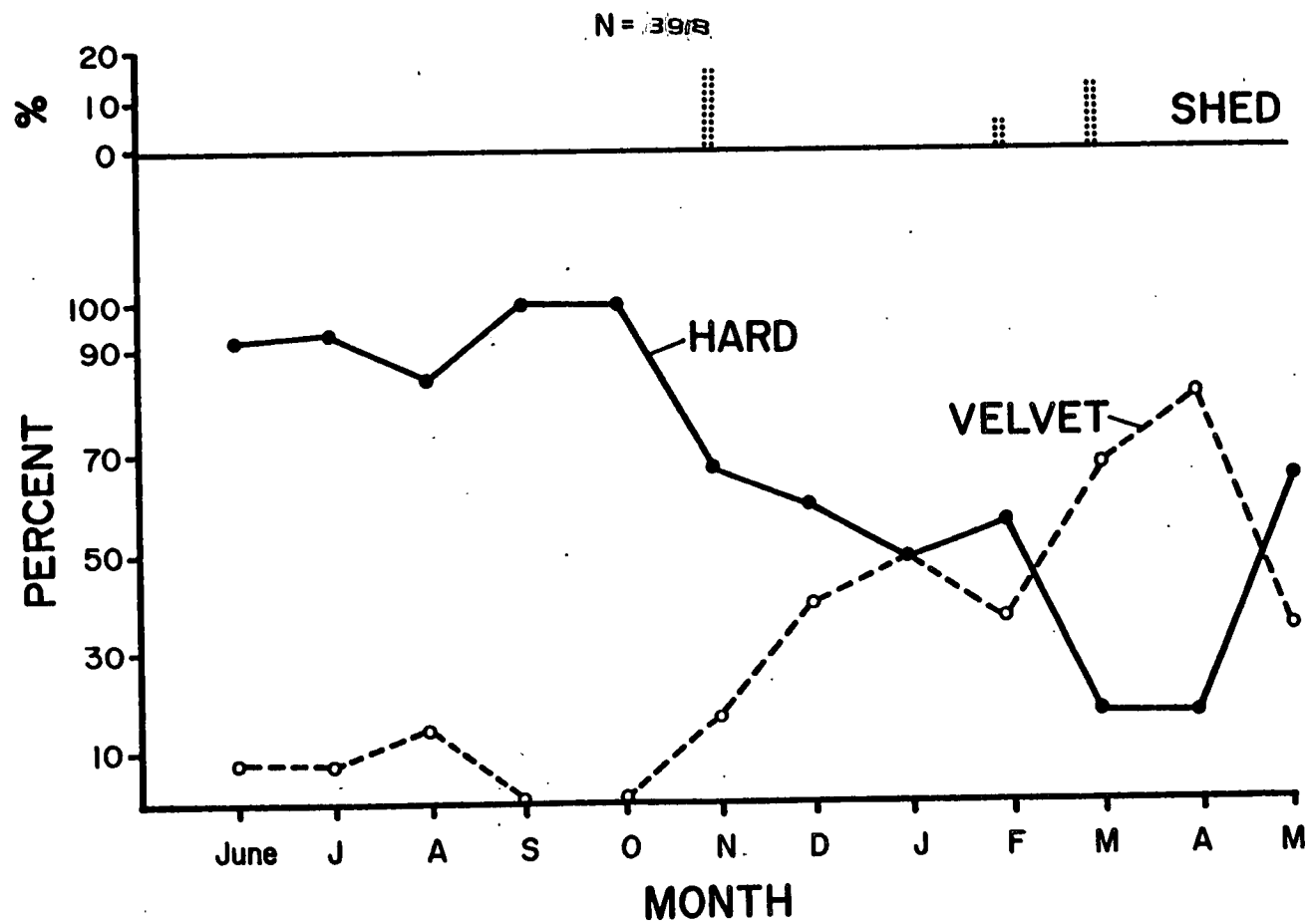


TABLE 7.8: SAMBAR: ANTLER CYCLE IN SHED,VELVET, HARD ANTLERS OBSERVED BY MONTH

Month	Total	Number			Percent		
		Shed	Velvet	Hard	Shed	Velvet	Hard
June	24	3	11	10	2.5	15.8	41.7
July	16	2	12	2	12.5	75.0	12.5
August	22	2	17	3	9.1	77.3	13.6
September	30	0	22	8	-	73.3	26.7
October	9	0	6	3	-	66.7	33.3
November	6	0	2	4	-	33.3	66.7
December	22	1	1	20	4.5	4.5	91.0
January	24	0	2	22	-	8.3	91.7
February	45	1	5	39	2.2	11.1	86.7
March	75	2	7	66	2.7	9.3	88.0
April	42	3	5	34	7.1	11.9	81.0
May	45	7	13	25	15.6	28.9	55.5

FIGURE 7.7: Sambar Antler cycle in percent shed, velvet and hard antlers observed in each month.

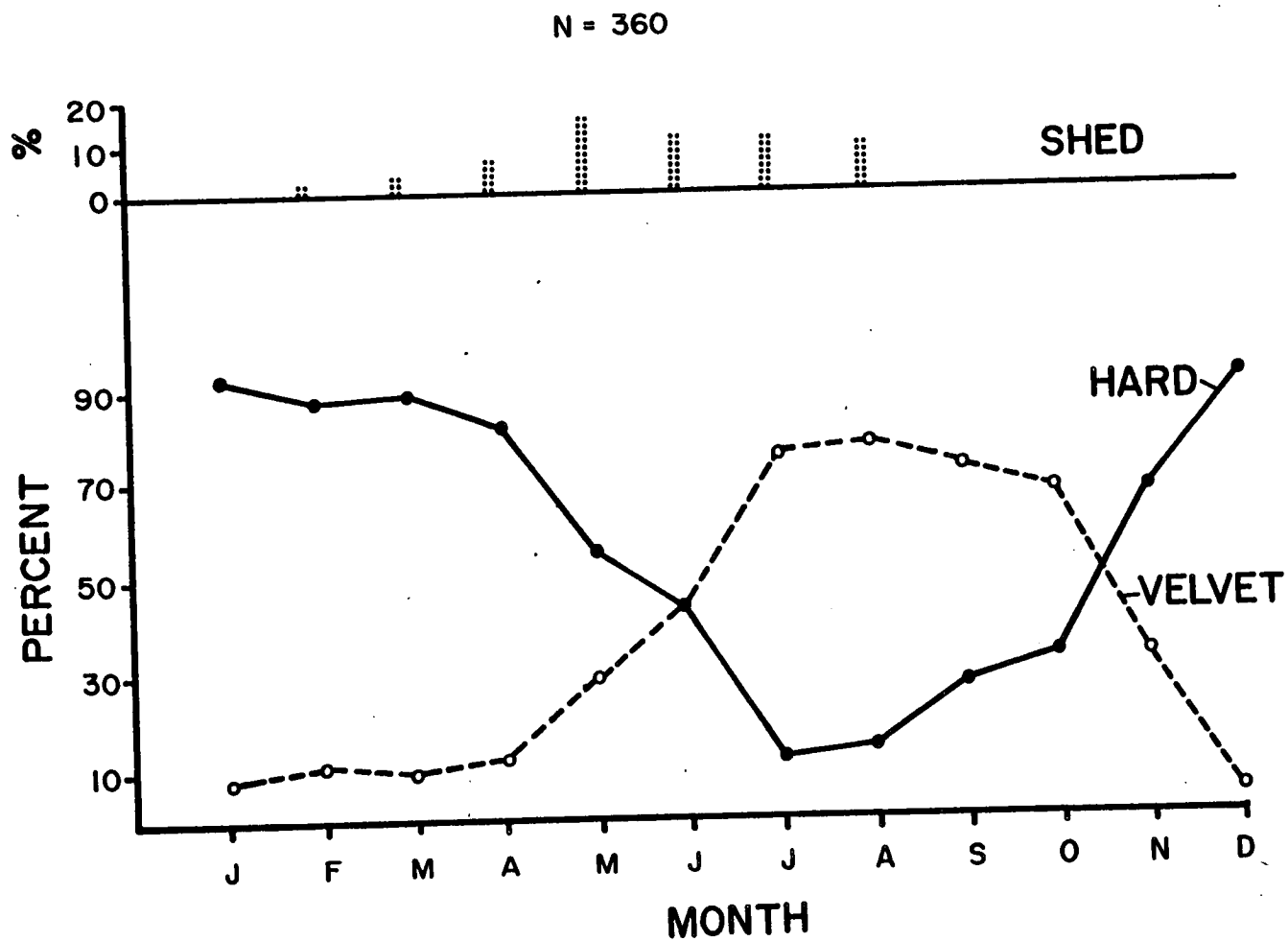
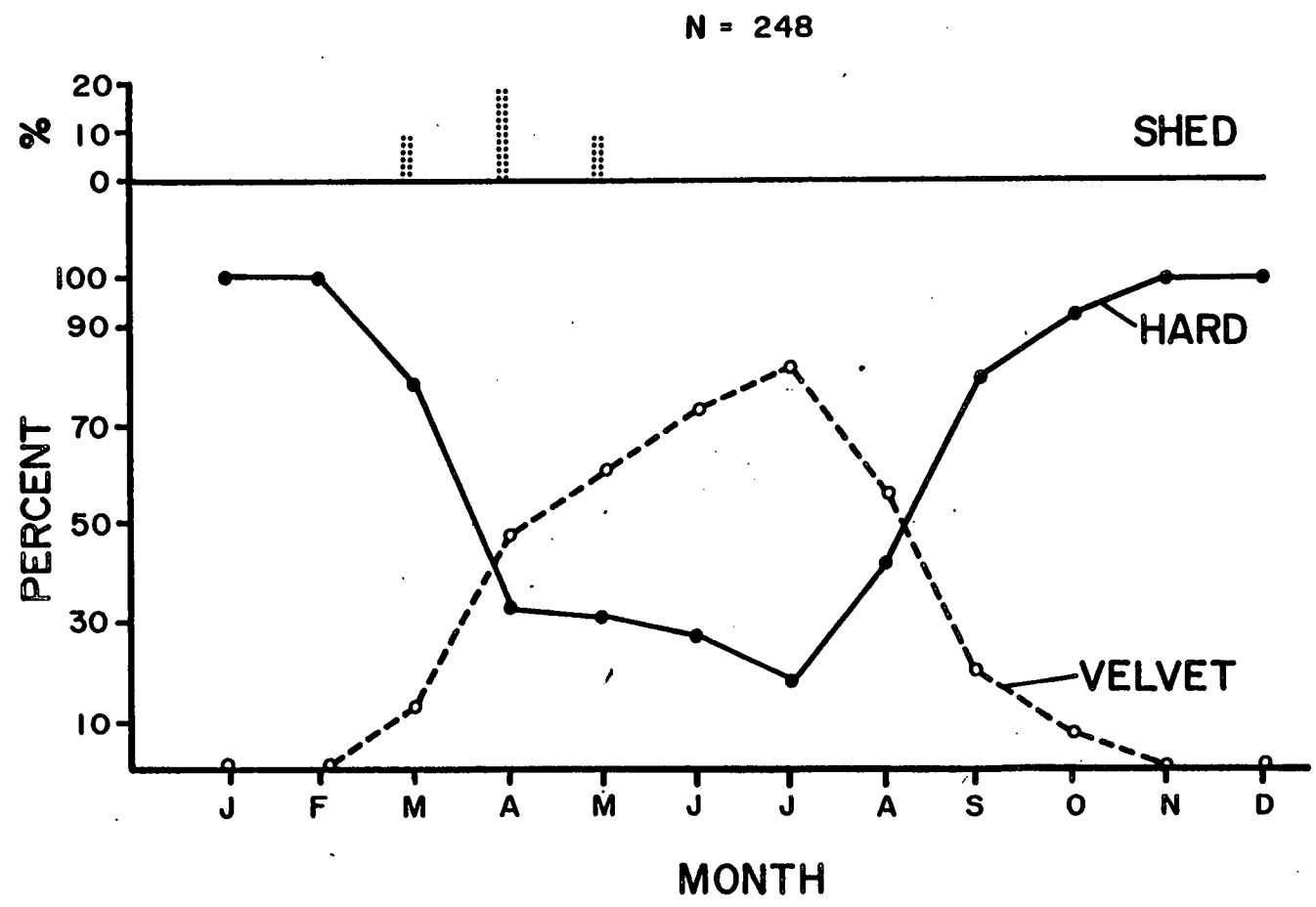


TABLE 7.9: BARKING DEER: ANTLER CYCLE IN SHED, VELVET, HARD ANTLERS OBSERVED BY MONTH

Month	Total	Number			Percent		
		Shed	Velvet	Hard	Shed	Velvet	Hard
June	22	-	16	6	-	12.7	27.3
july	11	-	9	2	-	81.8	18.2
August	24	-	14	10	-	58.3	41.7
September	15	-	3	12	-	20.0	80.0
October	14	-	1	13	-	7.1	92.9
November	16	-	-	16	-	-	100
December	26	-	-	26	-	-	100
January	13	-	-	13	-	-	100
February	12	-	-	12	-	-	100
March	23	3	3	18	8.7	13.0	78.3
April	27	5	13	9	18.5	48.2	33.3
May	45	4	27	14	8.9	60.0	31.1

Figure 7.8: Barking Deer: Antler cycle in percent of shed, velvet and hard antlers observed in each month



classified in percent observed shed, velvet and hard antler in each month. In Chitwan, Sambars started shedding their antlers in February and a few deer with shed antlers were seen until August. However the highest percentage of animals with shed antlers was seen in May (Table 7.8). The percentage of deer in velvet increased from 11.9 % in April and reached a peak of 77.3 % in August. From September velvet antlers began to decline and by December - January over 90 % of the animals were in hard antlers (Fig. 7.7). The antler cycle of the sambar was opposite to that of the Chital. When chital in velvet peaked in December - January, the Sambar were in a peak of hard antlers.

(b) Seasonal cycle of females: Of the total 89 fawns observed, only 7 were seen between September and January. The number of fawns per 100 does increased from 2.2 in December and reached a peak of 42.8 in June after which it declined to zero in October (Table 7.6). Parallel to the difference in antler cycle, the fawning cycles in chital and sambar were opposite (Fig. 7.10).

3. The Barking deer:

(a) Antler cycle: A total of 248 barking deer observations were classified according to the state of their antlers (Table 7.9). Because of its size and the presence of a long antler pedicle it was difficult to identify animals with recently shed antlers. Only 11 deer with shed antlers were recorded, all of them between the months of March and May. Animals with velvet antlers were seen in most months except from October to January. The peak in velvet was reached in July when over 50 % of the deer seen had velvet antlers. All deer seen between December and February had hard antlers (Fig. 7.8).

(b) Seasonal cycle in females: Only 19 barking deer fawns were seen as these small forest dwelling deer seldom come out of cover with

their young. The number of fawns per 100 does showed a peak in November with 2 smaller peaks in May and August - September (Fig. 7.10).

7.5 Discussion:

The antler cycle in chital indicates that they come into rut sometime during the pre-monsoon season from March - May. The frequency of bellows also indicate that rut commences in February and reaches a peak in May. The male-female interactions indicate that most mating occurred in April and May just before the monsoon rains. A comparison of the mating season in Chitwan with those reported from other parts (Table 7.10) suggests similarities from contrasting regions of the world. The annual cycle of breeding in males in the exotic environment of Texas (Ables 1974) and Hawaii (Graf and Nichols 1966) is similar to that in Chitwan. But then they are also similar to Kanha (Schaller 1967) and Gir (Berwick 1974) where climate vegetation and particularly rainfall contrasts to that in Chitwan. It is not clear why Eisenberg and Lockhart (1972) suggested two peak periods of rut in Sri Lanka.

The main season of parturition in the Chitwan chital was during the post-monsoon months of December and January and it is also similar to that in Texas and Hawaii (Ables 1974; Graf and Nicholls 1966). Though some breeding occurred throughout the year, the chital in Chitwan also exhibited a distinct seasonal pattern of breeding cycle contrary to the suggestions based on captive deer.

In the past, some authors have suggested that Sambars retain their antlers for 2-4 years before being changed (Fletcher 1911; Lydekker 1924), but I found no evidence of it in Chitwan and neither is there any evidence to support this view either in captive or wild populations in other parts of the world (Crandall 1964; Schaller 1967). The antler cycle of sambar in Chitwan is similar to that in Kanha (Schaller 1967)

FIGURE 7.9: Comparison of Antler cycle in the 4 species of deer
in percent of hard antlers seen in each month.

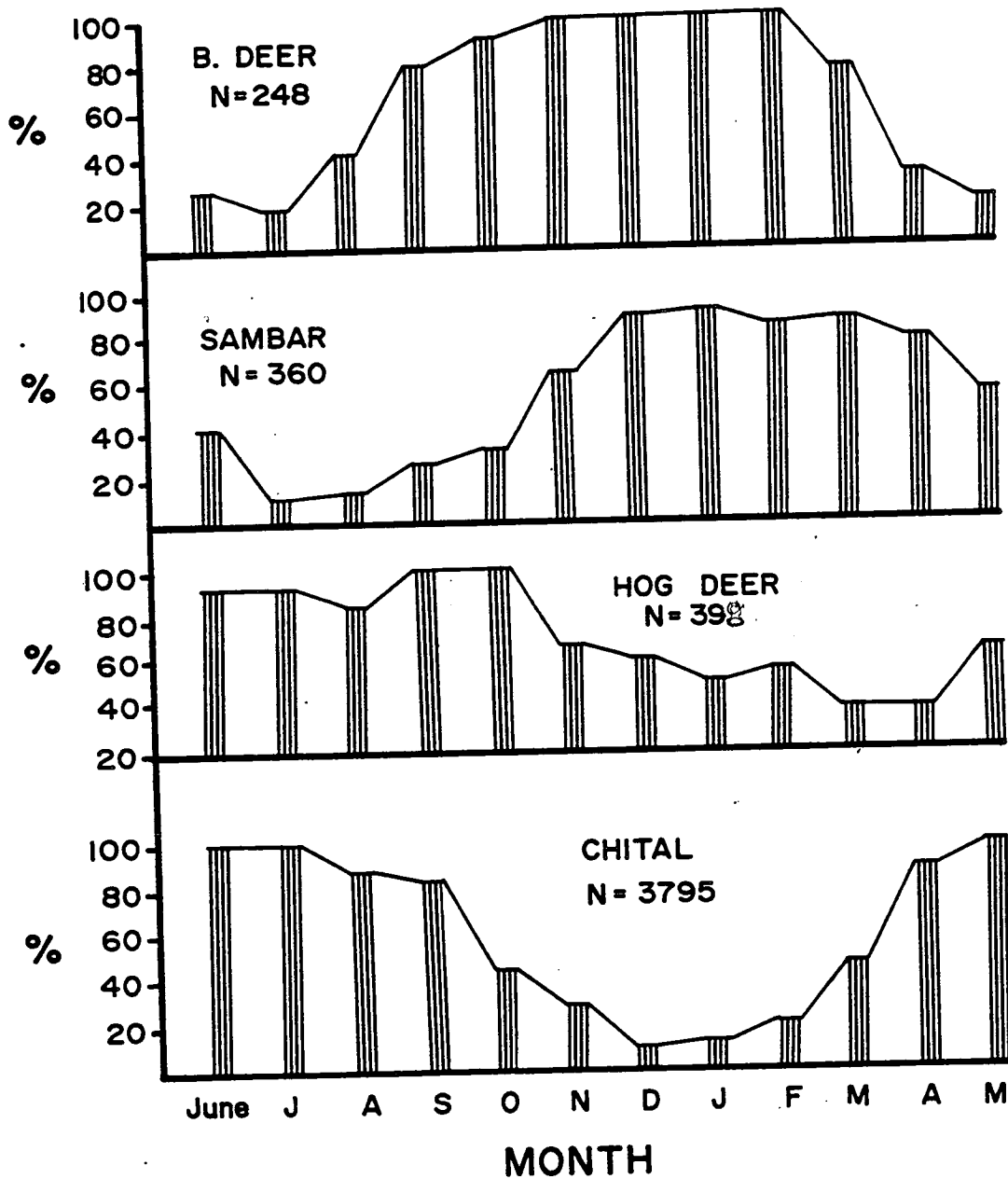
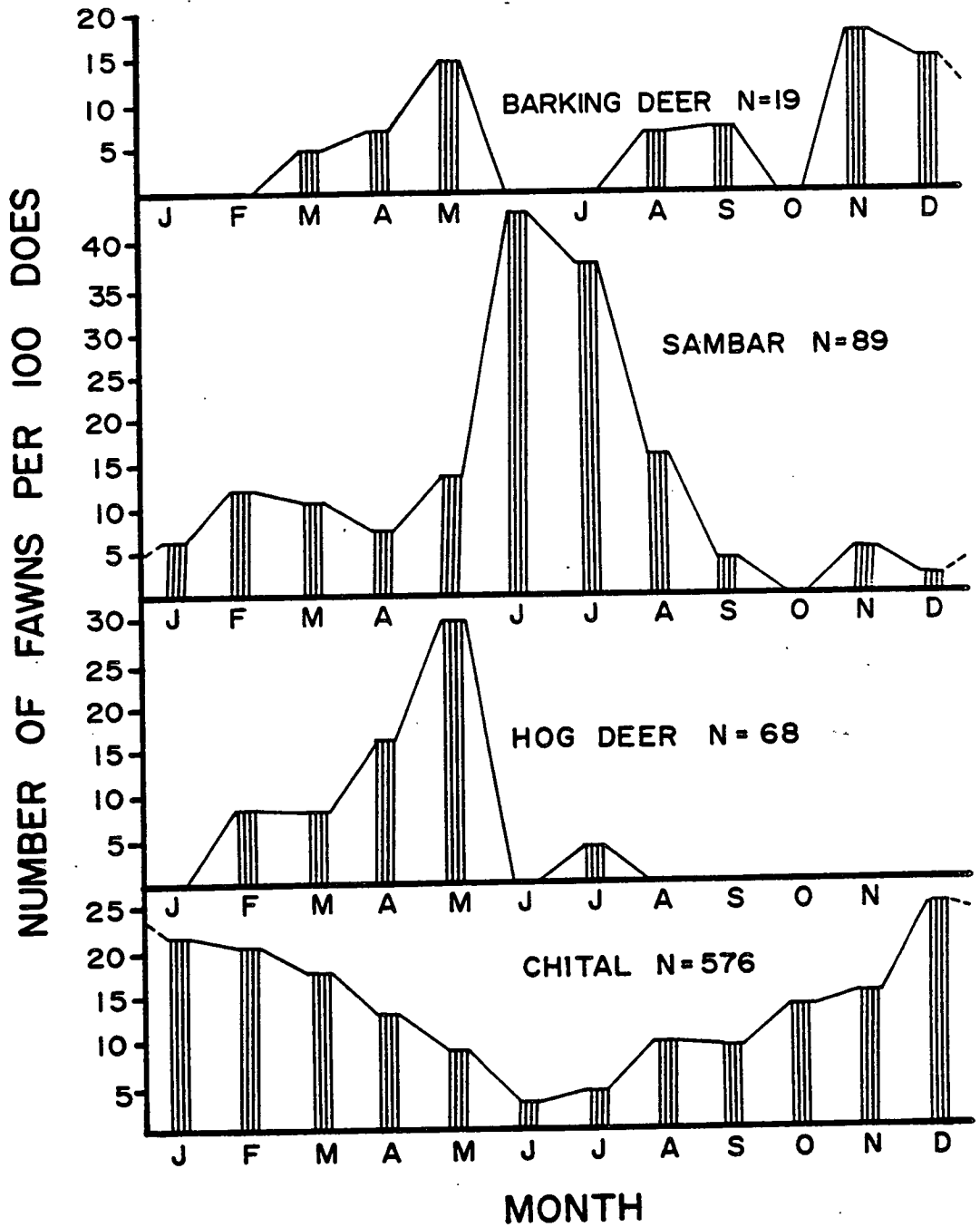


TABLE 7.10: LITERATURE REVIEW OF REPRODUCTIVE SCHEDULE IN CHITAL

Source	Place	Peak Mating Period	Date of Birth
Hodgson, 1847	N. India	Dec - Jan	Jun - Jul
Inverarity, 1895	N. India	Throughout the year	Throughout the year
Fletcher, 1911	S. India	Oct - April	-
Brander, 1923	Cent. India	Apr - May	October
Krishnan, 1959	S. India	Throughout the year	Throughout the year
Graf and Nichols, 1966	Hawaii, U.S.A.	Apr - Aug	Nov - Mar
Schaller, 1967	Khana, N.P. India	May	February
Berwick, 1974	Grier, India	March - May	Aug - Sept
Eisenberg and Lockhart, 1972	Wilpattee, N.P. Sri Lanka	Jan - Feb & Jun - Aug	Sept - Oct & Dec - Jan
Ables, 1974	Texas, U.S.A.	Mid-May	January
This study	Chitwan, N.P. Nepal	April - May	Dec - Jan

Figure 7.10: Comparison of breeding season in number of Fawns/
100 does observed in each month.



and to those reported by several hunters from different parts of India during the colonial era (Jerdon 1874; Baldwin 1877; Russel 1900; Stockley 1913; Brander 1923). In contrast to the chital, the rut and parturition in the sambar is six months out of phase.

In Chitwan, most hog deer come into rut in September - October and parturition occurred in April - May. This is similar to that reported in Corbett National Park in North East India (De and Spillett 1966) and Burma (U Yun Tin 1967).

The breeding cycle of hog deer appears to fit between the extreme differences in seasons of the chital and the sambar. Antler cycle indicates rut in hog deer is about 2-3 months after that of the chital and about 2-4 months before that of the sambar (Fig. 7.9). Similarly there is a difference of 2-4 months in parturition cycle of the hog deer with those of chital and sambar (Fig. 7.10).

The antler cycle of barking deer was also very seasonal though parturition did not appear to follow any particular seasonal cycle probably because of the shortage of data on this aspect. The antler cycle observed in Chitwan is similar to those reported in captive or wild barking deer throughout its range (Dubost 1971; Barrette 1977). One of the peculiarities reported in this species is the lack of synchrony between antler cycle and sexual activities (Barrette 1977). In Sri Lanka, Barrette (1977) also found that there was no distinct fawning season. Thus it seems hard to determine when it comes into rut. The bark was once regarded to indicate rut (Soaper 1969) but recent studies in captivity and in the wild failed to support this hypothesis (Yahner 1980). Though the period in hard antlers of barking deer and sambar overlap, most barking deer retained their hard antlers when sambar are mostly in velvet. Similarly the period of hard antlers in barking deer overlaps the period when chital and hog deer are shedding or in velvet.

Since this animal has smaller antlers than the others it retained hard antler longer than any other deer (Fig. 7.9.) as it probably does not take long for antlers to grow.

In the temperate region the effect of seasons on reproduction is obvious. Most deer rut in summer and autumn and most fawns are produced in spring when food is more abundant (Lindsale and Tommich 1953; Southern 1964; Taylor 1956; Sadleir 1969; Mitchell *et al* 1977). The growth of antlers and consequently reproductive cycles coincides with the increase in day length (Goss 1969 a and b; Lincoln 1971; McDowell 1970).

In the tropical regions the annual cycle of rainfall is closely associated with forage production and the breeding cycles of many ungulates (Phillipson 1975; Eltringham 1979; Delany and Happold 1979). One of the main differences between the temperate and tropical regions is that in higher latitudes winter is less productive because of shortage of energy in the form of sunlight (Eltringham 1979). But regardless of latitudinal differences, pregnancy and lactation add an extra burden to all ungulates and are the times of maximum nutritional need for females (Sadleir 1969). In comparison to day length, rainfall, particularly the onset and duration is not predictable thus some births in the tropical regions occur throughout the year but the peak is reached at a time when fawn survival is optimal (DuPlessis 1972; Skinner *et al* 1973; Estes 1976; Sekulic 1978; Eltringham 1979; Delany and Happold 1979).

There seem to be two differences between the breeding cycles of the deer in Chitwan and those of Europe and North America. In the latter the period of breeding is discreet and not as widely spread as observed in the Chitwan deer. In moose (*Alces alces*) in British Columbia, Edwards and Ritchey (1958) state that about 85 % of the

pregnant females produced young in a ten day period. In the red deer (*Cervus elaphus* L.) in Scotland over two thirds of the fawns were produced within 3 weeks (Guinness *et al* 1978) and in roe deer (*Capreolus capreolus*) over 80 % of the fawns are born within a month (Loudon 1980).

In Chitwan, though there is a distinct peak of breeding activity, most breeding is spread over a longer period of time than the deer of Europe and America.

The other difference is there is a lack of seasonal uniformity in the breeding cycles of the 4 species of deer. The period when most breeding occurred is not the same for all the species. In this respect the deer of Chitwan are more similar to the ungulates in Africa where breeding is spread over a longer duration and some of the species have different seasonality in peak periods (Leuthold and Leuthold 1975; Eltringham 1979; Delany and Happold 1979). There, some species conceived when days were short and some species conceived when days were getting longer and there were some in which breeding cycles were not correlated with day length (Spinage 1973). The chital produced their young during the cool and dry seasons (December - January) when day length was shortest and the sambar produced young in June - July when day length was about 2 hours longer and the peak period of parturition coincided with the onset of the monsoon. The breeding cycle of the hog deer was between these extremes.

In this respect they are similar to some of the African ungulates. In Coke's hartbeest (*Alcelaphus buselaphus cokei*), the main period of births is between February and April (Gosling 1969), while in Lichtenstein's hartebeest it is between July and August (Mitchell 1965). In blue wildebeest (*Connochaetes taurinus*) most births occur between December and February (Watson 1969) and several species breed throughout the year (Skinner *et al* 1974). In African ungulates there are also

regional differences in breeding cycles of the same species as climatic conditions vary from regions to regions (Eltringham 1979; Delany and Happold 1979; Sinclair and Norton-Griffiths 1979). Estes (1976) suggests that in wildebeest (*Connochaetes taurinus*) in the Ngorongoro crater in Tanzania, breeding synchrony is an adaptive strategy where young are protected from predators through a "confusion effect" by many calves being born at the same time.

Leuthold and Leuthold (1975) state that though rainfall in the tropics is often considered to be a causative factor governing reproductive cycle it often fails to explain why some species have restrictive breeding cycles and some breed throughout the year.

In the 4 species of deer in Chitwan it appears that there might not only be one but several factors that influence seasonality in the reproductive cycles. The mechanism evolved in the seasonal differences of breeding cycles is not clear without more research on the availability of forage with high nutritive qualities particularly during the breeding seasons for all the species of deer. It is generally known that the fawning coincides with peak season when nutritious forage is available (Verme 1965; Sadleir 1969; McCullough 1979; Picton 1979).

The breeding cycle of the sambar appears to be in agreement with the hypothesis that the peak season of births coincides with the onset of rainfall as in many of the African ungulates (Delany and Happold 1979; Eltringham 1979). During the monsoon, new growth of browse is more abundant than at any other season of the year.

In hog deer the main parturition season coincides with the time when most areas were burnt and new growth of grasses occurred. The history of fire as an ecological factor in Chitwan is not known. It

has been reported that man has been burning the grasslands in Asia for thousands of years (Bolton 1975; Laurie 1978) and there is also considerable evidence of natural fires caused by lightning (Wharton 1968; Ashton and Ashton 1972; Kozlowski and Ahlgren 1974). Assuming that fire has been a component of the hog deer's environment; the fawning season coincides with the annual fire and consequently new growth of grasses that become abundant and have high nutrient content (Kozlowski and Ahlgren 1974; Afalayan and Fafunsho 1978; Field 1976). The breeding cycle of hog deer appears to fit the hypothesis that fawning coincides with the period when both the quality and quantity of forage is at its highest.

Why is the peak period of fawning in the chital out of phase with the monsoon rains or burning in contrast to the hog deer and sambar ? Why do they give birth at a time of year when food availability is apparently low ? In the previous section I have pointed out that very little is known about the food and feeding habits of chital. The position is complicated by the fact that chital not only graze and browse but also feed in association with monkeys. The chital feed on leaves, petioles, flowers and fruits dropped by the foraging monkeys. The nutritive value of such foods is probably high. It would be important to calculate how much chital rely on this source of food compared with food collected by themselves. It may be that the food obtained from monkeys is very important and that one should examine the seasonal availability of food from this source when trying to understand breeding seasonality. The necessary information is not available at present.

Another factor that might influence breeding seasons is the extent of flooding from the monsoon. In areas close to rivers, where most chital occur, flooding to a considerable depth can develop in hours.

This might be expected to cause mortality to young fawns and breeding might be timed to avoid this. Blouch (1977) believed high rainfall to be important in the breeding seasonality of white-tailed deer in the Manos region of Colombia. However, if this were the only factor operating in Chitwan one would expect it to apply to hog deer as well and the seasonality of chital should be the same as the hog deer. Clearly other factors must be important.

It is important to remember that natural selection probably operates not only on the time of births but on other parts of the cycle as well. It is known that the condition of the female in ungulates at the time of mating is important for successful fertilisation and early embryo development (Sadlier 1969). Verme (1965) stated that deer on a high plane of nutrition began breeding earlier than those on a low plane. In east Transvaal in South Africa, Hall-Martin *et al* (1975) found that unlike most African ungulates, the giraffe (*Giraffa camelopardalis*) did not reproduce to coincide with the most favourable season for calf survival. There, it was the time of mating that coincided with the seasonal abundance of forage. McGinnes and Downing (1977) examined ten years data on factors that affected the peak period of fawning in white-tailed deer in Virginia. They concluded that the physical condition of the doe at time of conception was the only factor that was strongly correlated with the peak periods of fawning.

In Chitwan, most mating in chital appeared to take place during the pre-monsoon season when young grasses were abundant after the old crop was burnt. Presumably the females were in a better physical condition than at other times of the year indicating similarities to the predictions made by McGinness and Downing (1977). At present the exact significance of the chital's breeding season must remain an open

question and it is certainly an area where future research would be fruitful.

CHAPTER 8

8.

SOCIAL ORGANISATION

8.1 Introduction:

There have been many studies of the social organisation of ungulates in many different parts of the world and in many different habitats (Altman 1952; Leuthold 1970; Geist 1971; Hamilton 1971; Vine 1971; Estes 1974; Clutton-Brock 1974; Gossow and Schurloz 1974; Leuthold 1977; Mitchell *et al* 1977; Sinclair 1977; Geist and Pectoz 1977; Hirth 1977; McCullough 1979; Sinclair and Norton-Griffith 1979; Berger 1978). Basic information on social organisation is needed to understand its evolution and adaptiveness (Lack 1954; Wynne-Edwards 1962; Crook 1970; Wilson 1980; Wittenberger 1981; Eisenberg 1981) and also for proper management of populations (Dzieciolowski 1979; Jarman 1974; Sinclair and Norton-Griffiths 1979; Geist and Walther 1974). The requirements for management can be expected to increase as more stress is applied to natural habitats and as conflicts with human interests increase.

The ungulates of the Indian-subcontinent have not been studied in detail and only preliminary information is available on social organisation of chital in Western Nepal (Dinerstein 1979 and 1980); in central India (Schaller 1967); in Southern India (Sharatchandra and Gadgil 1981; Miura 1981) and in Sri Lanka (Eisenberg and Lockhart 1972; Santiapillai and Downie 1979). Similarly only limited information is available on the sambar (Schaller 1967; Eisenberg and Lockhart 1972) and barking deer (Barrette 1977).

The objective of this section was therefore to describe the social organisation of the four species of deer in Chitwan with emphasis on the chital. The aim was to determine the pattern of dispersion of the animals with respect to each other and how this

changed with seasons and habitats. This required consideration of the whole range of possible spacing from solitary to herding and of possible differences related to sex and age. The study was primarily concerned with describing the patterns and not the mechanisms by which they were achieved and maintained.

8.2 Methods:

The methods used consisted of direct observations from elephants (Chapter 5). Observation of the total number seen in a group and numbers in different sex age class were recorded while traversing through the transects as described previously (Chapter 5). The term "group" applies to all units of animals seen in one sighting. (Miura 1981). Here, I shall describe the criteria for sex and age classification in the field.

(1) Criteria used for ageing and sexing in the field:

Criteria for ageing and sexing were obtained from the literature (Schaller 1967; Eisenberg and Lockhart 1972) and from observations of semi captive animals of known age.

A. Chital:

Four age classes could be recognised in the field in Chital:

(a) Fawns: Fawns were approximated to be 1 to 30 days old and were identified by their longish hair and their size relative to the size of their mother. When standing beside their mothers, the level of their backs was below the level of their mother's belly.

(b) Juveniles: Juveniles were approximated to be one to 12 months old and were distinguished from fawns by their smooth coat and their size which was intermediate between fawns and yearlings (see below).

(c) Yearlings or sub-adults: They were regarded to be 12 to 24 months of age. Yearling males stood approximately 40 - 50 cms at

shoulder and females were 10-20 cm smaller. Yearling males also exhibited small humps on their frontal bones and in most cases spike antlers were visible.

(d) Adults: Adults of both sexes were regarded to be over two years of age and were readily distinguished from yearlings by their size.

B. Hog deer:

Similar criteria to those used for the chital were used to classify the hog deer. A young fawn less than 15 days old was obtained from a local villager. This animal resembled a chital fawn except for its characteristic piglet-like movement. Fawns of hog deer also have prominent spots on their coat and have longish hair that are not glossy as in the juveniles. Yearling hog deer had fainter spots along their back and which were not prominent in adults.

C. Sambar:

Fawns of sambar, unlike other cervids do not have spots on their coat. However they are much paler than juveniles. Here again the former were considered to be less than 7 months old and the latter between 2 to 12 months of age. The sub-adults and yearlings were the next class and were readily distinguished from adults.

D. Barking deer:

Though the young of barking deer have prominent spots on their coat, I found it difficult to distinguish fawns from juveniles. Furthermore, very few young barking deer were sighted. Thus I grouped the juvenile and fawns of barking deer together. Young seen with prominent spots were regarded to be less than 6 months old, while those exhibiting a few or faint spots were considered to be yearlings (Eisenberg and Lockhart 1972).

Animals were classified as unknown when field conditions or the reactions of the animals made identification impossible.

8.3 Results:

During the 3 year period a total of 4980 groups consisting of 24, 193 animals of the 4 species of deer were recorded. An analysis of variance (ANOVA) indicated that neither the number of sightings nor the total number of animals tallied were for all the species significantly different from year to year. Seasonal differences in the social system of each species were established by using all the data for 3 years broken down by months.

(1) The Chital:

A. Group Size:

Chital were seen both as solitary individuals and in groups. Group size was generally small with 63 % of all sightings having 5 or less individuals (Fig. 8.1). The average group size overall was 7.5. However, there were considerable variations (Fig. 8.2) in group sizes in relation to season and the average group sizes were significantly different ($F = 2.4$ $DF = 8$ $p < 0.01$) from habitat to habitat (Table 8.1). The following describes group size in relation to season and habitat.

(a) The River Bank Kans: The average group size in this habitat for all months combined was 9.3. Here, the average group size ranged from 4.5 in July to as high as 14.4 in November (Table 8.1). In contrast to other habitats group size was bigger during the cool period of the post-monsoon season than at other times of the year in this habitat. The peak in February (Fig. 8.3) was a result of the formation of larger groups in patches that had been cut.

(b) The Riverine Forest: The average group size in this habitat was 5.8 for all months combined. Here, the group size ranged from 4.0 in January to 8.6 in August (Table 8.1). In contrast to other habitats group size in the Riverine Forest did not vary significantly with

Figure 8.1: Chital: Group size in percent groups seen.

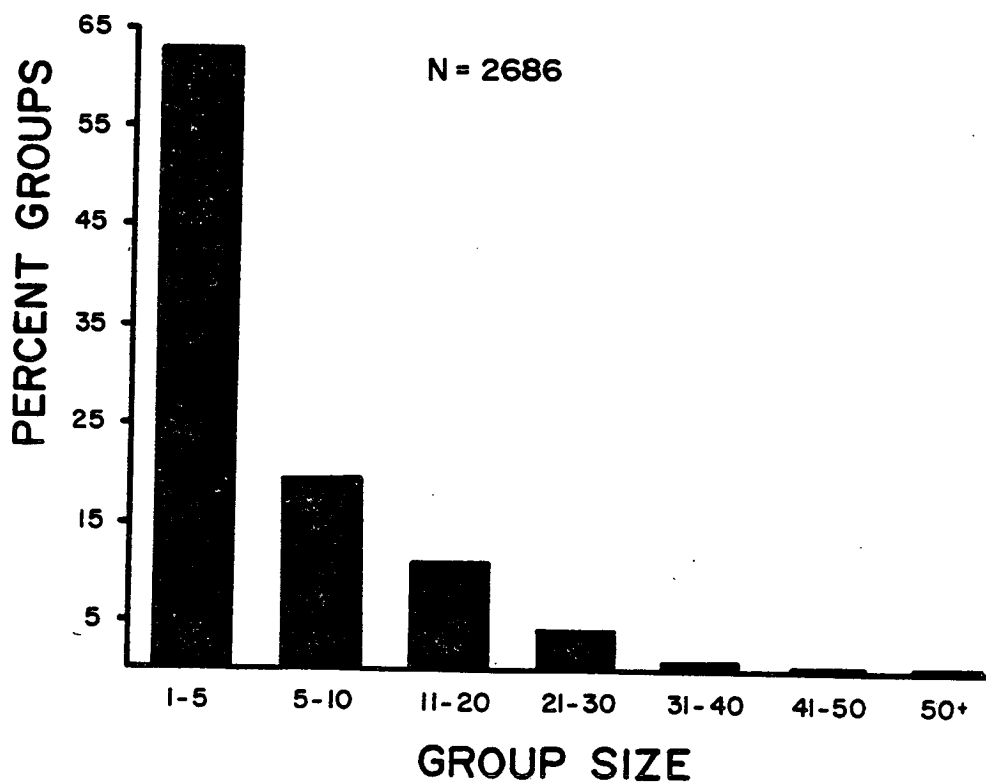


TABLE 8.1: CHITAL: AVERAGE GROUP SIZE/HABITAT TYPE

Month	Total Groups	Total Tallied	Average	River Bank Kans			Riverine Forest			Savannah Dhaddi			Old Village Sites			Sal Forest		
				Gr.	No.	Avg.	Gr.	No.	Avg.	Gr.	No.	Avg.	Gr.	No.	Avg.	Gr.	No.	Avg.
June	152	995	6.5	13	97	7.5	115	698	6.0	4	29	7.3	4	17	4.3	16	154	9.5
July	125	724	5.8	13	58	4.5	96	619	6.4	3	4	1.3	1	2	2.0	12	41	3.4
Aug	183	1588	8.7	13	161	12.4	159	1369	8.6	3	31	10.3	2	8	4.0	6	19	3.2
Sept	185	1447	7.8	10	128	12.8	156	1185	7.6	1	3	3.0	0	0	0.0	18	131	7.3
Oct	164	858	5.2	9	128	14.2	145	683	4.7	0	0	0.0	0	0	0.0	10	47	4.7
Nov	129	649	5.0	9	130	14.4	103	439	4.3	10	51	5.1	0	0	0.0	7	29	4.1
Dec	201	970	4.8	13	139	10.7	127	660	5.2	34	85	2.5	7	31	4.4	20	55	2.8
Jan	116	584	5.0	11	92	8.4	80	320	4.0	8	42	5.3	14	103	7.4	3	27	9.0
Feb	313	2800	8.9	7	93	13.3	135	640	4.7	64	431	6.7	97	1556	16.0	10	80	8.0
Mar	419	4163	9.9	12	92	7.7	178	1044	5.9	81	872	10.8	91	1517	16.7	57	638	11.2
Apr	320	2882	9.0	6	46	7.7	114	618	5.4	33	387	11.7	31	166	5.4	136	1665	12.2
May	379	2455	6.5	23	123	5.3	222	1182	5.3	32	177	5.5	7	41	5.9	95	932	9.8
Total	2686	20115	7.5	139	1287	9.3	1630	9457	5.8	273	2112	7.7	254	3441	13.5	390	3818	9.8

FIGURE 8.2: Chital: Average herd size by Habitat by Month

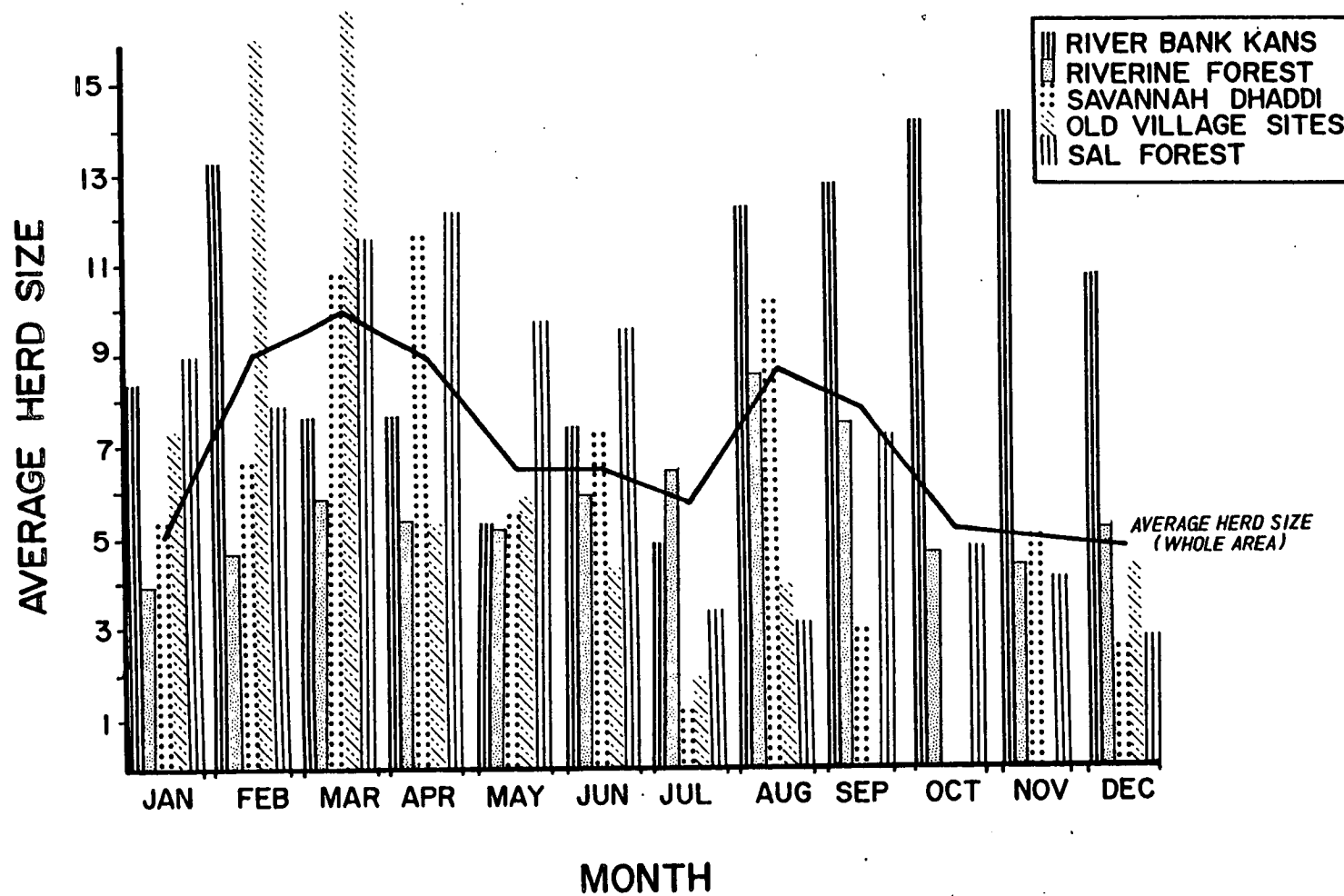


FIGURE 8.3: Chital: Group size by habitat

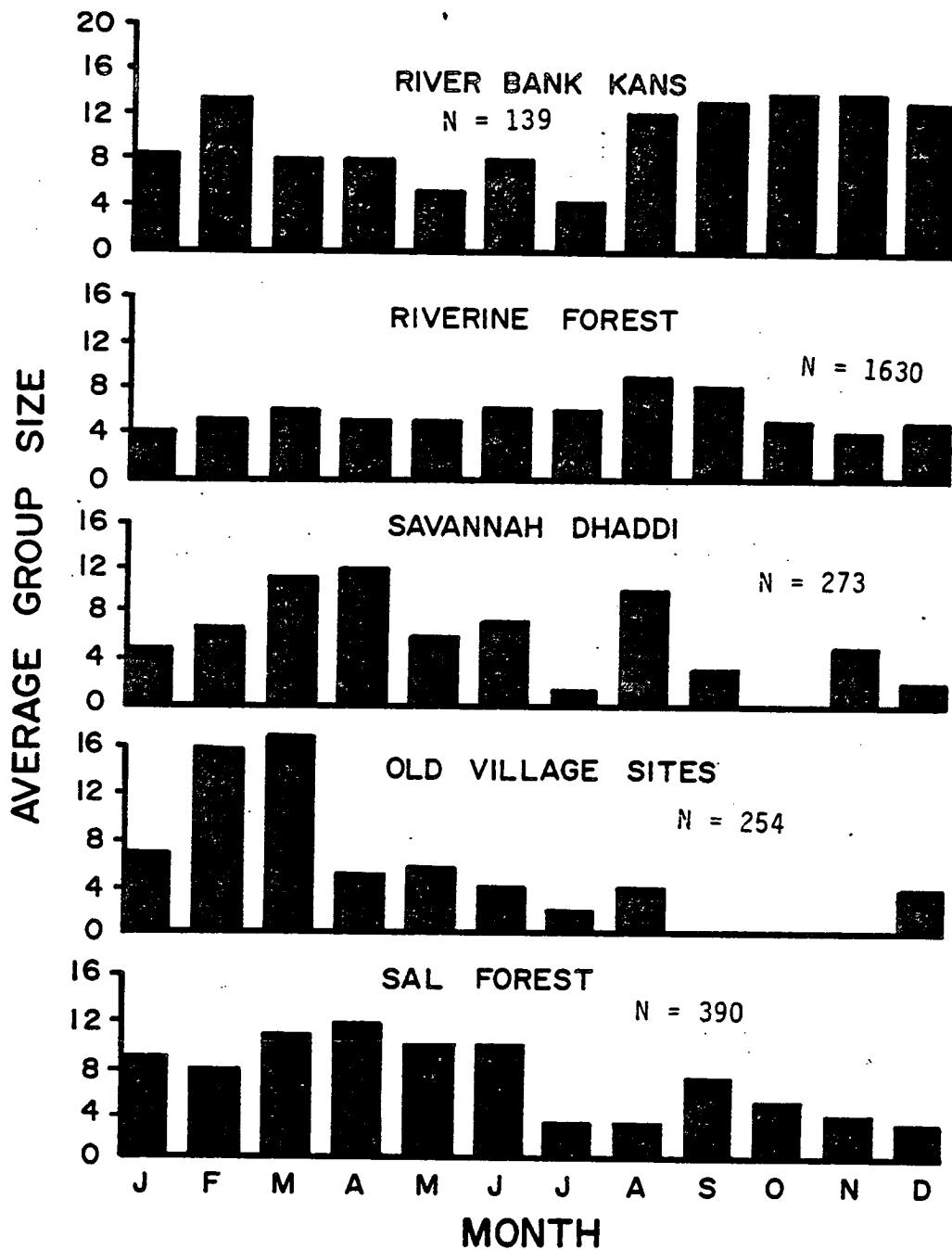


TABLE 8.2: HERD COMPOSITION IN PERCENT IN SEX AND AGE CLASS

Species	N	Adult Male %	Adult Female %	Yearling Male %	Yearling Female %	Juvenile %	Fawns %
Chital	11904	30.1	36.7	6.4	11.8	10.2	4.8
Hog Deer	1637	25.8	47.6	4.5	10.4	7.5	4.2
Sambar	493	21.5	45.3	4.4	13.9	8.9	6.0
Barking Deer	564	47.0	43.6	3.5	2.5	3.4	3.4

seasons (Fig. 8.2). Riverine forest had little grass in the understorey and was hardly affected by grasscutting and burning.

(c) The Old Village Sites: The average group size for all months combined was 13.5 which is almost double the average for all habitats combined. Here the average group size ranged from 2.0 in July to 16.7 in March (Table 8.1). In this habitat group size was largest in February and March immediately after the grass cutting and burning (Fig. 8.2). On one occasion I counted a herd of 210 chital in the month of February a week after the thatch grass harvest. Other large groups seen in this habitat consisted of 155 and 107 animals

(d) The Sal Forest: The average group size for all months combined in the Sal Forest was 9.8. Here it ranged from 3.2 in August to 12.2 in April (Table 8.1). Group size in the Sal Forest was greatest during the end of the dry season (Fig. 8.2).

Fire in the Sal Forest usually occurs after most of the grasslands have been burnt and as in the grasslands groups containing more than 20 chital were usually seen during the pre-monsoon season.

B. Group composition:

Of the total number of chital tallied that were classified into different sex and age class ($N = 11,904$), 30.1 % were adult males and 36.7 % adult females, 11.8 % yearling females, 6.4 % yearling males, 10.2 % juveniles and 4.8 % fawns (Table 8.2). The number of adult males per 100 adult females estimated to be 83, while the number of yearling males per 100 yearling female was estimated to be 54. The disparity in sex ratio between adults and young is probably due to errors in sexing techniques in the young rather than higher predation or mortality in young males.

In the above section, seasonal variations in group size were described. In this section I shall consider these variations in more detail, particularly in relation to age and sex composition of the herds. A total of 8 different social units was recognized :

- a) Solitary male
- b) Solitary female
- c) Multiple male group
- d) Single female with one fawn or juvenile
- e) Multiple female group with or without young
- f) Pair (one adult male and one adult female)
- g) Single male mixed group
- h) Multiple male mixed group

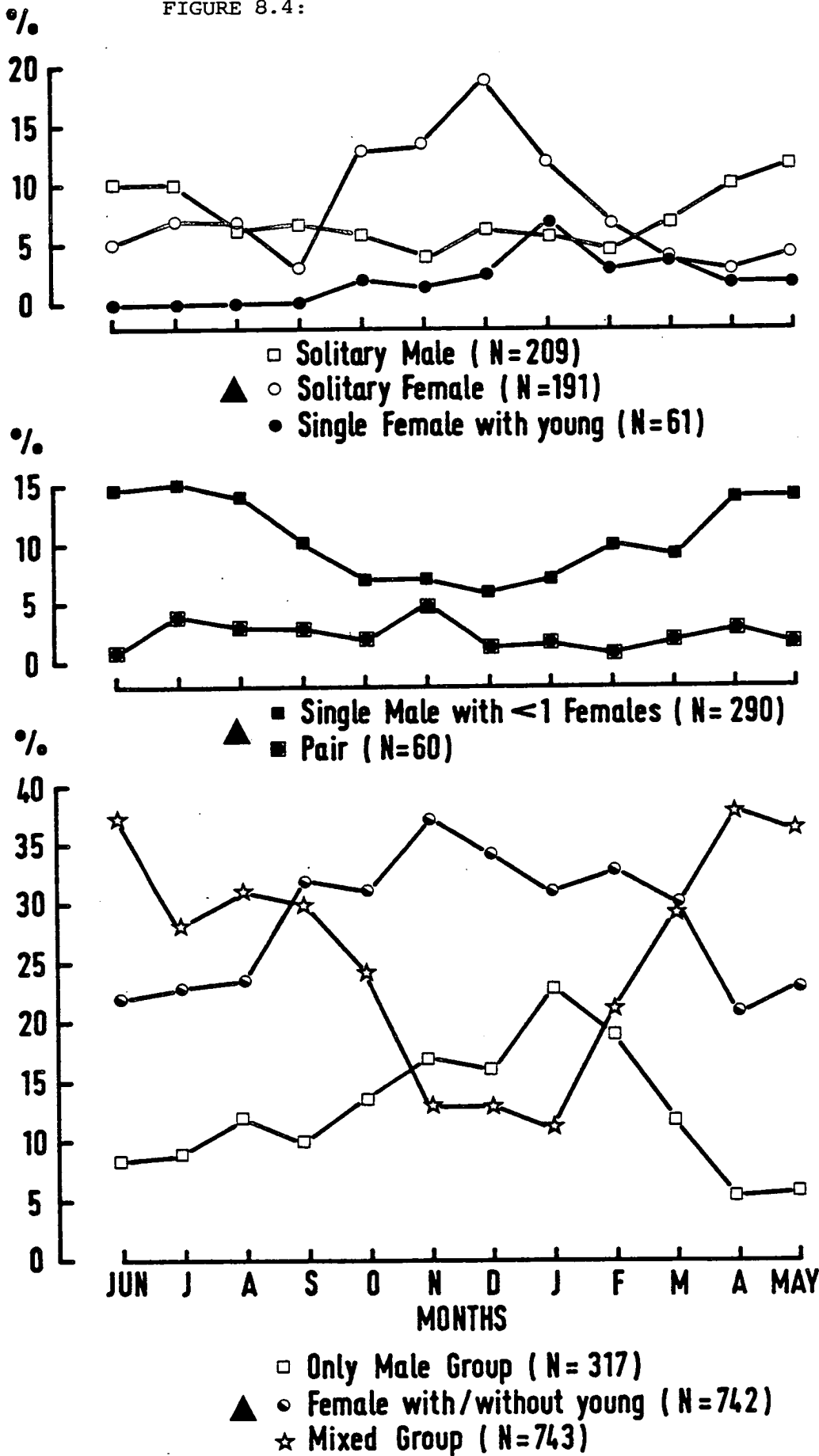
(a) Solitary male: Solitary adult males were seen throughout the year (N = 209). Of the total number of groups seen in each month the percentage of solitary male "group" ranged from 3.9 in November to 12.1 in May (Table 8.3). Except for the months of April and May, solitary male "group" comprised less than 10 % of all the groups. The increase in April and May might have resulted from sightings of wandering males, since this was the time of rut (Chapter 7). In many species of cervids males are known to be restless and wander around to their rutting grounds (Schaller 1967; Whitehead 1972; Chapman and Chapman 1975).

(b) Solitary Females: Like solitary males, solitary female "group" was observed throughout the year. Of the total number of groups seen in each month, solitary female "group" ranged from 2.8 % in April to 19.4 % in December. However in contrast to solitary male "group" most single female "group" were observed during the post-monsoon

TABLE 8.3: CHITAL: GROUP COMPOSITION IN % GROUPS OBSERVED BY MONTH

Months	Total Group	Male only groups			Female only group			Both sexes present					UKN
		Solitary	More than One	Totals	Solitary	Single Mother with young	More than One	Total	Pair	Only Male	>1 Male	Total	
June	152	9.9	8.5	18.4	4.6	0.1	21.6	26.3	1.3	14.5	36.8	52.6	2.6
July	125	9.6	8.8	18.4	7.2	0.0	23.2	30.4	4.0	15.2	28.0	47.2	4.0
Aug	183	6.5	12.1	18.6	6.6	0.0	23.5	30.0	2.7	13.7	30.6	47.0	4.3
Sept	185	7.0	10.3	17.3	3.2	0.1	31.8	35.1	2.7	10.2	29.7	40.5	4.9
Oct	164	6.1	13.4	19.5	12.8	1.8	31.1	45.7	1.8	6.7	23.7	32.3	2.4
Nov	129	3.9	17.0	20.9	13.9	1.5	37.3	52.7	4.7	7.0	13.2	24.8	1.4
Dec	201	6.5	15.9	22.4	19.4	2.5	34.3	56.2	1.5	6.0	12.9	20.4	1.0
Jan	116	6.0	23.3	29.3	12.1	6.9	31.0	50.0	1.7	6.9	11.2	19.8	0.9
Feb	313	4.5	18.8	23.3	7.0	3.2	32.6	42.8	0.9	10.2	21.1	29.1	1.6
Mar	419	7.2	11.7	18.9	4.1	4.1	30.0	38.2	2.1	8.6	29.3	40.0	2.9
Apr	320	10.0	5.6	15.6	2.8	2.2	20.6	25.6	2.8	13.8	37.8	54.4	4.4
May	379	12.1	6.1	18.2	4.5	1.8	22.7	28.0	2.1	14.6	35.8	51.9	1.8
TOTAL	2686	7.8	11.8	19.6	7.1	2.3	27.6	37.0	2.2	10.8	27.7	40.7	2.7

FIGURE 8.4:



GROUP COMPOSITION IN % OF GROUPS OBSERVED BY MONTHS

season (Fig. 8.4). This was also the time when most fawning took place (Chapter 7). These sightings were probably associated with parturition. In many species of ungulates females are known to isolate from their main groups to give birth (Lent 1974).

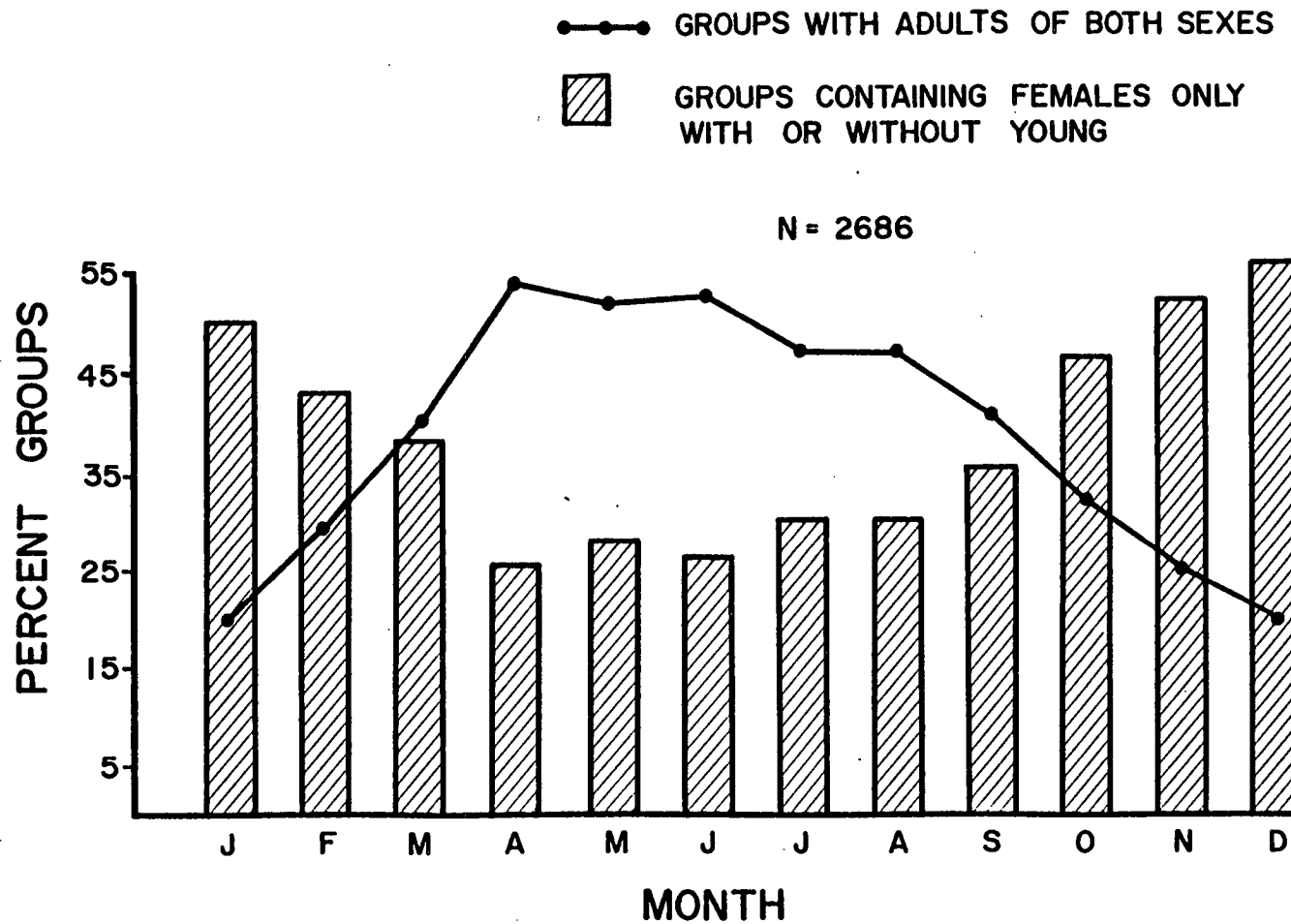
(c) Multiple male groups that consisted only of males were seen throughout the year ($N = 317$). Of the total number of groups recorded in each month, multiple male groups ranged from 5.6 % in April and reached a peak of 23.3 % in January (Table 8.3). Most males started forming their own groups in September and most male groups were seen in December - January (Fig. 8.4). As with most cervids the all male multiple male group formation coincided with the period when their antlers were in velvet (Chapter 7).

The average group size of multiple male groups based on observations of marked deer was 6.7 and most of them (77.8 %) were seen in the riverine forest.

(d) Single mother with young "group": Groups containing only one mother with a single juvenile or fawn comprised only 2.3 % ($N = 61$) the total observations. Of the total number of groups observed in each month, this composition ranged from none in July/August to only as high as 6.9 % in January (Table 8.3).

(e) Multiple female groups with or without young: Multiple female groups with or without young were recorded throughout the year ($N = 742$). The percentage of the total group sighted in each month ranged from 20.6 % in April to 37.3 % in November (Table 8.3). When males started to shed their antlers the sexes began to segregate and the peak period of separation of sexes was reached during the cool post-monsoon season (Fig. 8.4). The average group size of multiple female groups based on observations of marked deer was 5.3 and like multiple

FIGURE 8.5: Seasonal separation of sexes in % of groups observed in each month. Chital.



male groups most (74.4 %) multiple female groups were also observed in the Riverine forest.

(f) Pair group: Pair of a single male and single female was rare and was only 2.2 % of the total of 2686 groups observed (Table 8.3).

(g) Single male mixed sex group: Groups containing one adult male with more than one adult female with or without their young were seen throughout the year. The percentage of the total groups observed in each month ranged from 6.0 % in December to 15.2 % in July (Table 8.3). However the formation of a "harem" where a single male defends its territory with several females from intrusion by other males (Emlem and Oring 1977) was not noticed in Chitwan.

(h) Multiple male-female mixed group: Groups containing more than one adult of both sexes were also seen throughout the year (N = 290). The percentage of the total groups observed in each month ranged from 11.2 % in January to 37.8 % in April (Table 8.3). Though a few groups containing both sexes were seen throughout the year, the sexes started to mix in February and reached a peak in April - June after which the percentage of mixed groups decreased steadily and reached the lowest in December (Fig. 8.5). The seasonal cycle of sexual integration coincides with the seasonal cycle of antler development and sexual activity.

C. Group Stability:

During the day to day tracking of the radio collared deer a record was kept whenever possible of the size and composition of the groups in which the radio collared animals were located. These data could be used to determine the short and long term stability of social groups. Sightings of groups containing the same marked deer indicated that groups were not stable in size or composition (Table 8.4). The only stable association appeared to be mothers with their offspring.

TABLE 8.4: CHITAL: GROUP SIZE AND COMPOSITION CONTAINING THE SAME MARKED DEER.

Deer No.	Date	Time	Habitat	Numbers seen in sex/age/class							TOTAL
				AM	AF	YRM	YRF	JV	FWN	UN	
3 AM	9.12.78	13:13	RF	1	-	-	-	-	-	-	1
"	1.1.79	8:30	RF	1	-	-	-	-	-	-	1
"	28.1.79	8:45	RF	4	-	-	-	-	-	-	4
"	29.1.79	7:30	RF	3	-	-	-	-	-	-	3
"	5.2.79	8:00	RF	1	-	-	-	-	-	-	1
"	6.2.79	8:20	SD	12	-	-	-	-	-	-	12
"	9.2.79	17:30	RF	7	-	-	-	-	-	-	7
"	11.2.79	8:35	RBK	6	20	2	-	-	-	-	28
"	23.2.79	8:05	RF	3	-	5	-	-	-	-	8
"	24.2.79	8:15	RF	7	-	-	-	-	-	-	7
"	3.3.79	17:15	RF	1	2	2	-	1	-	-	6
"	4.3.79	6:25	RBK	6	8	2	3	3	-	-	22
"	3.12.79	7:45	RBK	10	-	-	-	-	-	-	10
"	1.10.80	7:43	RF	4	7	1	3	-	-	-	15
8 AM	23.3.79	7:55	RF	1	2	1	1	1	-	-	6
"	29.3.79	6:30	RF	2	3	1	3	1	-	-	10
"	3.4.79	6:25	RF	5	2	1	-	1	-	-	9
"	4.5.79	6:15	RF	4	5	1	3	1	-	-	14
"	12.5.79	7:00	RF	2	5	-	-	1	-	-	8
"	9.6.79	17:15	RF	2	3	-	-	2	-	-	7
"	26.6.79	5:55	RF	2	3	-	-	2	-	-	7
"	2.7.79	6:25	RF	2	1	1	-	1	-	-	5
"	3.7.79	6:05	RBK	7	11	2	4	2	-	-	26
"	17.11.79	7:45	RBK	6	8	1	3	2	1	-	21
"	4.3.80	7:35	RF	2	4	1	3	-	-	-	10
"	13.8.80	17:30	RF	1	1	-	-	-	-	-	2
"	19.8.80	7:55	RF	15	27	3	5	-	-	-	50
"	24.8.80	6:15	RBK	1	-	-	-	-	-	-	1
"	3.9.80	7:15	RF	1	1	-	-	-	-	-	2
"	19.9.80	17:10	RF	6	2	2	-	2	-	-	12
"	21.9.80	7:55	RF	1	1	-	1	-	-	-	3
"	25.9.80	6:25	RBK	19	9	7	-	-	-	-	35
"	30.9.80	15:25	RF	1	1	-	1	-	-	-	3
"	1.11.80	12:10	RF	7	-	4	-	-	-	-	11
"	26.12.80	8:35	RF	5	-	-	-	-	-	-	5
"	16.1.81	6:45	RBK	18	-	-	-	-	-	-	18
"	17.1.81	10:24	RBK	10	-	-	-	-	-	-	10
"	22.1.81	9:00	RBK	9	3	-	1	-	2	-	15
"	20.2.81	8:05	RBK	1	Mixed Herd					16	17
"	3.4.81	8:40	RF	1	4	1	1	-	-	-	7
2 AF	9.12.78	9:53	RF	-	1	1	-	-	-	-	2
"	9.12.78	16:40	RF	-	1	1	-	-	-	-	2
5 AF	25.3.79	18:40	RF	5	6	1	1	2	2	-	17
"	30.3.79	7:45	RF	-	2	-	-	2	-	-	4
"	11.4.79	16:30	RF	-	1	-	1	1	-	-	3
"	30.5.79	7:20	RF	1	2	-	-	2	-	-	5
"	17.5.79	7:10	RF	4	3	-	-	1	-	-	8
"	2.7.79	18:20	RF	-	3	-	3	1	-	-	7
"	15.7.79	16:10	RBK	1	3	2	3	1	-	1	11
"	23.8.79	5:55	RBK	11	14	3	5	4	-	-	37
"	13.9.79	16:54	RF	-	3	-	-	3	-	-	6
"	10.10.79	12:05	RF	5	8	-	-	3	-	-	16
"	11.11.79	16:40	RF	-	3	-	-	-	1	-	4
"	24.2.80	17:30	RF	-	1	-	-	-	1	-	2
"	28.2.80	9:05	SD	6	7	2	3	-	2	-	20
"	29.2.80	12:00	RF	-	1	-	-	-	1	-	2
"	5.4.80	7:30	RF	-	1	-	1	-	-	-	2
"	6.4.80	16:05	RF	1	3	2	1	-	-	-	7
"	11.4.80	8:50	RF	-	1	-	1	-	-	-	2
"	4.6.80	19:05	RF	1	1	-	1	-	-	-	3
"	7.7.80	8:00	RF	1	1	-	1	-	-	-	3

Continued/...

TABLE 8:4: CHITAL: GROUP SIZE AND COMPOSITION CONTAINING THE SAME MARKED DEER (Continued)

Deer No.	Date	Time	Habitat	Numbers seen in sex/age/class							TOTAL
				AM	AF	YRM	YRF	JV	FWN	UN	
23 AF	23.12.79	8:55	OVJ	-	10	-	3	1	-	-	14
"	30.12.79	11:50	RF	-	1	-	-	-	-	-	1
"	7.1.80	16:35	RF	-	1	-	2	1	-	-	4
"	10.1.80	9:15	RF	-	1	-	-	-	1	-	2
"	15.1.80	16:40	RF	-	1	-	-	-	-	-	1
"	16.1.80	7:45	OVJ	-	2	-	2	-	-	-	4
"	18.1.80	7:30	OVJ	-	2	-	2	-	-	-	4
"	19.1.80	8:30	RF	-	2	-	-	-	1	-	3
"	20.1.80	7:50	RF	-	3	-	2	-	-	-	5
"	20.1.80	15:15	RF	-	1	-	-	-	1	-	2
"	21.1.80	9:25	RF	-	1	-	-	-	1	-	2
"	22.1.80	10:30	RF	-	1	-	-	-	1	-	2
"	27.1.80	16:30	RF	-	3	-	-	4	1	-	8
"	30.1.80	7:30	OVJ	-	7	-	3	-	1	-	11
"	7.2.80	16:35	RF	-	3	-	-	-	1	-	4
"	20.2.80	17:50	RF	-	1	-	-	-	1	-	2
"	24.2.80	17:35	RF	-	2	-	-	-	1	-	3
"	25.2.80	6:15	RF	-	1	-	-	-	1	-	2
"	29.2.80	8:10	RF	-	1	-	-	-	2	-	3
"	1.3.80	16:25	RF	-	2	-	-	-	1	-	3
"	8.3.80	16:10	OVJ	-	3	-	-	3	1	-	7
"	22.7.80	17:47	RF	-	1	1	-	1	-	-	3
"	25.8.80	16:05	RF	8	7	3	5	7	1	-	31

In this section I have provided a brief summary on group stability based on both male and female marked deer.

(a) Males: Deer No. 3, an adult male was sighted 12 times between December 9, 1978 and December 3, 1980. On December 9, 1978 and January 1, 1979 it was seen alone. When sighted again on January 28, at 08.45 hrs., it was seen with 3 other adult males. It was with 2 other adult males when seen the next day at 08.45 hrs. It was sighted alone again on February 5, 1979 at 08.00 hrs. but was in a group of 12 males when seen next day at 8.20 hrs. It was sighted again on February 9 in a group containing six other males. Since that is the season when sexes separate no females were seen with it. However when sighted again two days later it was in an all male group of 28 that contained 2 yearling males. The deer was seen again on February 23, 1979 but this time in a group composed of 3 adult males and 5 yearling males. It was sighted the next day approximately at the same time and place in a group consisting of 7 adult males. It was seen again on March, 3 at 17.15 hrs. in a mixed group containing 2 adult females, 2 yearling males and one juvenile. Next morning it was seen at 06.25 hrs., near the same site with 21 other deer that were 5 adult males, 8 adult females, 2 yearling males, 3 juveniles and 3 fawns (Table 8.4).

Another male, Deer No. 8 was seen in a group containing 2 males, 1 adult female, one yearling male and one juvenile on July 2, 1979 at 06.25 hrs. It was sighted again the next day at 06.05 hrs. in group containing 7 adult males, 11 adult females, 6 yearlings and 2 young. It was also seen five times during September, 1980 and its group size was also different at different dates.

This animal was sighted 4 times between December 26, 1980 and January 22, 1981. Though the groups in which it was seen contained only males,

their sizes ranged from 5 to 18 (Table 8.4).

(b) Females: As with males neither group size nor composition were consistent except the association of mother and her young. Deer No. 2 was seen twice on December 9, 1979 at 09.55 hrs. and 16.40 hrs. Both times she was sighted alone with her male yearling. Deer No. 5 was seen 19 times between March 25, 1979 and August 7, 1980. Though the group size varied from 2 to 37, she was always seen with one or more young (Table 8.4). The size of the groups in which other marked adult females were seen were not consistent though one or more young were normally seen with them.

8.4 A comparison with other deer:

(1) The Hog Deer: Of the total of 843 groups observed most hog deer seen were solitary (49.6 %) or in pairs (24.7 %) and a few larger groups were seen in patches of cut grasslands (Fig. 8.6). The average group size was 2.2 and remained consistent (Table 8.5) throughout the year ($F = 0.87$ $DF = 8$ $p > 0.54$). Of the total of 843 groups observed single male "group" comprised 18.3 % of all sightings while single female "group" comprised 25.4 %. Groups of single mother with single young consisted of 12.5 % of the sightings while multiple female groups consisted of 9.4 % and multiple male groups were rare with only 3.2 % of the total groups observed throughout the year (Table 8.6). There was no distinct seasonal grouping of segregated or mixed groups. However, the percentage of observations of groups with both sexes present was highest (53.3 %) in June to September and lowest (3.4 %) in December (Table 8.6). Of the 1637 animals classified in sex-age class 25.8 % were adult males, 47.6 % adult females, 10.4 % yearling females, 4.5 % yearling males, 7.5 % juveniles and 4.2 % fawns (Table 8.2). The number of males per 100 females was 54 in adults and 55 in young.

FIGURE 8.6: Hog deer: Group size in percent groups seen

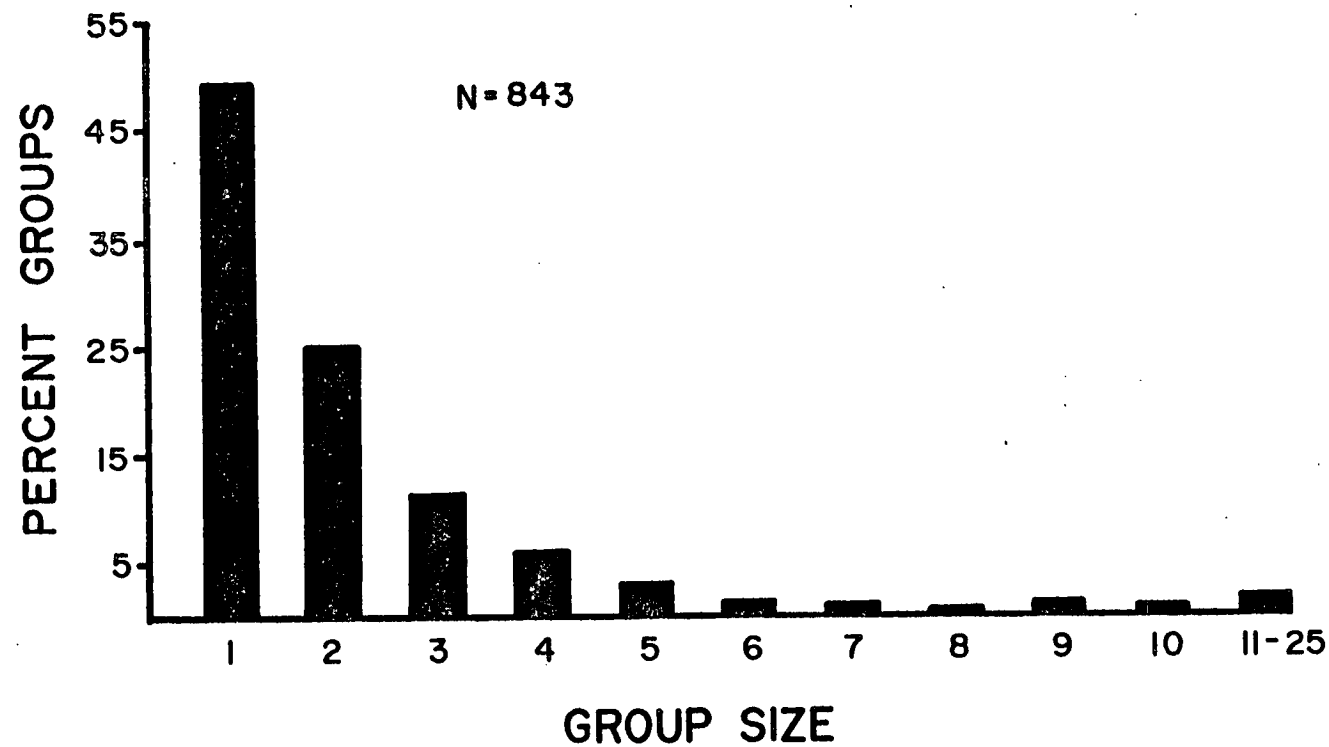


TABLE 8.5: HOG DEER AVERAGE GROUP SIZE/HABITAT TYPE

Month	Total Groups	Total Tallied	Average	River Bank Kans			Riverine Forest			Savannah Dhaddi			Old Village site			Sal Forest		
				Gr.	N	Avg.	Gr.	N	Avg.	Gr.	N	Avg.	Gr.	N	Avg.	Gr.	N	Avg.
June	46	150	3.3	23	66	2.9	-	-	-	15	74	4.9	8	10	1.3	-	-	-
July	16	46	2.9	10	34	3.4	-	-	-	2	4	2.0	4	8	2.0	-	-	-
August	28	49	1.8	13	26	2.0	1	1	1.0	3	5	1.7	9	15	1.7	2	2	1.0
Sept.	52	194	3.7	47	187	4.0	1	2	2.0	1	1	1.0	2	2	1.0	1	2	2.0
Oct.	36	73	2.0	29	65	2.2	4	4	1.0	3	4	1.3	-	-	-	-	-	-
Nov.	20	25	1.3	6	8	1.3	5	5	1.0	5	7	1.4	3	4	1.3	1	1	1.0
Dec.	29	39	1.3	1	2	2.0	1	1	1.0	15	20	1.3	9	13	1.4	3	3	1.0
Jan.	24	54	2.3	3	6	2.0	-	-	-	17	41	2.4	4	7	1.8	-	-	-
Feb.	116	258	2.2	11	24	2.2	10	14	1.4	56	149	2.7	37	69	1.9	2	2	1.0
March	213	441	2.1	25	67	2.7	11	14	1.3	78	127	1.6	90	223	2.5	9	10	1.1
April	186	421	2.3	22	40	1.8	4	5	1.3	39	79	2.0	108	272	2.5	13	25	1.9
May	77	146	1.9	22	43	2.0	3	4	1.3	12	24	2.0	40	75	1.9	-	-	-
Total	843	1896	2.2	212	568	2.7	40	50	1.3	246	535	2.2	314	698	2.2	31	45	1.5

TABLE 8.6: HOG DEER GROUP COMPOSITION IN % GROUPS OBSERVED BY MONTH

Month	Total Group	Male Only Groups			Female Only Groups with/without young				Both sexes present				
		Solitary	More than One	Totals	Solitary	Single mothers with young	More than One	Total	Pair	One Male	>1 Male	Total	UKN
June	46	21.7	2.2	23.9	4.3	8.7	6.5	19.6	17.4	10.9	26.1	54.3	2.2
July	16	37.5	0.0	37.5	12.5	6.2	6.2	25.0	6.2	18.8	12.5	37.5	0.0
August	28	21.4	3.6	25.0	28.6	3.6	7.1	39.3	10.7	3.6	7.1	21.4	14.3
Sept.	52	9.6	1.9	11.5	23.1	13.5	5.8	42.3	9.6	5.8	19.2	34.6	11.5
October	36	16.7	0.0	16.7	16.7	19.4	19.4	5.5	8.3	5.6	2.8	16.7	11.1
Nov.	20	25.6	0.0	25.0	40.0	0.0	10.0	50.0	5.0	5.0	0.0	10.0	15.0
Dec.	29	24.1	6.9	31.0	41.4	3.4	6.9	51.7	0.0	0.0	3.4	3.4	13.8
Jan.	24	20.8	8.3	29.2	16.7	12.5	16.7	45.8	4.2	4.2	8.3	16.7	8.3
Feb.	116	20.7	2.6	23.3	31.0	12.9	4.3	48.3	6.9	8.6	7.8	23.3	5.2
March	213	17.4	3.7	21.1	31.9	8.0	8.0	47.9	4.7	8.0	10.8	23.5	7.5
April	186	14.0	1.6	15.6	23.7	18.8	15.6	58.1	2.2	3.8	9.1	15.1	11.3
May	77	22.1	7.8	29.9	15.6	18.2	5.2	39.0	10.4	10.4	2.6	23.4	7.8
Total	843	18.3	3.2	21.5	25.4	12.5	9.4	47.2	6.2	6.9	9.6	22.7	8.7

(2) The Sambar: Of the total of 917 groups observed; 57.5 % were solitary animals and 25.8 % were in pairs and the rest consisted of more than 2 animals (Fig. 8.7); and most sambars were seen in the Riverine Forest (Table 8.7). The average group size was 1.7 with no significant seasonal variations ($F = 0.80$ $DF = 8$ $p > 0.45$). Of the total of 917 groups classified in different composition, solitary male "group" comprised of 23.6 % and solitary female "groups" consisted of 31.1 %. Groups of single mother with young consisted of 11.7 % and multiple female groups comprised of 10.3 % of the total observations. Multiple male groups were rarely (1.7%) sighted (Table 8.8). The seasonal separation of sexes was not prominent as in the chital. However, the formation of pairs by adult male and female was highest between November to February (Table 8.8); a period corresponding to the rut in Sambar (Chapter 7). Of the total 493 animals classified into sex and age classes, 21.5 % were adult males, 45.3 % adult females, 13.9 % yearling females, 4.4 % yearling males, 8.9 % juveniles and 6.0 % fawns (Table 8.2). The sex ratio of adults was 47 males per 100 females and that of young was 70 males and 100 females.

(3) The Barking deer: Of the total of 534 barking deer observations over 80 % of the barking deer sighted were solitary animals and of the rest were pairs (Fig. 8.8). Two groups consisting of 4 and 5 animals were seen at a salt lick set to bait chital. The average group size was 1.2 and it remained consistent (Table 8.9) with no significant seasonal changes ($F = 0.65$ $DF = 8$ $p < 0.72$). Solitary male "groups" comprised of 39.5 % and solitary female "groups" comprised of 33.5 % of the total groups sighted (Table 8.10). Pairs of an adult male and adult female consisted of 10.5 % of the total groups while other associations were rarely observed (Table 8.10). Of the 564 animals classified into sex and age classes 47.0 % were

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FIGURE 8.7: Sambar Group Size in Percent Groups Seen

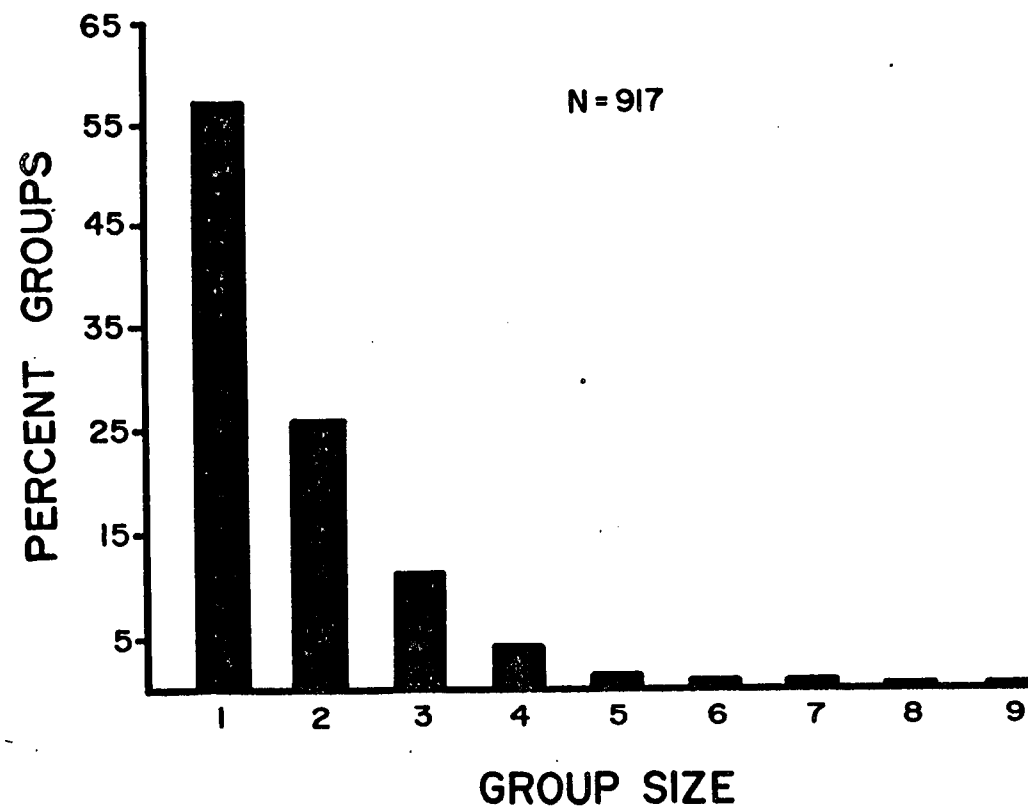


TABLE 8.7: SAMBAR: AVERAGE GROUP SIZE/HABITAT TYPE

Month	Total Groups	Total Tallied	Average	River Bank Kans			Riverine Forest			Savannah Dhaddi			Old Village Site			Sal Forest		
				Gr.	N.	Avg.	Gr.	N	Avg.	Gr.	N	Avg.	Gr.	N	Avg	Gr.	N	Avg.
June	59	121	2.1	3	5	1.7	48	103	2.1	-	-	-	-	-	-	8	13	1.6
July	45	75	1.7	4	10	2.5	39	63	1.6	1	1	1.0	-	-	-	1	1	1.0
August	79	126	1.6	1	1	1.0	72	118	1.6	1	1	1.0	-	-	-	5	6	1.2
Sept.	76	121	1.6	4	9	2.3	70	109	1.6	1	1	1.0	-	-	-	1	2	2.0
October	21	25	1.2	-	-	-	20	24	1.2	-	-	-	-	-	-	1	1	1.0
Nov.	25	33	1.3	-	-	-	24	32	1.3	-	-	-	-	-	-	1	1	1.0
Dec.	60	91	1.5	1	2	2.0	49	75	1.5	3	5	1.7	-	-	-	7	9	1.3
Jan	69	113	1.6	2	4	2.0	63	103	1.6	3	4	1.3	-	-	-	1	2	2.0
Feb	114	196	1.7	3	3	1.0	97	170	1.8	6	10	1.7	2	3	1.5	6	10	1.7
March	147	245	1.7	3	4	1.3	106	182	1.7	15	23	1.5	1	2	2.0	22	34	1.5
April	100	176	1.8	6	14	2.4	58	100	1.7	10	17	1.1	4	8	2.0	22	37	1.7
May	122	230	1.9	7	17	2.4	85	168	2.0	4	6	1.5	3	3	1.0	23	36	1.6
Total	917	1552	1.7	34	69	2.0	731	1246	1.7	44	68	1.5	10	16	1.6	98	152	1.5

TABLE 8.8: SAMBAR: GROUP COMPOSITION IN % OF GROUPS OBSERVED BY MONTH

Months	Total Group	Male only group			Female only group with/without young				Both sexes present				Total UKN
		Solitary	More than One	Totals	Solitary	Single mothers with young	More than One	Total	Pair	One Male	>1 male	Total	
June	59	23.7	1.7	25.4	27.1	15.3	6.8	49.2	13.6	5.1	5.1	23.7	1.7
July	45	26.7	0.0	26.7	33.3	4.4	22.2	60.0	0.0	2.2	8.9	11.1	2.2
August	79	15.2	0.0	15.2	41.7	17.7	7.6	67.1	6.3	2.5	6.3	15.2	2.5
Sept.	76	23.7	1.3	25.0	36.8	9.2	10.5	56.6	11.8	1.3	5.3	18.4	0.0
Oct.	21	38.1	0.0	38.1	42.9	4.8	4.8	52.4	4.8	0.0	0.0	4.8	4.8
Nov.	25	16.0	0.0	16.0	52.0	4.0	0.0	56.0	12.0	0.0	8.0	20.0	8.0
Dec.	60	25.0	1.7	26.7	35.0	5.0	3.3	43.3	13.3	8.3	6.7	28.3	1.7
Jan.	69	23.2	1.4	24.6	33.3	4.3	2.9	40.6	14.5	5.8	8.7	29.0	5.8
Feb.	114	22.8	0.0	22.8	32.5	13.2	7.9	53.5	12.3	3.5	6.1	21.9	1.8
March	147	30.6	4.1	34.7	22.4	11.6	12.9	46.9	6.1	5.4	1.4	12.9	5.4
April	100	21.0	1.0	22.0	26.0	18.0	9.0	53.0	10.0	2.0	6.0	18.0	7.0
May	122	20.5	4.1	24.6	25.4	13.9	19.7	59.0	6.6	4.1	4.1	14.8	1.6
Total	917	23.6	1.7	25.3	31.1	11.7	10.3	53.0	9.3	3.8	5.2	18.3	3.4

Figure 8.8 : Barking deer: Group size in percent groups seen

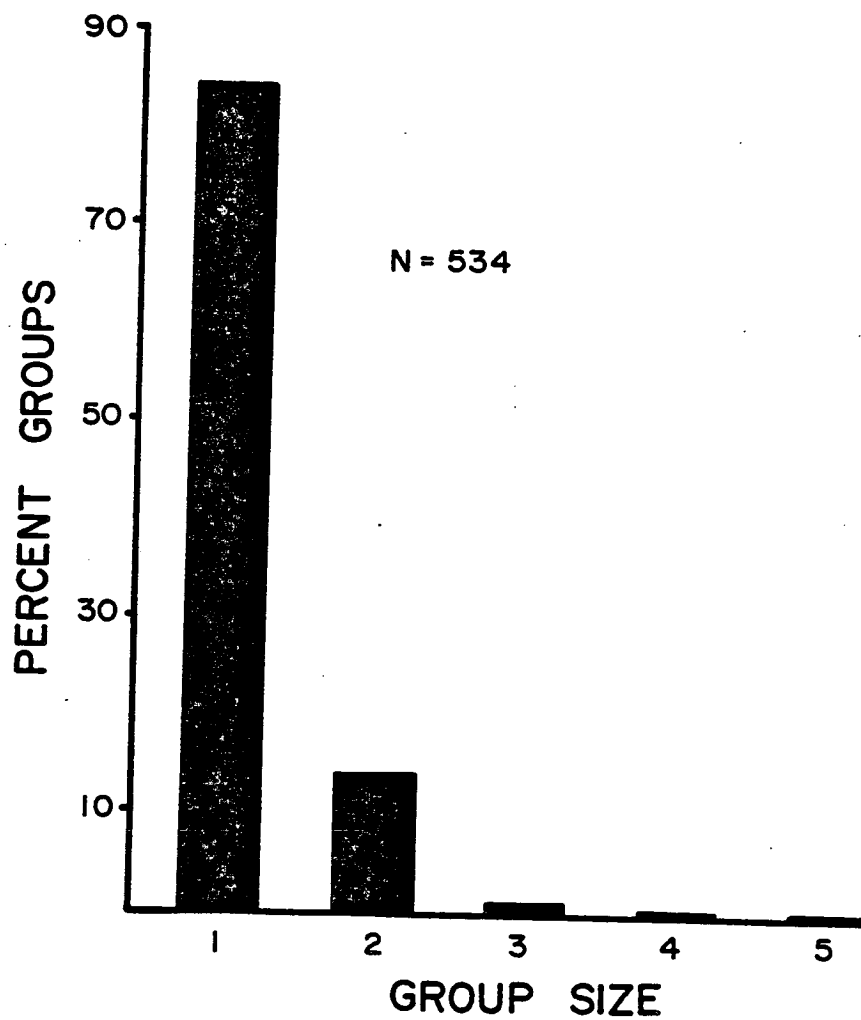


TABLE 8.9: BARKING DEER: AVERAGE GROUP SIZE/HABITAT TYPE

Month	Total Groups	Total Tallied	Average	River Bank Kans			Riverine Forest			Savannah Dhaddi			Old Village Site			Sal Forest		
				Gr.	N	Avg.	Gr.	N	Avg.	Gr.	N	Avg.	Gr.	N	Avg.	Gr.	N	Avg.
June	41	49	1.2	4	4	1.0	34	42	1.2	1	1	1.0	0	0	-	2	2	1.0
July	26	27	1.0	1	1	1.0	24	25	1.0	0	0	-	0	0	-	1	1	1.0
August	45	60	1.3	1	1	1.0	39	52	1.3	0	0	-	0	0	-	5	7	1.4
Sept.	32	37	1.2	1	2	2.0	28	32	1.1	0	0	-	0	0	-	3	3	1.0
Oct.	32	38	1.2	0	0	-	32	38	1.2	0	0	-	0	0	-	0	0	-
Nov.	36	39	1.1	1	1	1.0	32	35	1.1	0	0	-	0	0	-	3	3	1.0
Dec.	59	75	1.3	1	1	1.0	51	65	1.3	1	1	1.0	0	0	-	6	8	1.3
Jan.	24	25	1.0	1	1	1.0	21	22	1.0	1	1	1.0	0	0	-	1	1	1.0
Feb.	24	29	1.2	2	3	1.5	15	18	1.2	3	4	1.3	0	0	-	4	4	1.0
March	52	59	1.1	6	8	1.3	35	40	1.1	2	2	1.0	1	1	1.0	8	8	1.0
April	64	71	1.1	1	1	1.0	29	32	1.1	4	4	1.0	0	0	-	30	34	1.1
May	99	121	1.2	2	2	1.0	73	88	1.2	6	7	1.2	1	1	1.0	17	23	1.4
Total	534	63P	1.2	21	25	1.2	413	489	1.2	18	20	1.1	2	2	1.0	80	94	1.2

TABLE 8.10: BARKING DEER: GROUP COMPOSITION IN % GROUPS OBSERVED BY MONTH

Months	Total Group	Male Only Groups			Female Only Groups with/without Young				Both Sexes Present				UKN
		Solitary	More than One	Totals	Solitary	Single mothers with young	More than One	Total	Pair	One Male	>1 male	Total	
June	41	36.6	2.4	39.0	34.1	0.0	0.0	34.1	17.1	0.0	0.0	17.1	9.8
July	26	42.3	0.0	42.3	42.3	0.0	0.0	42.3	15.4	0.0	0.0	15.4	0.0
August	45	26.7	0.0	26.7	37.8	0.0	0.0	37.8	24.4	0.0	4.4	28.9	6.7
Sept.	32	43.8	3.1	46.9	28.1	3.1	0.0	31.2	9.4	0.0	0.0	9.4	12.5
Oct.	32	46.9	6.3	53.1	34.4	0.0	0.0	34.4	6.3	3.1	0.0	9.4	3.1
Nov.	36	50.0	0.0	50.0	19.4	2.8	2.8	25.0	2.8	0.0	0.0	2.8	22.2
Dec.	59	40.7	0.0	40.7	32.2	0.0	1.7	33.9	6.8	5.1	0.0	11.9	13.6
Jan.	24	50.0	0.0	50.0	29.2	0.0	0.0	29.2	4.2	0.0	0.0	4.2	16.6
Feb.	24	41.6	0.0	41.6	33.3	0.0	0.0	33.3	20.8	0.0	0.0	20.8	4.2
March	52	36.5	0.0	36.5	28.8	1.9	0.0	30.8	9.6	0.0	0.0	9.6	23.1
April	64	40.6	0.0	40.6	42.2	1.6	0.0	43.8	4.7	0.0	0.0	4.7	10.9
May	99	35.4	2.0	37.4	34.3	3.0	1.0	38.4	10.1	1.0	1.0	12.1	12.1
Total	534	39.5	1.1	40.6	33.5	1.3	0.6	35.4	10.5	0.9	0.6	12.0	12.0

adult males, 43.6 % adult females, 3.5 % yearling males, 2.5 % yearling females and 3.4 % were juveniles and fawns (Table 8.2). The sex ratio of adults was 108 Males:100 females and that of young was 144 males per 100 females.

8.5 Discussion:

There are two main hypothesis regarding herding behaviour in ungulates. One suggests that when in herds animals can avoid predation better than when alone (Hamilton 1971; Vine 1971; Geist 1974; Wittenberger 1981; Eisenberg 1981). This could be done by a variety of methods including improved predator detection, active group defence and predator confusion. The other hypothesis links the animals social organisation with the distribution and availability of its food supply (Altmann 1952; Lowe 1966; Jarman 1974; Clutton-Brock 1974; Gossow and Schurloz 1974; Leuthold 1977; Sinclair 1977). Small species, it is suggested have high nutritional requirements and have to feed in a highly selective way. They therefore cannot live in large groups. Larger species can afford to be less selective and can therefore live in larger groups. In species which exhibit flexible social systems it is suggested that they will form large groups when there is an abundance of high quality forage but will be forced into smaller groups when high quality food supply is less abundant and dispersed in distribution.

These two ideas of predation and food supply are not necessarily mutually exclusive and it is likely that both have operated simultaneously resulting in the selection of observed behaviours. However, it is of interest to try to elucidate the relative contribution of the two. How do the observations of deer in Chitwan fit with the above suggestions ?

In the chital group size varied according to habitat and season.

Groups were smaller in closed forest habitat than in open grassland habitat and in grassland habitat group size increased greatly after cutting and burning. In forest habitat, particularly the riverine forest, there was little ground vegetation available to chital. Most forage occurred in small clearings. Food supply was clearly less abundant and more scattered in comparison with the grasslands. However, as mentioned earlier, chital often feed in association with primates in forest habitat. No information is available on the abundance of primates but they did occur in troops so that the food produced by them was certainly highly localised. In the grasslands cutting and burning produced large rather uniform areas of fresh new growth. In such areas the largest herds formed. The formation of large herds could have been a response to feeding in the open. A predator such as the tiger would find it difficult to approach and make a kill in these large herds. The formation of large herds in open habitats has been observed in other species of deer (Mitchell *et al* 1977; Hirth 1977).

The other three species in Chitwan provide interesting contrasts and parallels with the chital. The sambar and the barking deer were both specialist forest species. They both occurred in very small groups and as solitary animals and did not change their group sizes with season. The sambar is clearly an unusual species in that it is very large and more or less solitary as adults. From the above hypothesis one would predict that its food supply would occur at low levels of abundance. A study of the food of sambar would be very rewarding. There is a striking similarity between the Sambar and the African Bongo (*Tragelaphus euryceros*). The latter is a large antelope and a specialist closed forest species. Like the Sambar it is essentially solitary (Delany and Hapold 1979). The barking deer would fit with Jarman's suggestion that small species would mostly be solitary

because of specialised food requirements.

The hog deer occurred in small groups or as solitary animals in its grassland habitat except when the grass was cut and burned when it formed into large herds.

Although a few groups containing both sexes occurred throughout the year, the chital showed a seasonal pattern of segregation of sexes. During the winter months (November - January), all male groups were formed, while groups of females with young foraged separately. Seasonal separation of sexes has been reported in other cervids (Mitchell *et al* 1977; Skoog 1958; McCulloch 1979). Geist (1971) has reported similar behaviour in wild sheep and the formation of "bachelor groups" (Leuthold 1977) is reported in many of the African ungulates (Sinclair and Norton-Griffiths 1979). There have been a few suggestions as to why sexes separate. From red deer (*Cervus elaphus*) studies in Scotland, Mitchell *et al* (1977) put forward the hypothesis that seasonal differences in nutritional requirements and hence food selection contributes to seasonal segregation. They suggest that hinds are found in better quality habitat because of the nutritional requirements of pregnancy and to increase calf survival. Geist and Pectoz (1977) support similar views and reason that spatial and habitat segregation in big horn sheep (*Ovis canadensis canadensis*) is maintained to reduce competition for resources between males, reproducing females and young. However, McCullough (1979) suggested that there is a greater danger to females and their young by association with males. His arguments are based on the higher proportion of male white tailed deer (*Odocoileus virginianus*) preyed upon by wolves even in an area where females outnumbered males. In Kanha, Schaller (1967) did not find any evidence to support selective killing of male chital by predators. The peak of separation of the sexes in chital was during the cold season when most

males were in velvet and most young were born. During this period green short grasses were neither as abundant nor were found in as big patches as during the pre-monsoon season. An intensive study of the food habits of the males and females at this time is needed for more light to be shed on this problem.

The size and composition of chital groups were not stable. Although the species was highly social the social system was clearly very fluid. Animals formed groups, moved out of them, and formed new groups in periods of days or perhaps even less. However, as will be shown later (Chapter 9) each animal nevertheless had a fixed home range that was stable, in some cases for years. It is therefore possible, regardless of the apparent lack of stability of groups, that there existed long-term associations between animals. It is not known how many other individuals an animal might expect to encounter within its home range but it is possible that all such individuals were known to the animal. A detailed study of individual relationships would be worthwhile.

CHAPTER 9

9.1 Introduction

In the previous chapter the social organisation of the chital was described. In this section I shall consider in more detail the movement and home range behaviour of individually known animals. The term "home range" used here follows Jewell (1966) as being the "area over which an animal normally travels in pursuit of its routine activities". Such activities will include feeding, mating, care of young, and avoidance of predators (e.g. Burt 1940; Blair 1953; Brown 1962; Sanderson 1966; Jewell 1966). The home range must include all the environmental parameters necessary for the animal's existence (Mitchell *et al* 1977). Climatic variations and subsequent changes in the availability and distribution of forage, shelter and cover can influence the location and size of an animal's home range (Lowe 1966; Staines 1974; Leuthold 1977; Clutton-Brock and Harvey 1977; Clutton-Brock and Harvey 1978; Nelson 1979).

The objectives of this section were primarily to determine the size of the home ranges of adult and yearling males and females, and to investigate seasonal changes in range size.

9.2 Methods

I have described the "home range" in three categories similar to those given by Chapman and Chapman (1975); and Leuthold (1977).

(1) Daily range: This provides an estimate of the area than an animal moved within a period of 24 hours. It is based locations of deer within a period of 24 hours in different seasons.

(2) Seasonal Range: The seasonal range provides an estimate of the size for the pre-monsoon (February to May); monsoon (June to September)

and the post-monsoon (October to January) seasons. It is based on location of deer movements in the 4 months in each season.

(3) Annual Range: The third category describes the home range for the whole year and only includes deer that were monitored for at least one full 12 month cycle.

The methods consisted of capturing free ranging chital, attaching radio collars and following their movement by the use of radio telemetry techniques described previously (Chapter 6). Radio tracking was done from elephants by scanning along set trails that were marked with numbered plates at 100 metre intervals. These served as known reference points. Bridges, road junction and other topographical features provided additional reference points. The positions of collared chital were determined by triangulation (Chapter 6) as described by Heezen and Tester (1967). Radio locations were plotted on an enlarged map (1.5 cm = 200 metre) that was drawn from aerial photographs taken in 1977/78. The approximate range of reception for the equipment in use in Chitwan was estimated to be 2,133 m for radio tracking from elephants with an average linear error (difference between radio location and true location) of ± 0.067 km (Sunquist 1981). Methods for calculating home range size have been reviewed in the literature (Hayne 1949; Jennrich and Turner 1969; Village 1982). I estimated the home range by calculating the "polygon area" given in Mohr (1947), which is an area of the polygon formed by connecting all the outer-most locations. This method is similar to methods used by Nelson (1979); Sunquist (1981) and Village (1982) for home range estimation based on radio locations for white-tailed deer (*Odocoileus virginianus*); tiger (*Panthera tigris*) and European Kestrels (*Falco tinnunculus* L.).

Home range size estimated by this method is dependent on a minimum number of locations. To ascertain what constituted an adequate sample size, I utilized a cumulative curve area as described by Odum and Kuenzler (1955) and plotted the relationship between the number of successive days located and the cumulative home range area. It increased towards an asymptotic limit after which the size remained more or less consistent. A cumulative curve of 2 adult males and 2 adult females each indicated that after about 15 days locations, there was no significant increase in home range size. (Fig. 9.1). Thus my data includes only those animals that were located at least for 15 days in each season.

To illustrate the dispersion pattern of radio locations, I have given as examples the locations of 2 adult males and 2 adult females. In addition the locations were also projected on a 3 dimensional scale using the SYMAP computer programme (Mills *et al* 1980).

9.3 Results

Of the total of 27 radio collared deer (Chapter 5), only 16 adults and 8 yearlings could be monitored for at least one whole year with a minimum of at least 15 days locations for each season. Others were lost to predators or produced an inadequate number of locations because of malfunction of the transmitters. Among the adults 6 males and 6 females were monitored once in each season on a 24-hour cycle to estimate their daily range. One sub-adult male dispersed about ~~36~~ km west from the area it was captured. Since this is the only observation of dispersal of chital in record, its movement pattern is discussed separately and this animal has been excluded from comparison of home range sizes.

(1) Daily range:

FIGURE 9.1

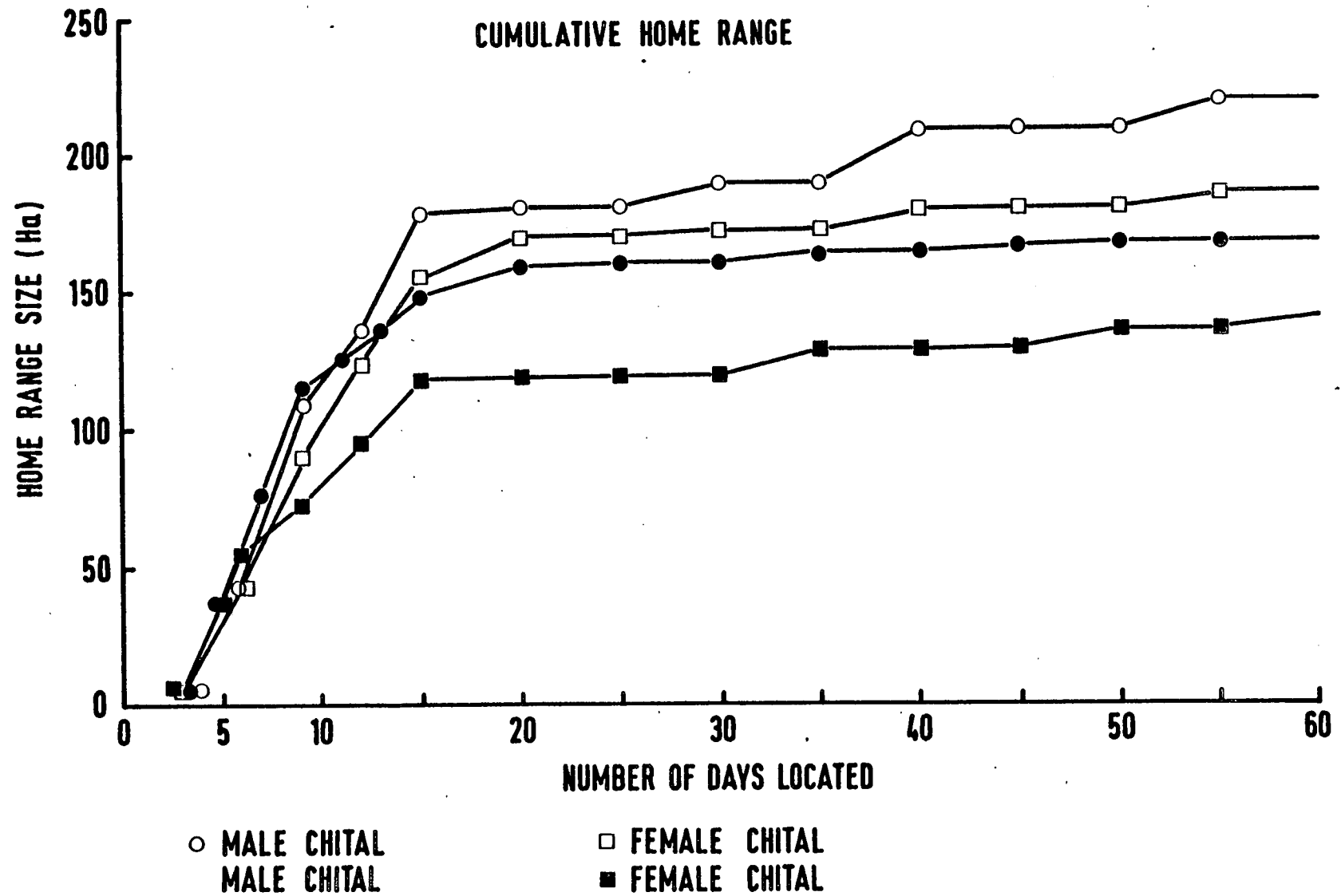


TABLE 9.1: CHITAL : DAILY HOME RANGE AREA (HA) BASED ON 24 HOUR OBSERVATION

Deer No/ Sex	Seasons			Deer No/ Sex	Seasons		
	Pre-Monsoon	Monsoon	Post-Monsoon		Pre-Monsoon	Monsoon	Post-Monsoon
8 AM	18.80	11.82	14.75	5 AF	14.93	10.57	17.19
10 AM	17.75	10.66	15.39	13 AF	19.27	13.84	18.36
11 AM	19.09	14.03	15.98	16 AF	15.70	17.80	10.33
17 AM	27.35	13.18	18.16	20 AF	18.95	18.35	16.24
21 AM	25.28	18.68	16.25	23 AF	21.07	12.09	13.61
19 AM	13.04	16.23	19.95	36 AF	18.13	15.67	15.79
Mean	20.22	14.10	16.74	Mean	18.0	13.88	15.25

TABLE 9.2: CHITAL DAILY RANGE COMPARISON
MAN-WHITNEY U TEST

Variable	Pair	N1	N2	U	P
Male	Pre-Monsoon/Monsoon	6	6	5	0.021 *
Male	Pre-Monsoon/Post-Monsoon	6	6	9	0.090
Male	Monsoon/Post-Monsoon	6	6	7	0.047 *
Female	Pre-Monsoon/Monsoon	6	6	4	0.013 *
Female	Pre-Monsoon/Post Monsoon	6	6	9	0.090
Female	Monsoon/Post-Monsoon	6	6	12	0.197
Male/Female	Pre-Monsoon	6	6	14	0.294
Male/Female	Monsoon	6	6	17	0.469
Male/Female	Post-Monsoon	6	6	14	0.264

* - Significant

The estimates of area utilised by adult males and females are based on 6 cases each. The mean daily range for all seasons combined for adult males was estimated to be 16.94 ha and for females it was 15.71 ha. Here, I have compared the seasonal differences between the daily range of males - males and females - females using the Mann-Whitney U test (Siegal 1956) to estimate if the differences are statistically significant.

(a) Male-male comparison:

The daily range of males during the pre-monsoon was significantly ($p = 0.02$) larger than that of the monsoon but was not significantly different from the post-monsoon ($p = 0.09$). The daily range of males during the post-monsoon season was also significantly ($p = 0.047$) larger than that of the monsoon (Table 9.2).

(b) Female-female comparison:

As in the males, the daily range covered by the females during the pre-monsoon was significantly ($p = 0.013$) larger than during the monsoon. There were no significant differences between the daily range of pre-monsoon with the post-monsoon ($p = 0.09$) and between the monsoon and post-monsoon seasons (Table 9.2).

(c) Male-female comparison:

The mean daily range covered by males during the pre-monsoon season was estimated to be 20.37 ha and that by females was 18.0 ha. In the monsoon it was slightly less for both the sexes as the estimated daily range for males was 14.10 and of females was 13.88 ha. In the post-monsoon season the daily range of males was estimated to be 16.74 and of females it was 15.25 ha (Table 9.1). Though the daily area covered by males was slightly larger than females there were no significant differences for any of the seasons (Table 9.2).

TABLE 9.3: CHITAL : SEASONAL RANGE OF ADULT MALE AND ADULT FEMALE IN (HA)

SN	Deer No/ Sex	No. of days located	Area Pre-Monsoon	No. of days located	Area Monsoon	No. of days located	Area Post-Monsoon
1	3 AM	25	220.6	28	250.0	32	97.2
2	7 AM	28	357.6	26	135.9	20	126.9
3	8 AM	44	137.6	108	156.6	160	159.4
4	10 AM	84	164.1	71	84.5	74	163.4
5	11 AM	185	170.6	90	129.7	94	156.0
6	17 AM	63	152.7	65	140.7	155	62.0
7	19 AM	109	212.5	70	91.9	66	167.0
8	21 AM	132	348.5	34	185.8	43	303.4
9	5 AF	60	158.9	54	69.4	49	168.9
10	6 AF	25	112.5	72	151.4	21	82.0
11	13 AF	57	122.8	22	69.6	41	119.0
12	16 AF	71	95.3	151	176.3	46	159.2
13	20 AF	166	151.2	65	92.7	73	50.6
14	23 AF	164	140.7	79	87.8	21	130.3
15	26 AF	35	206.2	43	105.9	19	151.8
16	36 AF	65	153.6	84	112.8	175	150.3

Mean	Pre-Monsoon	Monsoon	Post-Monsoon
AM	220.5	146.89	154.45
AF	142.6	110.2	126.5

TABLE 9.4: CHITAL: SEASONAL RANGE COMPARISON OF *AXIS AXIS*
MANN-WHITNEY U TEST

Variable Pair		N1	N2	U	P
Male	Pre-Monsoon/Monsoon	8	8	13	0.025 *
Male	Pre-Monsoon/Post-Monsoon	8	8	15	0.041 *
Male	Monsoon/Post-Monsoon	8	8	29	0.399
Female	Pre-Monsoon/Monsoon	8	8	15	0.041 *
Female	Pre-Monsoon/Post-Monsoon	8	8	29	0.399
Female	Monsoon/Post-Monsoon	8	8	23	0.191
Male/Female	Pre-monsoon	8	8	10	0.010*
Male/Female	Monsoon	8	8	18	0.080
Male/Female	Post-Monsoon	8	8	23	0.191

(2) Seasonal Range:

The estimates of seasonal home range size are based on 8 adult males and 8 adult females. Again Mann-Whitney U tests were used throughout.

(a) Male-male comparison:

The mean home range size of males was estimated to be 220.5 ha in the pre-monsoon; 146.89 ha in the monsoon and 145.45 ha in the post-monsoon seasons (Table 9.1). Home range size in the pre-monsoon season was significantly greater ($p < 0.05$) than in the monsoon and post-monsoon seasons (Table 9.2). There was no significant difference ($p = 0.399$) between the monsoon and post-monsoon seasons.

(b) Female-female comparison:

The mean range size of females was estimated to be 142.65 ha in the pre-monsoon; 110.2 ha in the monsoon and 126.51 ha in the post-monsoon seasons (Table 9.3). As in the males, the pre-monsoon range size was significantly greater ($p = 0.04$) than the monsoon range size. However, there was no significant difference ($p = 0.399$) between the range of the pre-monsoon season and post-monsoon season. Likewise, the range in the monsoon season was not significantly different ($p = 0.19$) from that of the post-monsoon (Table 9.4).

(c) Male-female comparison:

In the pre-monsoon season the range of males was significantly greater than that of females ($p = 0.01$). There was no significant difference in range sizes of males and females in the monsoon season ($p = 0.08$) or in the post-monsoon season ($p = 0.19$).

(3) Annual Range:

The mean annual home range area was estimated to be 301.41 ha for adult males; 201.91 ha for adult females; 229.13 ha for yearling males

TABLE 9.5: CHITAL : ANNUAL HOME AREA OF DIFFERENT SEX/AGE/CLASS IN (HA)

Adult Male	Adult Female	Year Male	Year Female
330.8	259.4	296.0	110.6
386.1	129.3	201.6	209.5
193.2	219.0	189.8	360.8
230.0	156.5	-	480.8
237.9	289.5	-	-
230.7	154.1	-	-
287.1	314.1	-	-
515.5	165.4	-	-
$\bar{X}$ 301.41	210.9	229.13	290.4

TABLE 9.6: ANNUAL HOME RANGE COMPARISON BETWEEN SEX/AGE/CLASS
MANN-WHITNEY U TEST.

Variable Pair		N1	N2	U	P
Yearly Home Range	Adult Male/Adult Female	8	8	15	0.041 *
"	Adult Male/Year Male	8	3	6	0.139
"	Adult Male/Year Female	8	4	14	0.404
"	Adult Female/Year Male	8	3	9	0.315
"	Adult Female/Year Female	8	4	12	0.285
"	Year Male/Year Female	3	4	4	0.314

and 290.4 ha for yearling females (Table 9.5). The annual range size of males was significantly larger ($p \leq 0.04$) than that of the female whereas it was not significantly different ($p > 0.05$) from that of yearling males and yearling females. The annual home range of adult females did not differ significantly ($p > 0.05$) from those of yearling males and yearling females (Table 9.6). However, it is emphasized that the sample size of yearlings is only 4 as compared to 8 of adults.

(4) Position of the home ranges:

The home range of both males and females were concentrated around the Riverine forest (Fig. 9.2 to Fig. 9.5). In all seasons both sexes spend most of the time in the riverine forest. Over 74 % of the total locations of both sexes were in the Riverine Forests (Table 6.2).

(5) Stability of home range:

The home range of both males and females appeared to be stable. Some of the deer that were located for more than a year indicate no significant changes of their movement pattern as illustrated by two examples (Fig. 9.2 and Fig. 9.5).

(6) Overlap of home ranges:

Annual home range of both sexes overlap, throughout the year. Though males and females foraged separately during the post-monsoon season (Chapter 8) their range during this season also overlapped (Fig. 9.10). Riverine forest were an important component of the range of both sexes throughout the year.

(7) Dispersion pattern of locations within the total (annual) home range:

The dispersion patterns of the locations of a male (Fig. 9.2) and a female are shown (Fig. 9.3) to illustrate that there was usually

TABLE 9.8: CHITAL : MEAN DAILY AND SEASONAL RANGE

Seasons	Daily Range		Seasonal Range		Daily range as % of seasonal range	
	(N = 12)		(N = 16)			
	Male	Female	Male	Female	Male	Female
Pre-Monsoon	20.22	18.00	220.50	142.65	9.17	12.61
Monsoon	14.10	13.88	146.89	110.20	9.59	12.59
Post-Monsoon	16.74	15.25	154.45	126.51	10.83	13.23

TABLE 9.7: CHITAL : SUMMARY OF CAPTURED AND MOVEMENT OF YEARLINGS

Deer No.	Sex	Date Captured	Site Captured	Last Radio Location	Site last Located	Remarks
1*	YRM	Dec. 1978	Patch 4	Sept. 1981	Bogmara/ Tiger Tops	Dispersed 36 Km
22	YRF	Dec. 1979	Patch 1	Sept. 1981	Patch 1	Within less than 1 Km of capture site
24	YRF	Dec. 1979	Patch 2	Aug. 1980	Patch 2	"
28	YRM	March 1980	Kachmani	April 1981	Patch 4	"
29	YRM	March 1980	Kachmani	Oct. 1981	Patch 4	"
30	YRF	March 1980	Kachmani	Sept. 1981	Patch 4	"
32	YRF	April 1980	Kachmani	Sept. 1981	Patch 3	"
37	YRM	Aug. 1980	Itcharni	Sept. 1981	Itcharni	"

* Last location based on sighting

FIGURE 9.2: CHITAL HOME RANGE
ADULT MALE No.17

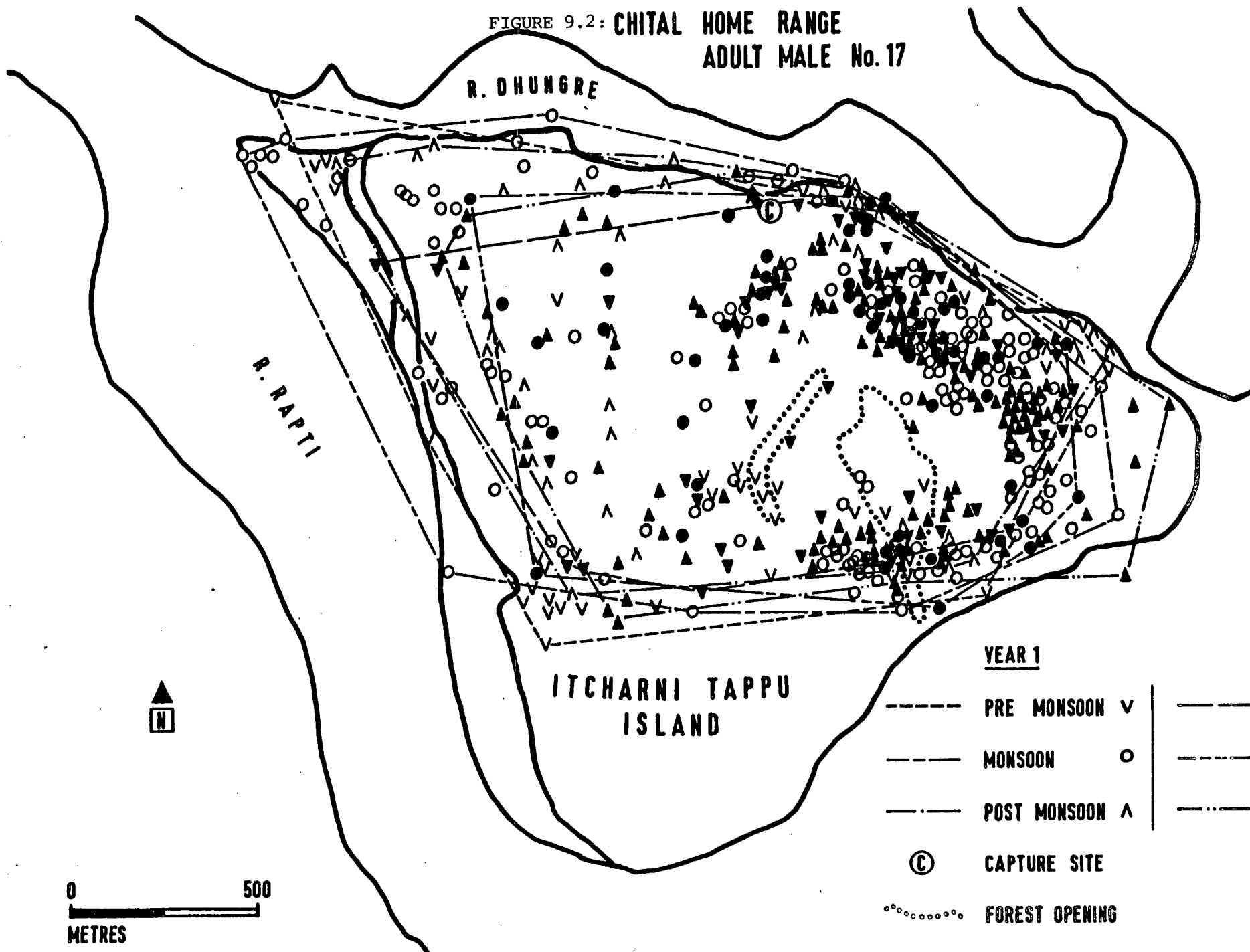
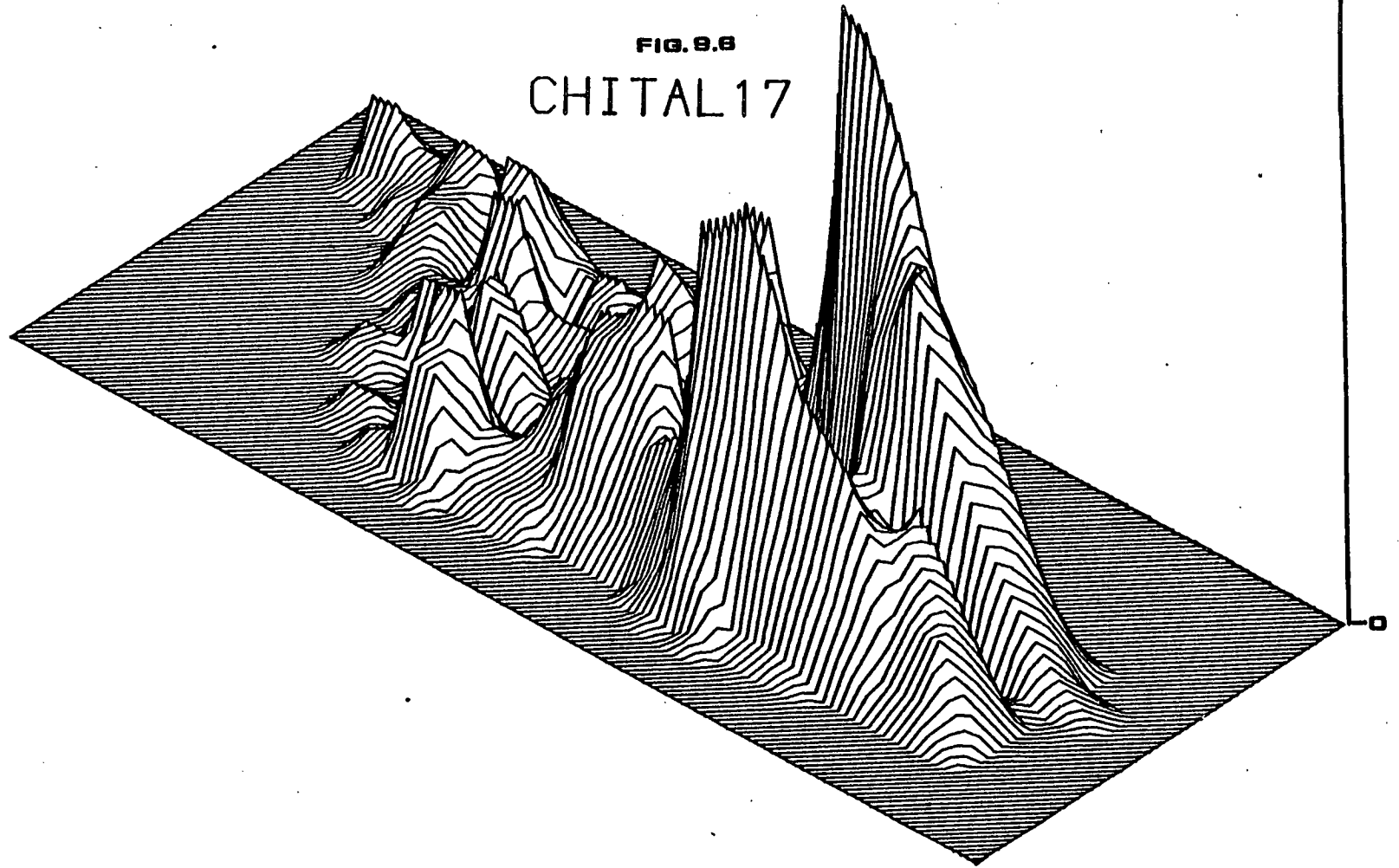
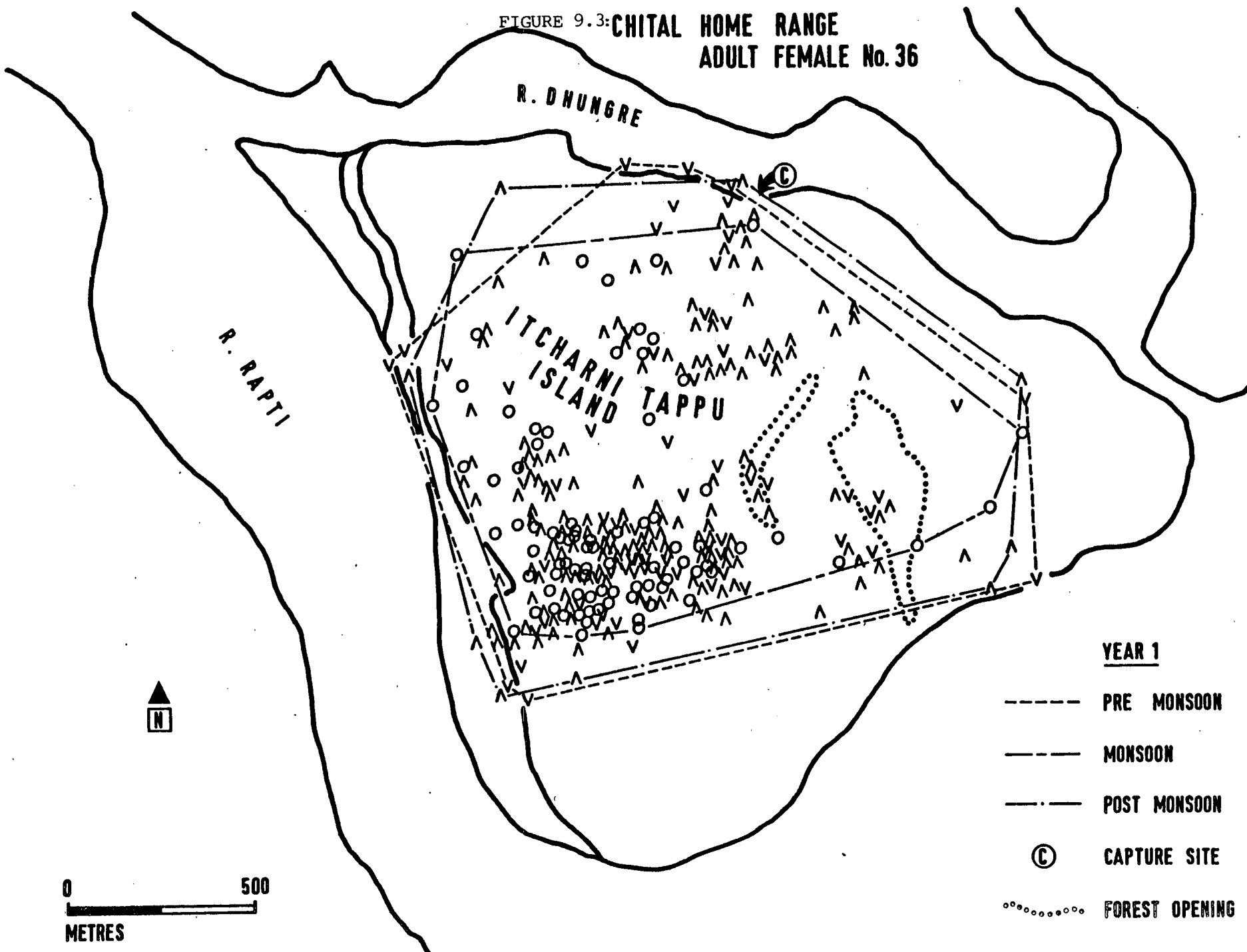


FIG. 9.8
CHITAL 17



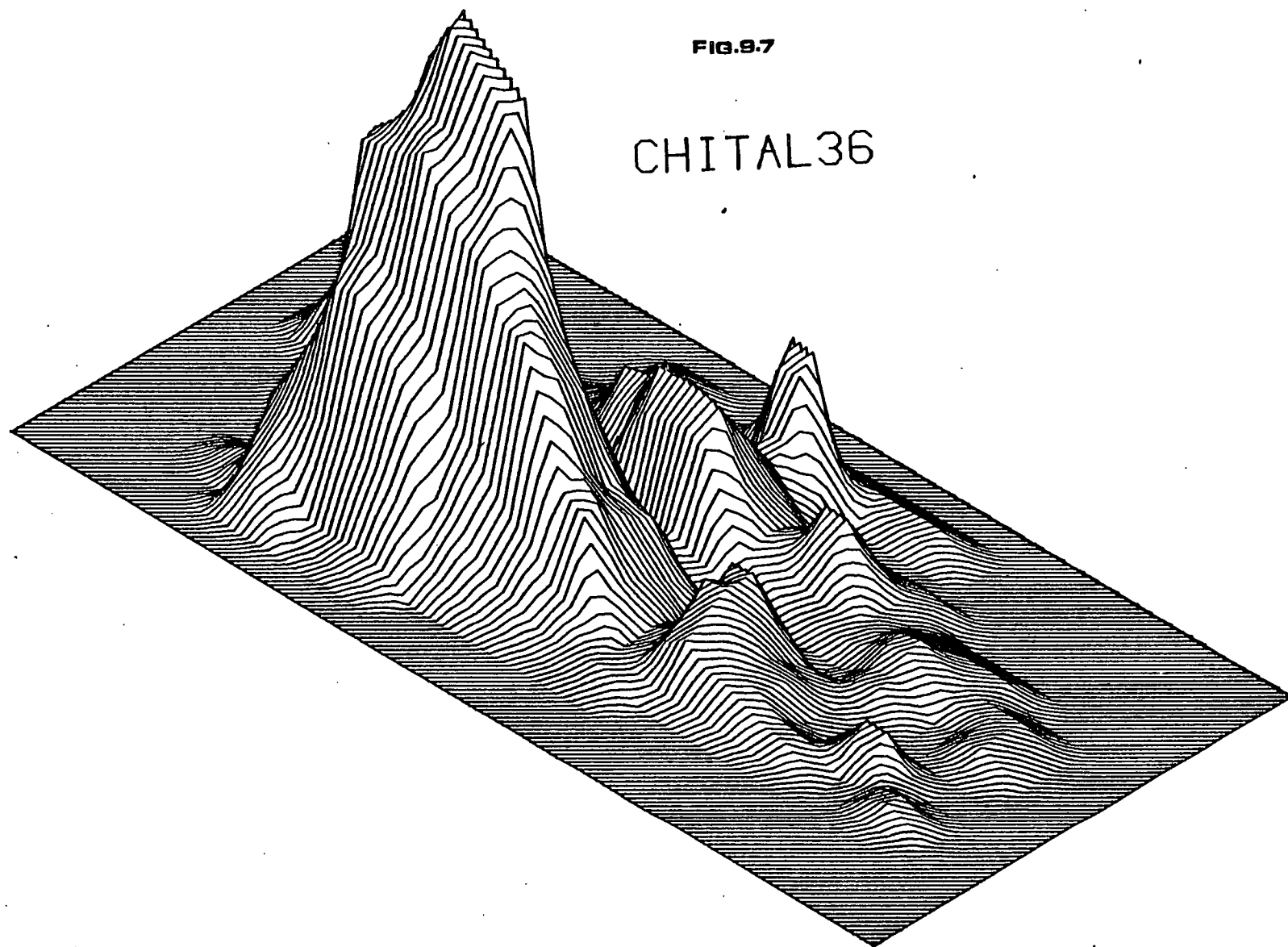
A three-dimensional map generated by SYMVU, of deer locations. The scale represents numbers of locations per quadrats of size 2ha. The area covered by the map and the orientation are as in Fig. 9.2.

FIGURE 9.3: CHITAL HOME RANGE
ADULT FEMALE No. 36



YEAR 1

- PRE MONSOON v
- MONSOON o
- . - . POST MONSOON ^
- Ⓒ CAPTURE SITE
- FOREST OPENING



A three-dimensional map generated by SYMVU, of deer locations. The scale represents number of locations per quadrats of size 2 ha. The area covered by the map and the orientation are as in Fig. 9.3.

FIGURE 9.4: CRITICAL HOME RANGE
ADULT FEMALE No. 23

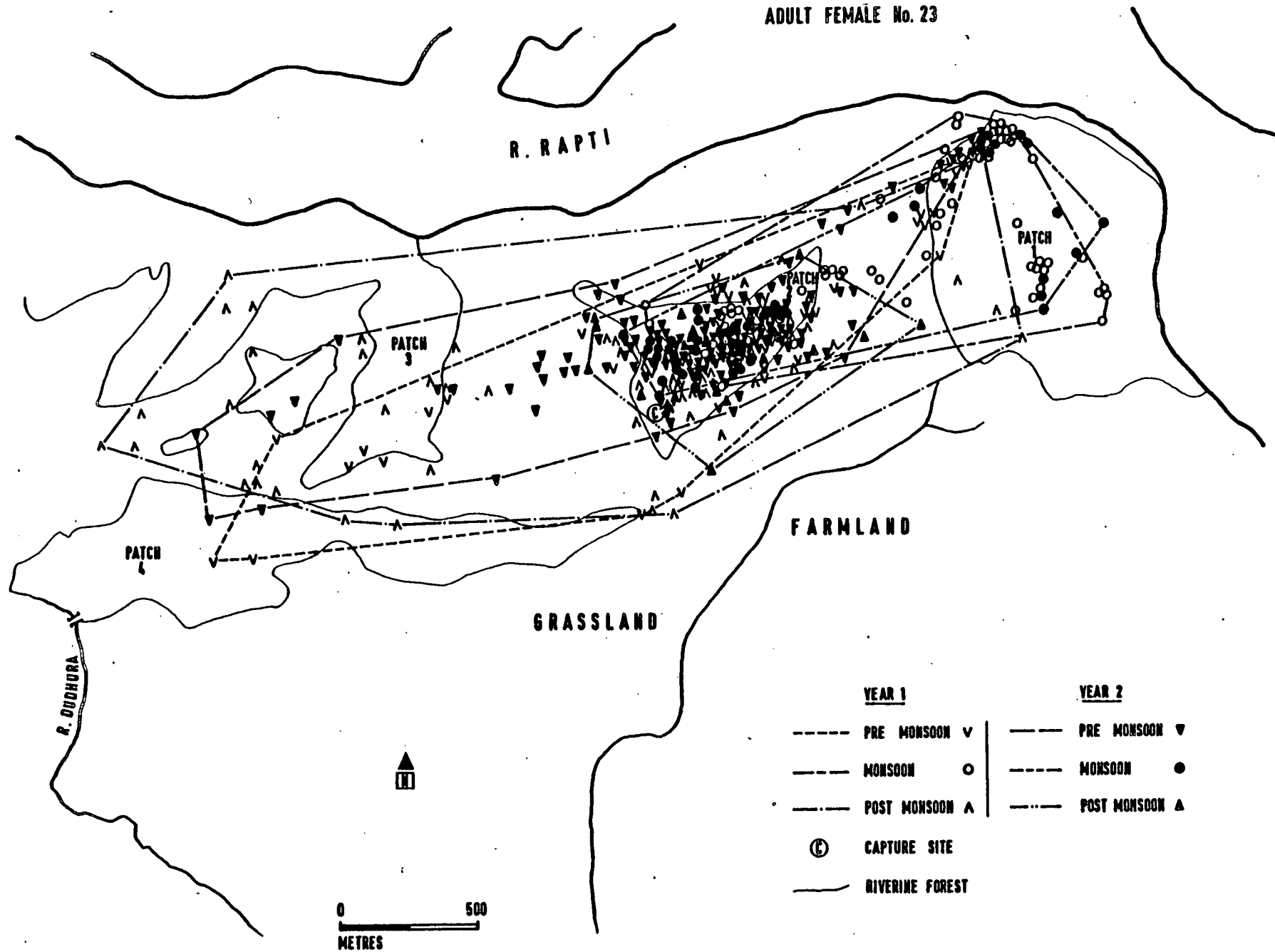
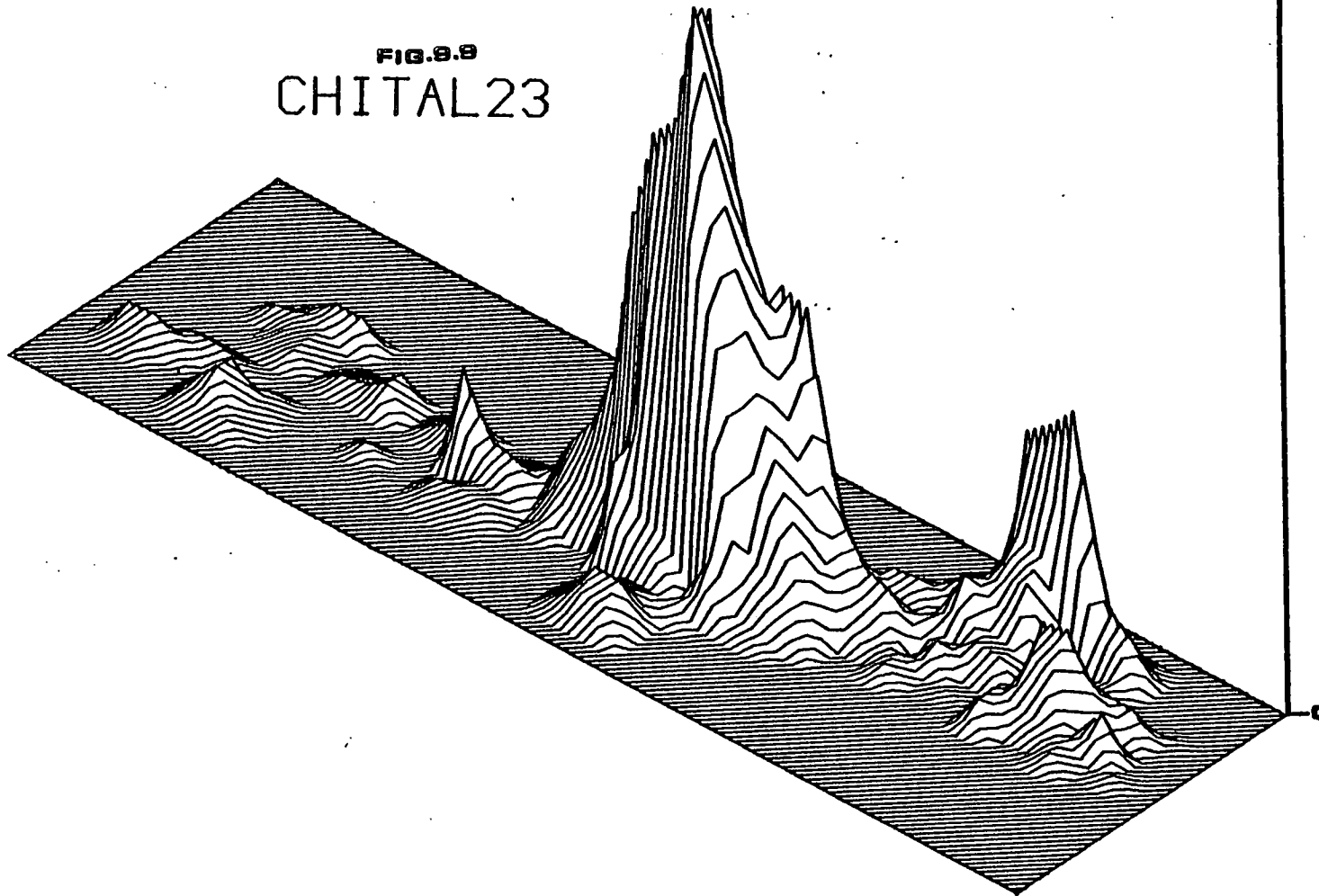


FIG.9.9
CHITAL23



A three-dimensional map generated by SYMVU, of deer locations. The scale represents number of locations per quadrats of size 2ha. The area covered by the map and the orientation are as in Fig. 9.4

FIGURE 9.5: CHITAL HOME RANGE
ADULT MALE No. 19

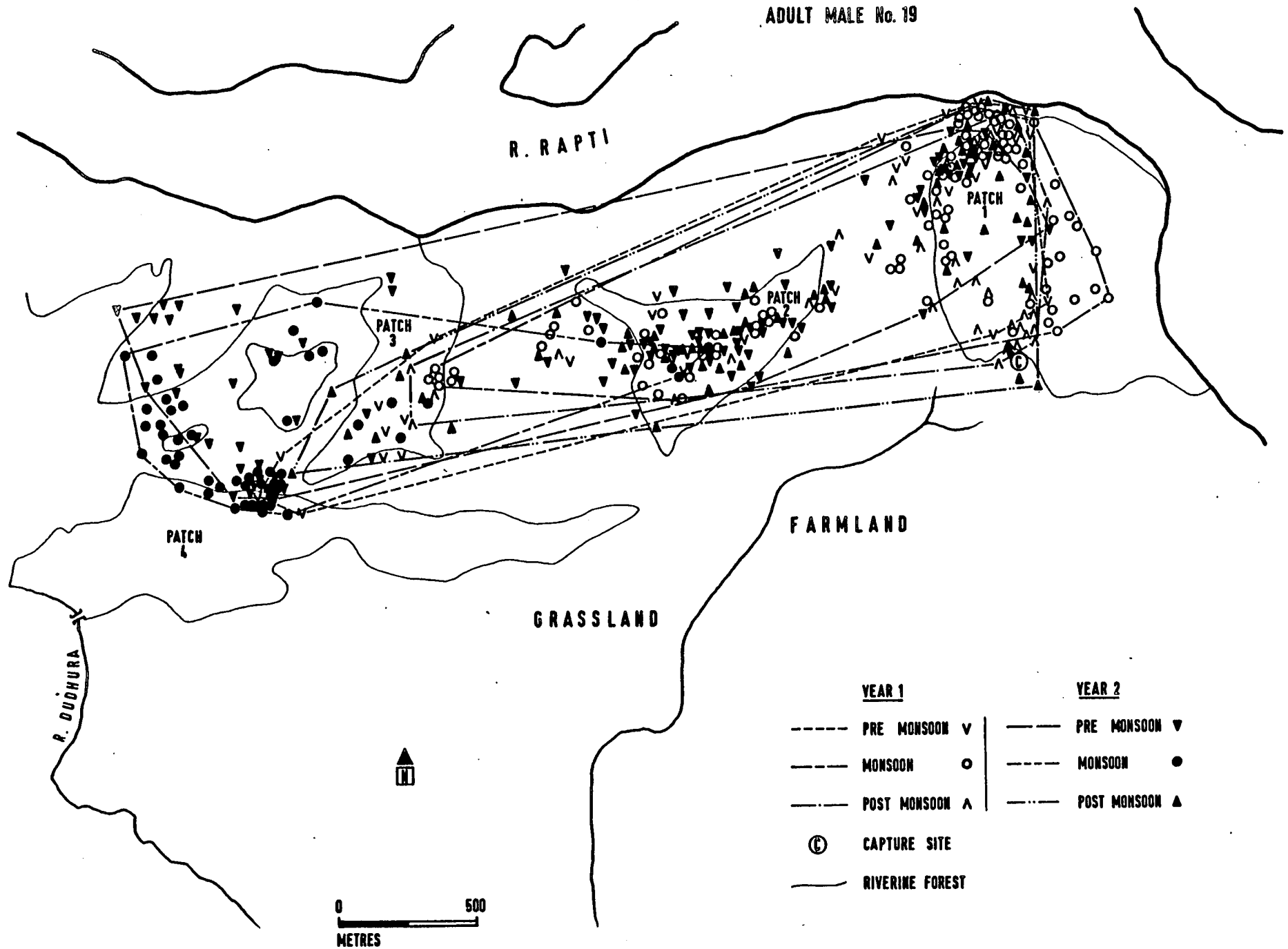
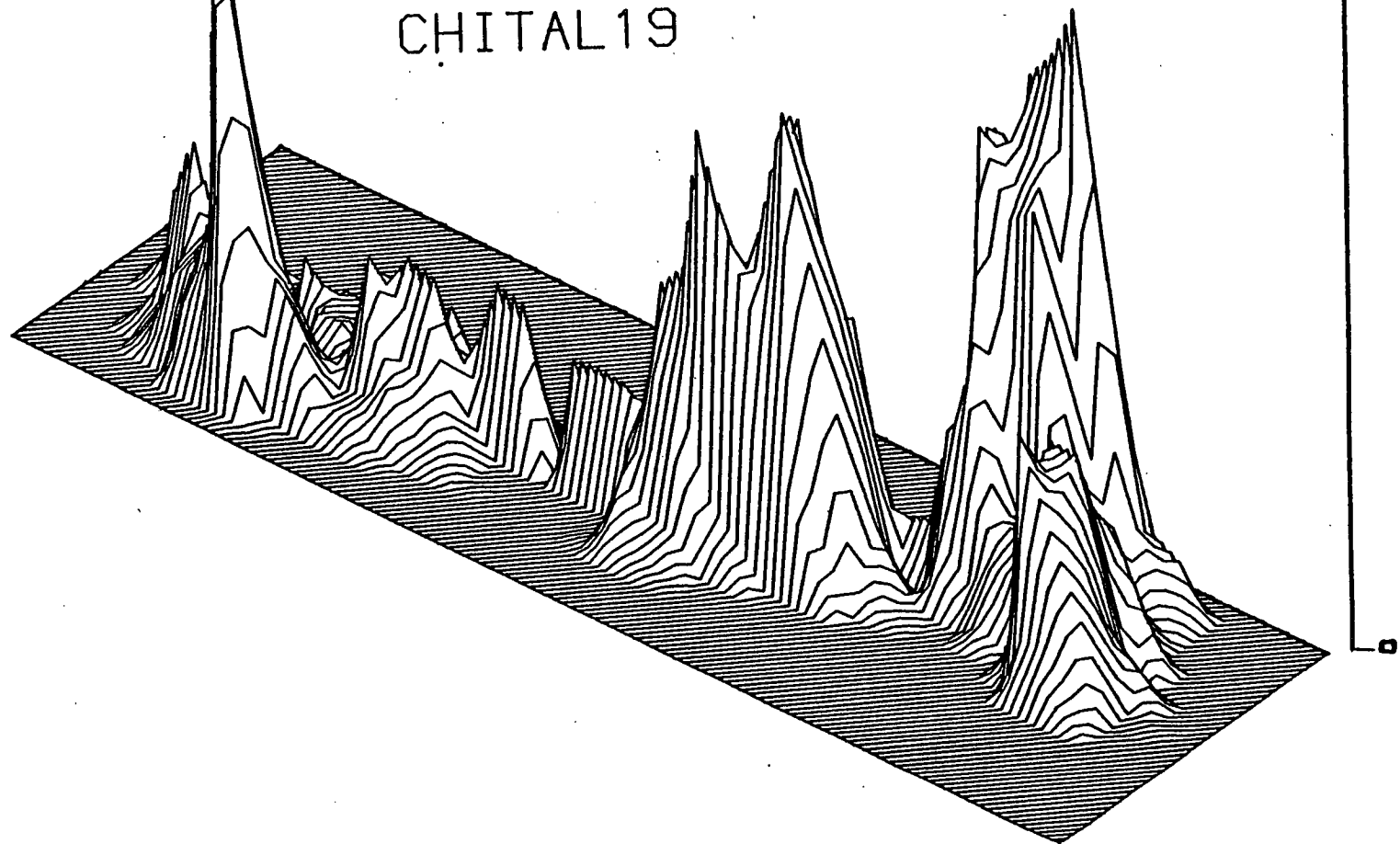


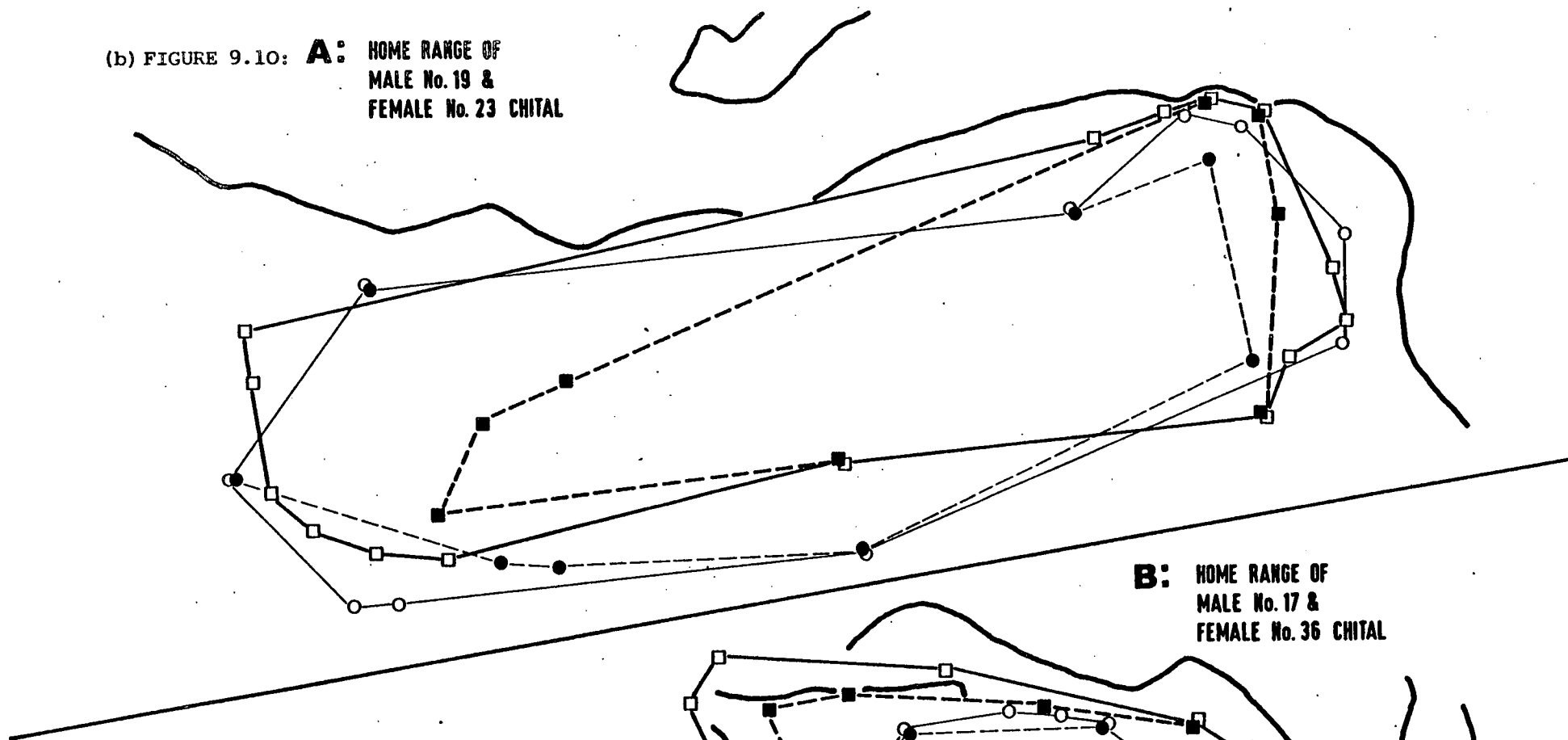
FIG. 9.8

CHITAL 19

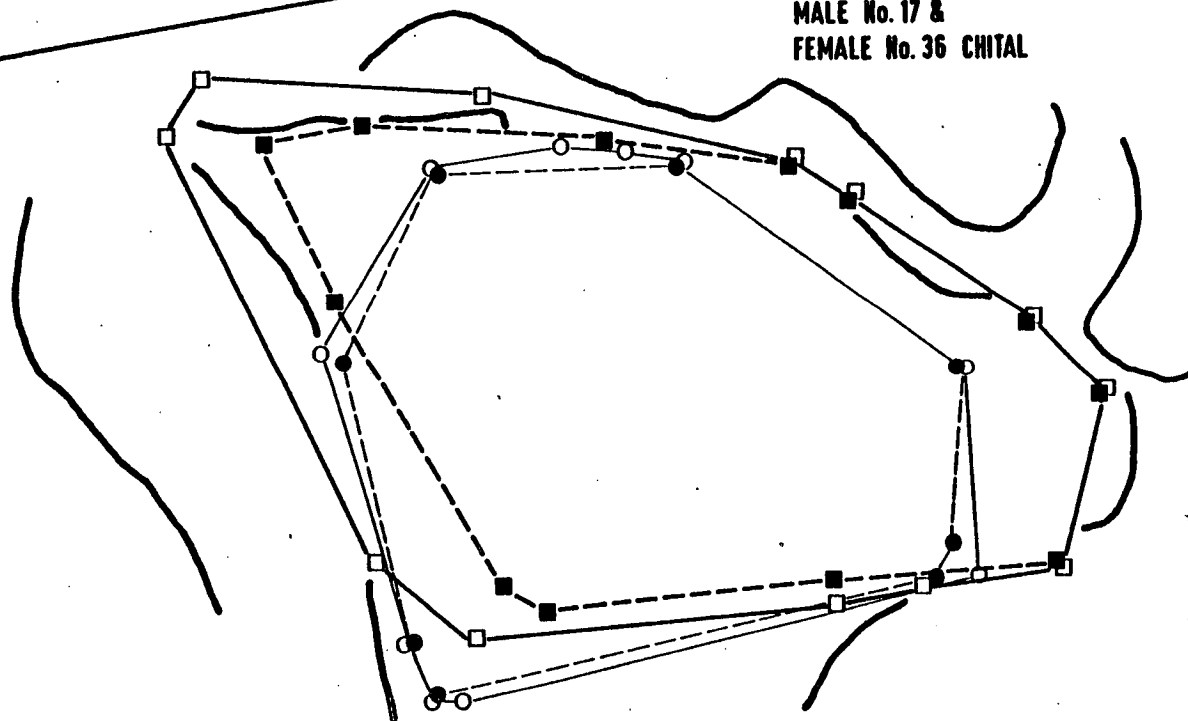


A three-dimensional map generated by SYMVU, of deer locations. The scale represents number of locations per quadrats of size 2ha. The area covered by the map and the orientation are as in Fig. 9.5.

(b) FIGURE 9.10: **A:** HOME RANGE OF
MALE No. 19 &
FEMALE No. 23 CHITAL



B: HOME RANGE OF
MALE No. 17 &
FEMALE No. 36 CHITAL



- HOME RANGE MALE
- HOME RANGE FEMALE
- - ■ POST MONSOON MALE
- - ● POST MONSOON FEMALE

0 500
METRES

FIGURE 9.11 : MOVEMENT PATTERN OF A YEARLING MALE (No.1)

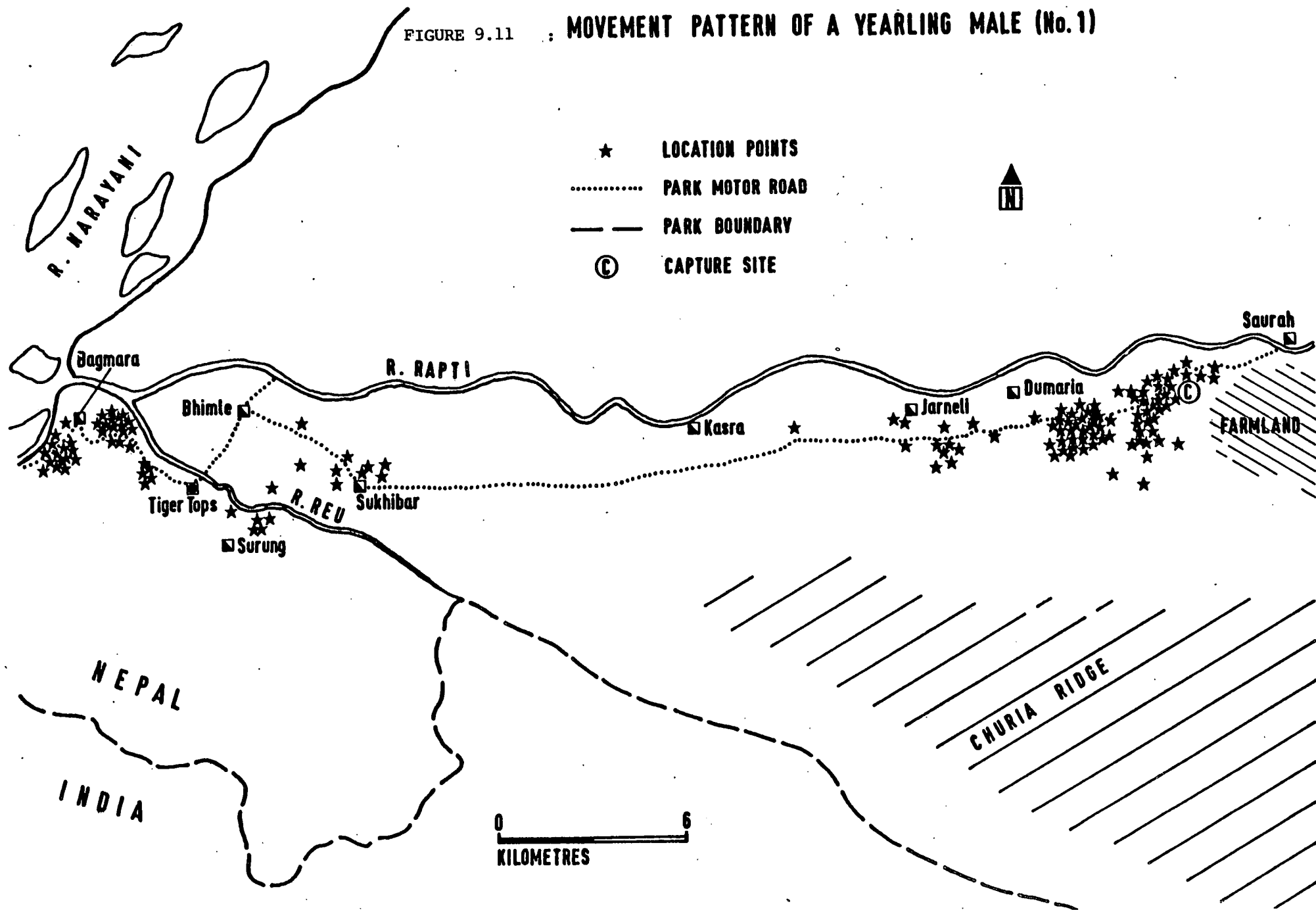
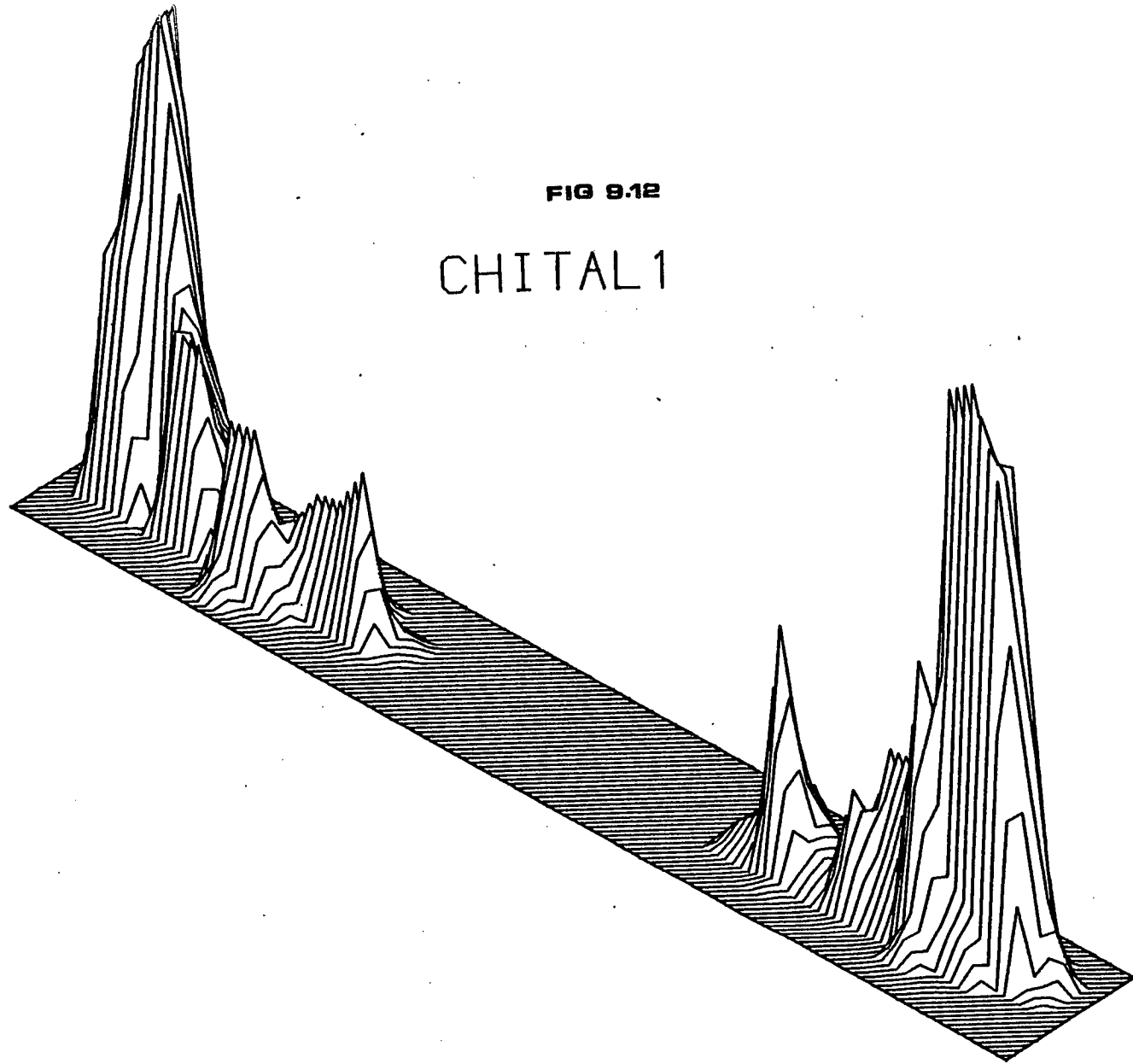


FIG 9.12

CHITAL 1



A three-dimensional map generated by SYMVU, of deer locations. The scale represents number of locations per quadrats of size 2 ha. The area covered by the map and the orientation are as in Fig. 9.11.

one or two sectors within the total range where the locations were clustered. These sites were always in the Riverine forest for both males and females (Fig. 9.2 - Fig. 9.5). From there other locations radiated in several directions indicating areas where the chital made excursions to carry out its normal activities. The locations of the same figures were projected on a 3 dimensional map to indicate the number of locations in a quadrat of approximately 2 ha. They illustrate that there are core areas with a distinct peak where deer spend most of the time and other smaller peaks represent areas where the animal moved for foraging or other daily or seasonal activities (Figs. 6, 7, 8 and 9). The core area was in the Riverine forest for all seasons for both sexes.

(8) Dispersal of yearlings:

A total of 4 yearling males and 4 yearling females were trapped and radio collared. Three of the males and all of the females remained around the area of capture (Table 9.7).

Only one, a male (Chital No. 1) which was radio collared in December, 1978 near Saurah dispersed away from the area of capture. It was located around its capture site until February 1979. Then it shifted west to Dumaria about 6 km from its capture site (Fig. 9.11) and was located around that area from March to May. In June/July it was located about 2 km further west after which I did not radio locate it for the next 9 months except for one location near Kasra in September 1979. In February 1980, I radio tracked him around Sukhibar area from an aeroplane approximately 20 km west of the capture site. In the next two months it was sighted near the Tiger Tops area by one of their staff in a small patch of riverine forest. From then I sighted and radio located it several times near the Bagmara area until July

1981, by which time the radio reception was only audible from a distance of less than 200 metres. However, it was frequently sighted by Tiger Tops staff up to the end of September 1981, at which time I left Chitwan.

In a period of near 3 years the animal has moved a distance of approximately 36 km from its natal area before its movement appeared to be stabilized.

9.4 Discussion

The estimates of daily range size show that males covered between 9 and 10 percent and females 12 to 13 percent of the total seasonal range size in 24 hours. Total range size was reached when between 12 and 15 days locations were obtained for the animals. These two figures are of great interest because they show that the animals must have moved rapidly round their home ranges. The area utilised by an animal on any one day must have overlapped little if at all with the area utilised the previous day. No animals were followed all day for 15 consecutive days so the exact day to day paths followed by the animals were not known. However it is possible that the animals exploited their ranges in a systematic fashion. Such a pattern of movement could have been imposed on the animals if they were feeding in association with troops of monkeys which were themselves moving round their ranges to exploit food efficiently. Alternatively, the deer themselves might have been foraging in an optimal fashion, returning to a patch after an interval during which the food resources had renewed. Water resources were distributed throughout the ranges of all the animals so daily movements were not determined by water supplies as has been demonstrated for a number of African ungulates (Leuthold 1977; Delany and Happold 1979).

In many species of deer the seasonal changes in the environment are main factors that determine movement patterns and range sizes (Linsdale and Tommich 1953; Dasmann and Taber 1956; Lowe 1966; Chapman and Chapman 1975; Mitchell *et al* 1977). In both sexes of chital, the daily range during the pre-monsoon season was significantly larger than during the monsoon while there were no significant differences in other seasons. In the pre-monsoon, the annual grass cutting and burning produced short and fresh crop of forage which is normally tall and dense during the monsoon and thus presumably unavailable or unpalatable for the chital. During the pre-monsoon the chital appears to make daily excursion to forage in cut and burnt patches from the Riverine forest thus increasing the total range size. Furthermore, during the monsoon, there is fresh growth of several species of creepers, herbs, and shrubs in meadows, forest openings and open high banks within the Riverine forest. Movement during the monsoon may also be limited by the seasonal floods in rivers and streams.

The seasonal range for both males and females was significantly larger in the pre-monsoon than in the monsoon. As with the daily range the differences can be attributed to the seasonal changes in the environment. However, the ranges of the males in the pre-monsoon was significantly larger than the post-monsoon though there was no difference in females. The pre-monsoon season is the period when males come into rut. Many cervids during rut become restless and wander about more (Espmark 1964; Lincoln *et al* 1970; Chapman and Chapman 1975). Male chital also wander more in the rut and this might therefore add to the range size. This may also be the reason why the home range of males were significantly larger than the females during the pre-monsoon season,

whereas there were no significant differences in the monsoon and post-monsoon ranges. The annual home ranges of the males were significantly larger than those of the females. This is similar to findings for red deer in Scotland (Mitchell *et al* 1977) and the White tailed deer in Minnesota (Nelson 1979) but different from that of fallow deer (*Dama dama*) in England, where it is suggested that females have larger home ranges than males (Chapman and Chapman 1975).

The dispersion of radio locations shows that there was considerable overlap in the home ranges of males and females throughout the year. Similarly the seasonal ranges though different in sizes, overlapped for both males and females.

Wilson (1980) proposed an "optimal area hypothesis" suggesting that the home range of an animal should be small enough to yield adequate supplies of energy and not too large since the animal would unnecessary be exposed to predators. Red deer studies have illustrated that there are considerable variations in home range size from area to area and the availability of adequate shelter is suggested as one of the main environmental factors for the regional differences in home range size (Mitchell *et al* 1977). Such regional differences in home range size in some of the African ungulates is given in Leuthold (1977). There is no record available to compare the home range of the chital in Chitwan with other areas. Nevertheless, it seems that the effects of grass cutting and burning in bringing changes in food supply and distribution is a prime environmental factor for seasonal differences in movement pattern and home range of chital. Similar shifts in movement pattern have also been reported in white tailed deer in the United States (McCaffery and Creed 1969; Byford 1970; Kohn and Mooty 1971).

It is not known why only one of the yearling males dispersed a

distance of nearly 36 km whereas all others remained within their natal areas. Caughley (1977) has described the need for dispersal. The cause of dispersal may be genetical as suggested by Howard (1960) where the movement is spontaneous and lies with the dispersing individual rather than environmental conditions.

CHAPTER 10



The Tiger (*Panthera tigris*) is the
largest predator of the Park.

10.1 Introduction

It was intended that this study of the deer in Chitwan should relate as much as possible to the requirements of the Tiger population. Therefore it was important to obtain quantitative information on mortality in the deer especially that caused by the Tiger. In this Chapter I will consider mortality in the chital in detail and also present information on the relative importance of the different species of deer in the Tiger's diet. Observations of the behavioural responses of each species of deer to danger are also given.

10.2 Methods

Data on mortality of chital were obtained from the radio collared animals. Attempts were made to locate all the radio collared animals on a day to day basis. Not all were located that frequently but all were located several times each month. At each location attempts were made to establish whether or not the animal was alive and moving by the change in the radio signal. If the position of the animal did not change during the course of a day the radio signal was followed up until the animal was seen and established to be dead or alive. In this way freshly dead animals were located and from examination of signs, especially pug marks, around the dead animal it could be established if they had been killed by Tiger, Leopard or other predators. During the study, especially towards the end a number of radios stopped transmitting. These animals were then eliminated from the total of radio collared animals available to be killed. The killing and eating method of the Tiger would not cause damage to the transmitters. There were no signs of damage on the collars of any of the dead deer

found during the study.

One possible objection to the use of this method is that because of collars these animals were not representative of the chital population. This objection must be examined in relation to the hunting methods of the Tiger and leopard. Both hunt by stealth; by creeping slowly up on their prey and by attacking at very close range (McDougal 1977). The prey are probably detected initially by sound and scent. Long distance visual detection could not operate very effectively in the dense vegetation. Sight is however undoubtedly used in the final attack. Attacks do not involve long distance pursuit. Therefore given this style of hunting it seems unlikely that the presence of a collar would significantly increase the chitals' chances of being killed. It is possible that the process of capturing the animals initially might have increased their susceptibility to attack for a few days. To allow for this possibility all animals that died within a week of capture were eliminated from the analysis.

During the course of fieldwork a constant look-out was kept for freshly dead animals of all species. Scavenging species such as vultures and jackals quickly disposed of the remains of dead animals so that the frequency of finding them was rather low. However, from June 1978 to September 1981, 151 freshly dead animals were found. All were examined for the possible cause of death. Evidence such as pug marks, bite marks, drag marks and even odour were used. The validity of the use of these could be confirmed by following radio collared Tigers and one collared leopard and examining kills made by them. A bias in the use of this method is that it potentially underestimates kills of fawns and young animals. It would be expected that the predators would consume most if not all of such a small kill, or that

any remains could be quickly carried off by scavengers. Small carcasses would also have been more difficult to detect.

An alternative possible method of obtaining data on the prey eaten by Tiger and Leopard is the identification of hair in faeces. However Sunquist (1981) has examined hairs of barking deer, chital and hog deer and reported that they could not be distinguished even using a scanning electron microscope. This method is thus not workable.

10.3 Results

(1) Mortality of chital

Mortality was estimated from the deaths of the radio collared animals. Table 10.1 shows for each month of the study, the number of radio collared animals available at the start of each month, the number whose radios stopped functioning during the month and the number that died along with cause of death. At the peak of the study there were 25 animals with radio collars. All the "deer-months" were added up. This gave a total of 460 deer months in 32 months of the study period. Thus throughout the study there was on average the equivalent of 14.4 deer available per annum. A total of 8 deer died in the 32 months which indicates on average 3.0 died per annum. Thus, on average, one could expect 3 out of 14.4 to die per annum - a mortality of 20.8 % per annum. This estimate includes all animals over the age of 1-year. Thus the average expectation of further life of chital over the age of 1-year was almost exactly 5 years.

The only apparent cause of death was predation. Three were killed by Tiger, 4 by Leopard and 1 by an unidentified predator. As all the dead animals had been followed regularly before death the history of their behaviour and physical condition was known. The carcasses could

TABLE 10.1: Deaths of radio collared chital

Month	Number of radio collared deer alive at start of month	Number dying during month			Transmitt failures
		Killed by Tiger	Killed by Leopard	Unknown	
Dec. 1978	2				
Jan. 1979	2				
Feb. 1979	3				
March 1979	7				
April 1979	7				
May 1979	10				
June 1979	10	1			
July 1979	9				
Aug. 1979	9				
Sept. 1979	9				
Oct. 1979	15	1			
Nov. 1979	15		1		
Dec. 1979	21				
Jan. 1980	21				
Feb. 1980	21				
March 1980	24				
April 1980	24			1	
May 1980	24				
June 1980	24				
July 1980	24		1		1
Aug. 1980	24				1
Sept. 1980	23				1
Oct. 1980	22		1		3
Nov. 1980	18				2
Dec. 1980	16				1
Jan. 1981	15				1
Feb. 1981	14				
March 1981	14				
April	14		1		
May	13				
June	13				1
July	12	1			

also be examined after death. All of the animals killed by predators were as far as could be ascertained as normal healthy individuals. They did not look in poor physical condition before death and their behaviour did not differ in any discernable way from that of the radio collared animals that were not killed. The carcasses did not give any evidence of poor physical condition or of disease. It is concluded that predation was the primary cause of death. Throughout the study there was no case of an animal collared or otherwise that had clearly died of starvation or disease, or where these could be said to have contributed significantly to death. It is concluded that predation by the two large cats, Tiger and Leopard, was the only significant cause of death of chital aged 1-year and over in the park.

Other causes might have been important in animals younger than this but mortality in that age class could not be examined in this study.

It is interesting that out of a total of 30 radio collared animals used in this study 8 were aged between 1 and 2 years and the rest were older. None of these 8 yearlings died, all the mortality falling on the older animals. This point will be raised again when considering the data from carcasses found in the park (below).

Although the samples sizes are small, all the deaths of radio collared chital occurred between April and November. None were killed from December to March. This might be significant as this was the driest season and after cutting and burning had occurred the vegetation was at its lowest and visibility therefore at its highest. The chital might have been less vulnerable to predation at that time.

(2) The analysis of carcasses

One hundred and fifty one (151) freshly dead ungulates were found in the park during the study. Of these 137 were deer. The other 14

TABLE 10.2: An analysis of the cause of death of all deer carcasses found within the study area during the study. The figures in brackets are the number of males and females expected from the sex ratio obtained from observations, if there was no selection for sex in the kills.

Species of Deer	Killed by Tiger			Killed by Leopard			Other
	Total	Male	Female	Total	Male	Female	Total
Chital	54	23 (24.3)	31 (29.7)	7	2 (3.1)	5 (3.9)	1
Hog deer	23	9 (8)	14 (15)	1	1		1
Sambar	45	21 (14.6)	24 (30.4)	0			0
Barking deer	1			4	1 (2.1)	3 (1.9)	0

14 were 11 wild boar, 2 Rhinoceros and 1 Gaur. Of the deer found 123 were killed by Tiger and 12 by Leopard. One hog deer was killed by a python (*Python molurus*) which itself died in its efforts to swallow its kill (see plate p.44). One dead very small fawn chital was found with an Eagle Owl (*Bubo nipalensis*) sitting nearby and the signs suggested that the owl had recently killed the fawn. No deer were found that had died of causes other than predation. None were found that had died of starvation or disease.

Out of the 123 deer killed by Tiger, 54 were chital, 23 hog deer, 45 sambar and only 1 barking deer. It is possible, because of their small size, that barking deer were underestimated. The deer killed by Leopard were very different in their proportions. Out of the total of 12 kills, 7 were chital, 1 hog deer and 4 barking deer. No sambar were killed by Leopard.

The sex of all dead deer was recorded. The sex ratio of the dead animals could then be compared with the sex ratio estimates from direct observations of live animals. In no case did the sex ratio of the dead animals differ significantly from that of the live animals.

(3) Antipredator behaviour

The density of the vegetation and the crepuscular feeding behaviour of the Tiger and Leopard made it impossible to describe the reactions of the deer to the approach and attacks of predators. In the absence of these observations information was collected on the behavioural responses of the deer to the approach of a human being. Humans have long been predators of deer in Nepal and it is likely that their response to humans was similar, if not identical, to their response upon detecting possible danger from other sources.

TABLE 10.3:

BEHAVIOUR PATTERNS TO POTENTIAL DANGER.

ROYAL CHITWAN NATIONAL PARK

Reaction	Reaction to Observer							
	Chital		Hog Deer		Sambar		Barking Deer	
	N	%	N	%	N	%	N	%
Walk away with neck and ears erect	310	23.6	53	10.2	73	18.6	68	30.2
Stand alert and stare	236	18.0	36	6.9	157*	40.1	13	5.8
Walk away slightly crouched	168	12.8	149	28.6	100	25.5	19	8.4
Flee at sight	204	15.6	196	37.6	19	4.8	98	43.6
Be alert, stare walk and flee at the end	394	30.0	87	16.7	43	11.0	27	12.0
TOTAL	1312	100	521	100	392	100	225	100

* The Sambar stands motionless and virtually freezes while other cervids move their head and ears at times.

(i) The Chital The response of most chital was to become alert, stare at the observer and either sneak away quietly or flee hurriedly (30 % of 1312 observations - see Table 10.3). Often they walked away into cover in an alert posture without pausing to stare at the source of danger (23.6 %). 15.6 % of the animals fled hurriedly and 12.8 % walked away in a slightly crouched posture, immediately on sighting the observer. 18 % stood alert and looked at the observer without fleeing.

(ii) The Hog Deer The reaction of most hog deer was to run off into cover (37.6 %) or walk away quickly into cover in a slightly crouched pig-like posture (28.6 %) immediately on sighting the observer. Only 6.9 % stood alert and stared at the observer and only 10.2 % walked away slowly (Table 10.3).

(iii) The Sambar The most frequent reaction (40.1 %) on sighting the observer was to freeze completely. Although most other deer will sometimes stop and stare at the observer they nearly always move and twitch their ears, head and tail in an agitated manner. In the Sambar it is a total freeze: nothing moves. For this reason most hunters in Nepal refer to it as a "Latto" animal, meaning a dumb or stupid animal. Another common reaction of sambar was to sneak away quietly in a crouched posture (25.5 %). Sambar rarely fled (4.8 %) in a hurried conspicuous manner (Table 10.3).

(iv) The Barking Deer Barking deer rarely stood or paused to stare at the observer (5.8 %). Most often they fled hurriedly (43.6 %) or walked quickly (30.2 %) into cover immediately on sighting the observer. They rarely (5.8 %) walked away in a crouched posture (Table 10.3).

10.4 Discussion

Predation, by Tiger and Leopard, was the only known cause of death of chital in Chitwan. Evidence from two sources - the deaths of known radio collared chital and the examination of predated carcasses - showed that the animals that were killed were healthy. They were not suffering from malnutrition or disease. Also there was no bias in favour of one sex or the other. Evidence from carcasses suggested that the same patterns were found in Sambar and Hog deer. Too few Barking deer were found for any conclusions. Both Tiger and Leopard hunt by stealth in thick cover. They do not have to outrun or tire their prey. It is perhaps not surprising then that they do not show a selection for weaker animals, either injured, poorly nourished or the smaller females. This contrasts strongly with the carnivores that hunt by pursuit and rely on tiring their prey. Wild Dogs (*Lycaon pictus*) in the Serengeti kill mainly adult female Zebras (*Equus burchelli*) that tire more easily than males. Hyenas (*Crocuta crocuta*) take many old, sick or injured animals (Kruuk 1972; Estes and Goddard 1967; Malcolm and Lawick 1975). Lions (*Panthera leo*) that ambush their prey take a more random selection of the population (Schaller 1972).

There was no evidence that any deer died directly of starvation, malnutrition or disease. This was probably because the environment was not extreme at any time of year and food supplies were available throughout. Although there was a dry season, young growth of vegetation was available because of grass cutting and burning. There was no season of severe cold as in temperate and sub-arctic areas. This absence of noticeable nutritional stress contrasts vividly with African savanna ecosystems where there is a severe dry season during which many ungulates die of starvation (Sinclair and Norton-Griffiths

1979). It also contrasts with the upland ecosystems in temperate countries such as Scotland where species such as Red Deer can suffer severe mortality from starvation after a long severe winter.

The annual mortality estimated for chital over the age of 1-year was 20.8 %. There are relatively few estimates of mortality for similar sized ungulates in natural environments but there are estimates of 20 percent p.a. for Thompson's Gazelle (*Gazella thomsoni*) and 15 percent p.a. for Grants Gazelle (*Gazella granti*) in East Africa (Sinclair and Norton-Griffiths 1979). Both of these are smaller than the chital. The figure given by the same authors for the Topi (*Damaliscus korrigum*) which is slightly larger than the chital is 10 percent p.a. Thus the chital appears to have a slightly higher annual mortality than these species.

Attempts were made to estimate the importance of each species of deer in the diet of the Tiger and Leopards. Sunquist (1981) examined 55 Tiger faeces from Chitwan and found that most samples, as expected, contained only one prey species, probably representing one kill. Deer hair was identified in 45 of the 55 samples. Deer then are clearly the main prey of the Tiger. The results of this study show that in order of importance the four species can be ranked Chital, Sambar, Hog deer and Barking deer. However, the first three species are all important. The Sambar was shown to be mainly a Riverine forest species and the Hog deer a grassland species. Chital occurred mostly in Riverine forest but were also found in grassland. This demonstrates that the Tiger must hunt both in Riverine forest and grassland but it stresses the overwhelming importance of the Riverine forest habitat.

The deer killed by Leopard can be ranked Chital, Barking deer and Hog deer. No Sambar kills were found in this study but Siedensticker (1976b) and Sunquist (1981) have recorded a few Sambar killed by

Leopard. Clearly though the Leopard prefers the smaller species reflecting the smaller size of the Leopard.

The antipredator behaviour of the four species is interesting. Undoubtedly the antipredator strategy of each involves aspects of social behaviour described in an earlier chapter as well as the behaviour described here. The barking deer is a small mainly solitary forest species and relies on sneaking off furtively on detecting potential danger. This strategy could function well; because of the animal's small size it could move off quietly and inconspicuously. This resembles very closely the strategy found in African duikers (Jarman 1974). The Sambar is also a mainly solitary forest species. However it has adopted a rather different strategy. Instead of trying to sneak off most often it freezes completely not even moving ears or tail. Probably the animal's large size would make it difficult for it to move off without being seen or heard. The hog deer, again mainly solitary, relies on moving off stealthily into thick cover. In contrast to these species the chital adopted a more leisurely approach. Most often they would either walk away slowly on the alert or stand, closely scrutinising the source of suspected danger. This strategy might have evolved from the grouping behaviour of the species. Being mostly in herds it is probable that danger is detected sooner enabling them to assess it more precisely and giving time for an organised escape. Also they may be relatively protected in the group by possibly being able to confuse an attacking predator.

CHAPTER 11

The main points of biology have been discussed in the relevant chapters throughout this book. In this final discussion I want to consider three important points.

1. Priorities for future biological research in Chitwan
2. The management of Chitwan in relation to the biological information already available
3. An appraisal of the future of the park.

11.1 Some Priorities for further biological research

It has become clear that a top priority must be to learn as much as possible about the feeding behaviour of all four species of deer. Although some information is available for Chitwan and elsewhere this is superficial. There is a need for highly detailed studies. Only in this way will we ever be able to understand fully the significance of many of the findings of this and other studies. One can think particularly of the problem of breeding seasons and why all four species differ. Also how it is that the largest species, the Sambar, manages to live in the Riverine forest, the habitat that seems to have very little food at low levels ? What do Sambar eat ? One can also think of the association with arboreal primates. How important are they in providing food for the deer - do the chital even rely on the primates in the Riverine forest ? Is the low density of deer in the Sal forest a result of shortage of suitable food ?

Although this study provided some information on all four species of deer it concentrated on the chital. There is an urgent need for much more detailed studies of the other species especially Sambar and Hog deer. Sambar were shown to be as important, if not more so,

as prey for the Tiger as chital.

At present almost nothing in detail is known about the social system and population density of the sambar. What size are their home ranges ? Are individuals restricted to separate patches of Riverine forest ? Do home ranges overlap ? Are adult males territorial ? These and many other questions need to be answered.

The hog deer needs to be studied because it is probably more endangered than any of the others. It relies on extensive areas of tall grassland usually in the flood areas of the rivers. This is exactly the kind of area that is most in demand for agriculture. Again we know little about its social structure and density. It is essential to know these so that we can assess the adequacy of sizes of existing suitable habitat. We will eventually need to answer the question "What is the minimum size of area needed to support a viable population ?".

In this study I tried to provide as much information as possible on the importance of the different species of deer as food for Tiger and Leopard. Sunquist (1981) also has provided some data for Tiger. However this existing information undoubtedly has biases. Therefore more research is needed especially for Leopard to find out how much they rely on deer and other species and how much they rely on domestic animals caught close to or outside the park boundaries.

11.2 Management and Conservation

In an area like the Royal Chitwan National Park, conservation and management of deer cannot be taken in isolation. It has to be considered in relation to habitat conservation for other species and the productive utilisation of the park. However, scientific information is not available through the lack of adequate research on many

aspects of the ecology of the flora and fauna of the national park. Thus, the task of writing management proposals becomes difficult and can only be based on limited information. Thus, given the limited information available, I have provided some options as a part of management practice. These must be considered as initial preliminary proposals

Before any management recommendations can be made one has to examine the purpose and objectives of the national park (Myers 1972). In addition, the future of the national park and how its objectives can be reconciled with the encroaching human pressures has to be thoroughly reviewed.

The Royal Chitwan National Park Regulations (2030) have specified the general objectives of the setting up of a national park in Chitwan. One of the main objectives is to conserve the wild flora and fauna particularly the endangered species for the benefit and enjoyment of future generations. The other aim is to earn revenue by the introduction of wilderness orientated tourism without its adverse effects. I will appraise the future of the national park in the next section (3) and the question of economical returns from tourism has been briefly appraised elsewhere (Mishra 1982). Here I shall discuss management needs with particular reference to the conservation of the deer and the tiger.

The tiger is the largest of all the carnivores in the park and thus is at the top of the food chain. It is linked to the deer for its survival. The present population of Tigers in Chitwan has been estimated at between 50 and 60 (Smith and Mishra 1981). Most are concentrated in the Riverine forest and grassland habitats (Sunkist 1981). It has been shown in this study that these are the habitats that contain the greatest diversity and concentration of deer. Large

areas of pure Sal forest or grassland contain much lower densities of prey.

The shape of the national park is elongate and the riverine forest/grassland habitat occurs mostly along the northern edges, separated only by the rivers from adjacent farmland. The rivers do not form an effective barrier to the movements of either deer or Tiger. Along the edges, it is not only wild ungulates but also domestic cattle that are preyed upon by the Tiger (Tamang 1979). This brings park management into direct conflict with the local population. It is also along the edges of the park that humans have been killed by Tigers (Mishra 1981 and 1982). Though these incidents are rare, loss of livestock and life causes an increase of antagonistic attitudes against the Tiger. Tigers have also been poisoned in forest and grassland in close proximity to villages.

Besides prey, water is also an important component of the Tigers habitat requirements (Schaller 1967; Singh 1973; Sankhala 1977; Sinha 1979). Seasonal changes in habitat structure have been known to influence the hunting strategies of the Tiger and this may be because of changes in availability and distribution of prey and water within the tiger's range (Mcdougal 1977; Sunquist 1981).

The home range of tigers varies extensively especially between males and females. In Chitwan, large males range varied from 60 - 100 sq. km. and of females varied from 14 - 40 sq. km. (Mcdougal 1977; Sunquist 1981). Sunquist (1981) estimated that the range of a male overlaps with home ranges of 3 - 6 females. Studies of tigers in Chitwan indicate that the availability and distribution of prey is an important factor that regulate movement patterns of tigers. A similar situation was observed in Leopards in Sri-Lanka where the Leopards

concentrated around large scattered "villus" (lakes) around which prey density were concentrated (Eisenberg and Lockhart 1972; Muckenhirn and Eisenberg 1973). The movement patterns of other species of wild cats have also been related to the distribution of prey (Bailey 1974; Berrie 1973). The distribution and density of food is known to be important factor that influences density and movement pattern of many species of mammals (Clutton-Brock and Harvey 1978; Harestad and Bunnell 1979).

It is not known if a population of 50 - 60 Tigers will have long-term viability. However it seems desirable to increase the population of Tiger if possible and to alleviate the conflicts along the park boundary. One possible way of achieving both these objectives would be increase the density of prey especially in areas away from the park boundary that at present have low prey populations. Such a change in density and distribution could possibly be achieved on a limited scale by habitat manipulation. Most of the interior of the park is Sal forest and is therefore the poorest habitat for deer and Tiger. Much of this is on steep-sided valleys where attempts to alter the habitat could prove disastrous. The lower lying flatter ground below the hills on the northern side offers more potential for habitat manipulation. It would not be possible with present knowledge to change any of this into riverine forest. However, it seems a workable possibility to convert patches of it into grassland.

Tiger research in Chitwan has revealed that the stretch of Sal forest between Jarnali and Sukhibar is little used by Tigers (Mcdougal 1977; Sunquist 1981). Permanent sources of water are available in this area. This tract of Sal forest would seem to be suitable for experiments with habitat manipulation. It is suggested that patches of Sal forest be opened up and attempts be made to intersperse a number

of patches of grassland that are maintained regularly by grass cutting and burning. These patches should be close to the many permanent sources of water already in existence. According to the information presented in this thesis one would expect chital to be the main species to benefit from this treatment. Hog deer have been shown to be specialist grassland species and they might also increase in number. However for this to occur very precise management is probably required. The greatest increase in chital would occur if the grassland was kept permanently short and the palatability of the vegetation therefore kept high. Hog deer would, however, require at least some grass kept permanently high and dense for cover. There is no reason why a balance in these could not be struck. The rhinoceros (*Rhinoceros unicornis*) can also be expected to increase with the increase of grassland habitat.

The opening up of Sal forest will also create "edge effect" (Leopold 1933) and the density of many deer is known to have increased when pure stands of woodland is broken up and interdispersed with forest openings (Westel 1954; Taylor 1956; McCaffery and Creed 1969). Tourism may also benefit and be less destructive if people can view wildlife from restricted sites.

Both fire and grass cutting are and will remain an important part of the park management. Little is known of the long-term effect of these practices. Fire probably has been part of the ecosystem for thousands of years but such intensive grass cutting is relatively new. Thus it is recommended that a programme to monitor vegetation in general and the grassland in specific be implemented as a day to day programme of park management. Sykes and Horrill (1977) have suggested plans for vegetation monitoring in India's tiger reserve. This can only happen if research and management go hand in hand and not independent of each

other as is often the case in most national parks and reserves in the developing world.

A proposal to extend the national park boundary further east to provide adequate habitat to accommodate dispersing tigers has been submitted to His Majesty's Government (Mishra and Smith 1981). The Nepalese Government is implementing a proposal to resettle over 10,000 people from the Jaimangla-Bhimpur salient that lies on the northern-bank of the Rapti river. Such programmes will make Chitwan one of the largest "Tiger Reserves" in Asia.

11.3 An appraisal of the future of the Park

In Europe and America the human impact on deer habitat has diminished as their present habitat is often unsuitable or uneconomical for agriculture. This is not the case for many areas in Asia where there are bigger conflicts with the growing needs for agriculture. Land use planners often suggest that national parks and reserves should only be established in "marginal land" where they will be secure from human pressures. Adherence to this idea will wipe out most of the existing national parks and reserves in southern Asia. Most of the present parks and reserves also appear to be good for agriculture or other human use and are also the only areas where many of the endangered species have a chance for survival. As it is, most of the parks and reserves are "islands" in a sea of growing human population.

Biologists have often elaborated on the relationship between shape, size and other parameters of reserves to maximize species diversities (e.g. Diamond and May 1981). But the hard fact in reality is that parks and reserves have to be established where land is available and those existing at present have only been accomplished by a compromise between political and human interest groups. There is very little

doubt that the survival of large mammals in national parks and reserves will be accomplished only with the involvement, interest and support of the local population who dwell around such areas (Leuthold 1977; Kellert 1979; Mishra 1982).

Milton and Binney (1980) and Mishra (1982) have outlined the areas of conflicts between park management and the needs of the local people in Chitwan. Loss of human life, livestock and crops are the most important immediate problems. The park - people problem has become more complex and severe as the rhinoceros population has increased since park establishment in 1973 (Laurie 1978; Milton and Binney 1980) with an increase in the severity of damage to crops. The concept of a national park in a strict sense of "preservation" induces conflicts of land use with the local people who have had traditional use of areas like Chitwan. The concepts based upon intellectual or aesthetic values have little meaning to the local villagers who have to struggle day to day for existence. When the source of the next meal is a major worry, aesthetic or environmental logic for conservation have little relevance to a majority of people in Southern Asia. The future of any national park can only be assured if the needs of the local people are provided and if conservation measures are approached in a manner that they can understand.

The park-people conflict occurs not only in Chitwan but through most of Asia and it is a conflict of the use of resources. Tourism does not seem to have benefited the local people as very few of them are involved in this trade. The availability of thatch grass appears to be the only benefit the local population receives from the establishment of a national park in their region. The people pressure on park land can be expected to get more severe when population growth cannot cope with resources such as fire wood, building materials,

grazing when land with these resources outside parks and reserves is depleted. When resources become limited the people will one way or another take precedence at the expense of flora or fauna, endangered or otherwise. This historical fact cannot be ignored by any research or management authority.

The rate of human population growth (2.5 to 3 % per annum) indicates that the Royal Chitwan National Park may not be able to sustain such pressures by the early part of the next century, unless alternatives are available to provide the basic needs of the local population. One of the main problems seems to be that the establishment and management of national parks and reserves in most of the developing countries has been progressing in isolation without much appreciation of the human ecology in areas adjacent to national parks and reserves. While there have been many studies of endangered species in many parts of the developing world, little effort has been made to understand the human dimensions of conservation programmes. Thus it is concluded that one of the immediate tasks must be to undertake research to investigate how the park-people conflict can be minimised and how the local people can be involved and derive benefits from the national park. Unless a symbiotic relationship between the needs of conservation and the needs of local people can be developed it is doubtful if any park or reserve will survive well beyond the next few decades. Then, it will not be only the endangered species in any particular park or reserve that will be extinct but the whole ecosystem.

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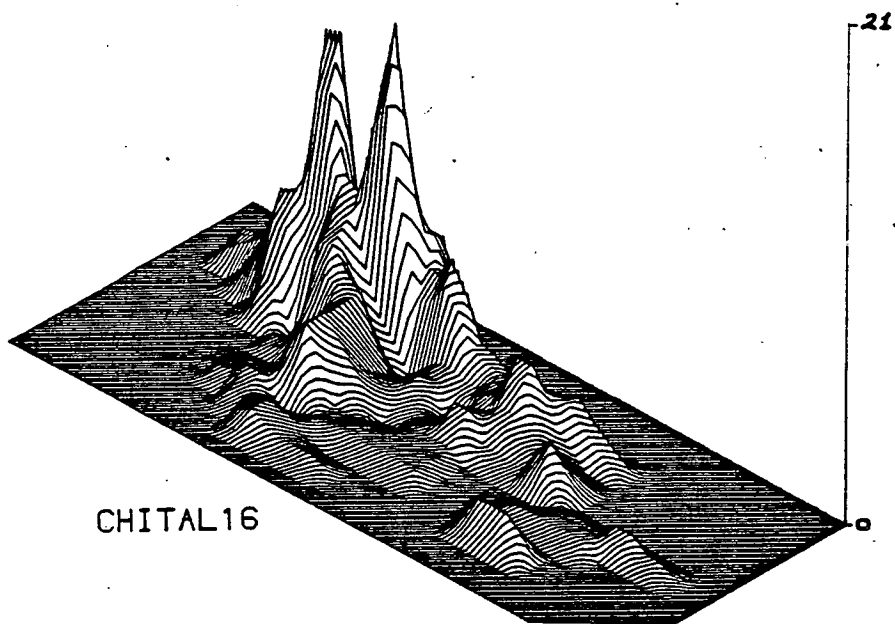
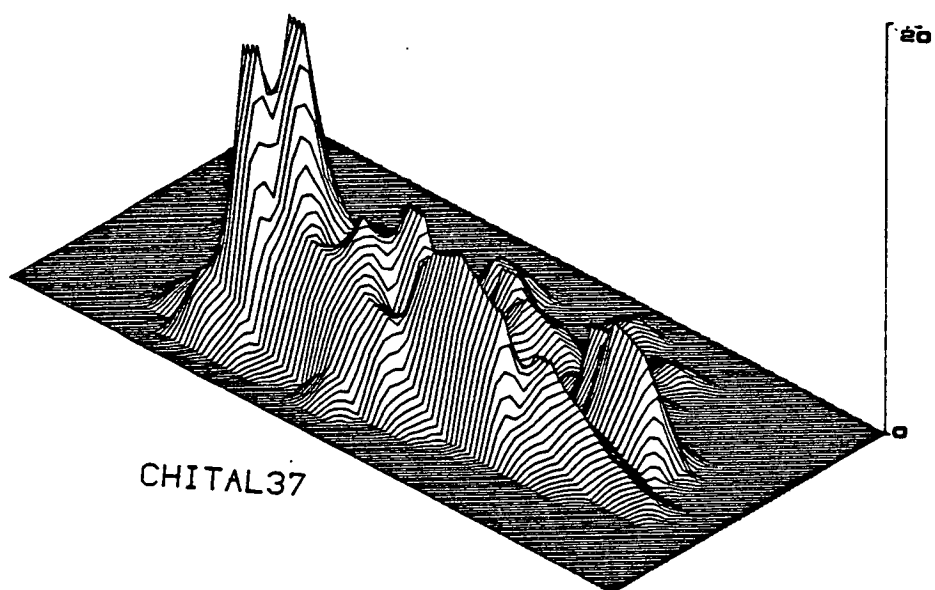
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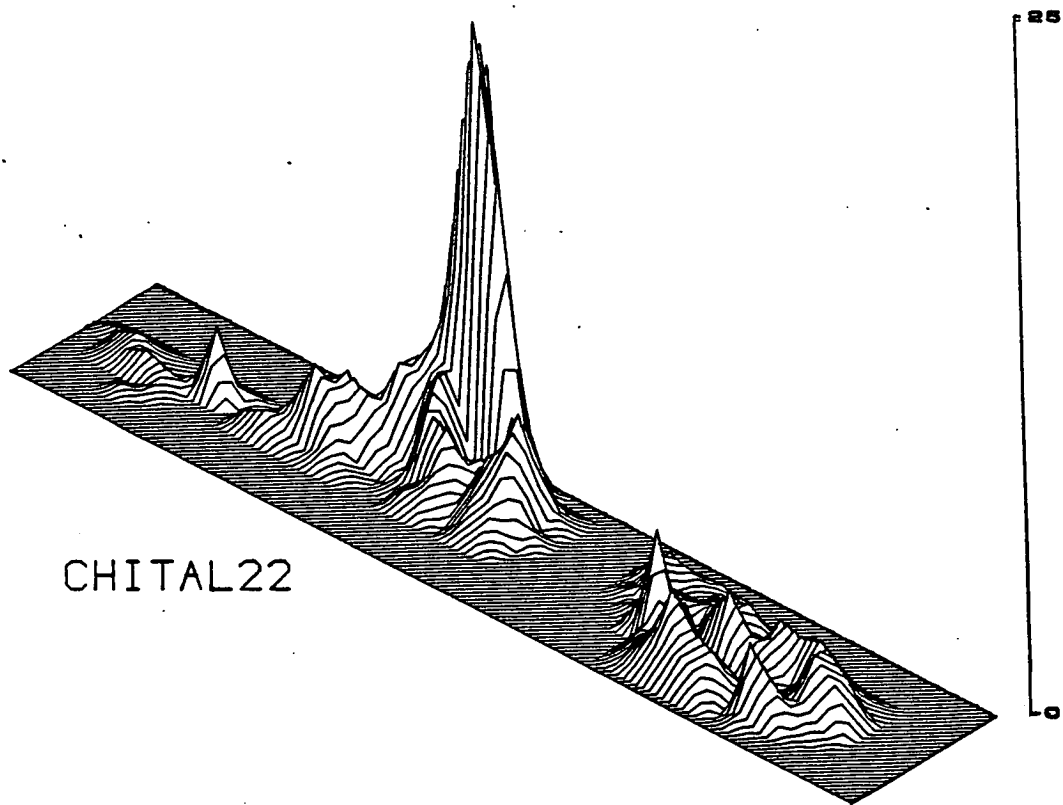
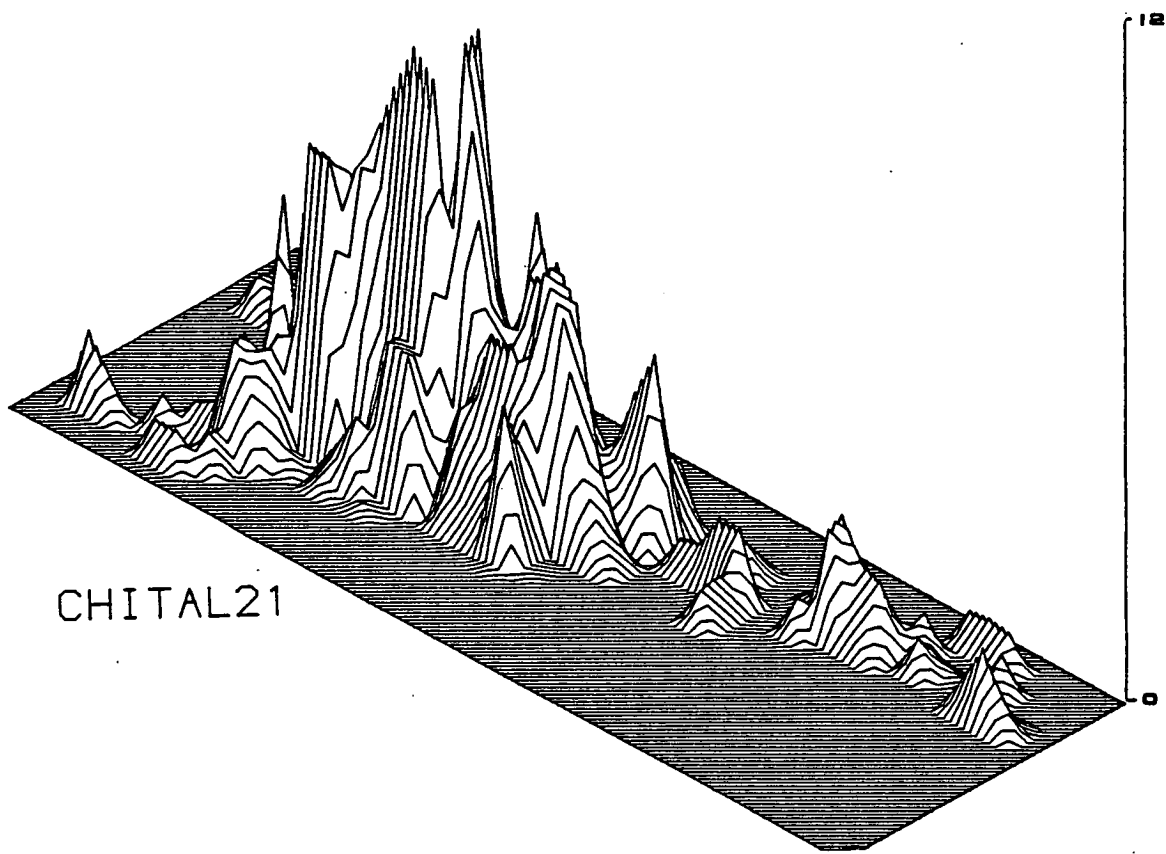
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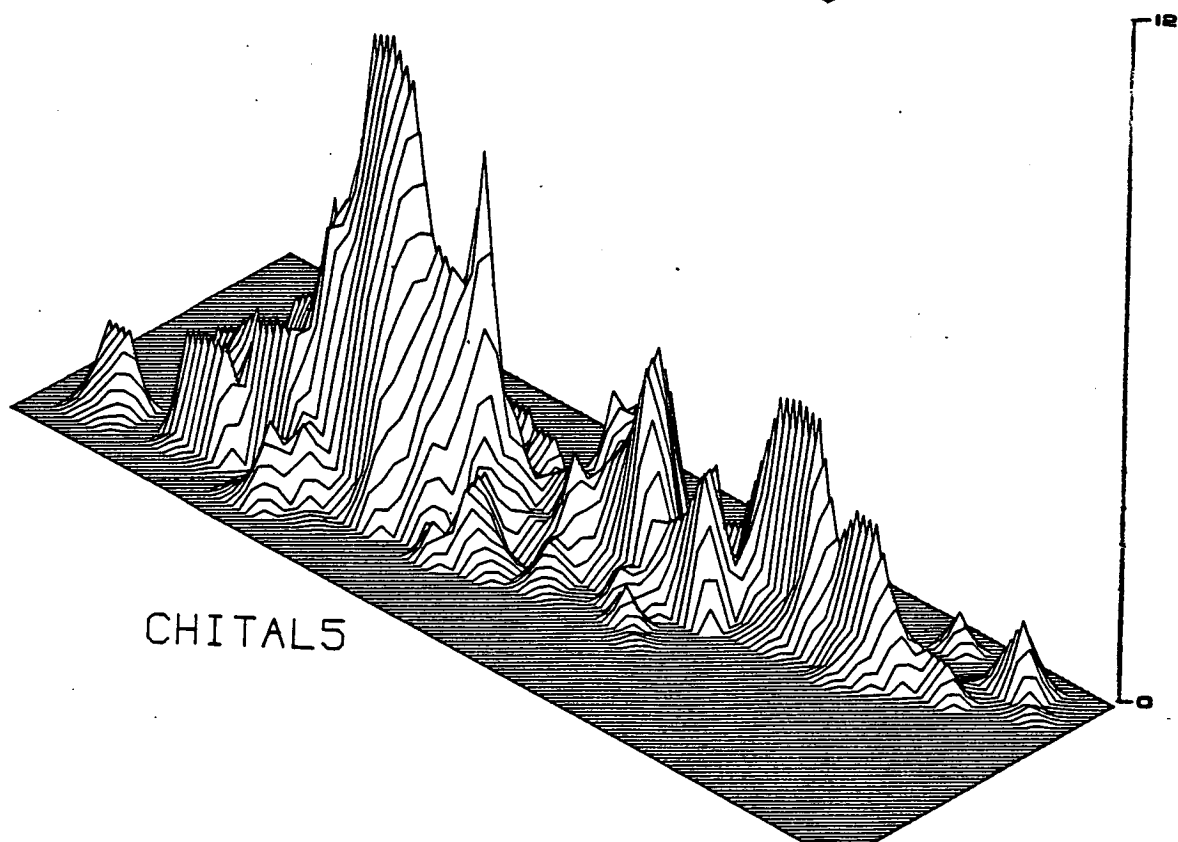
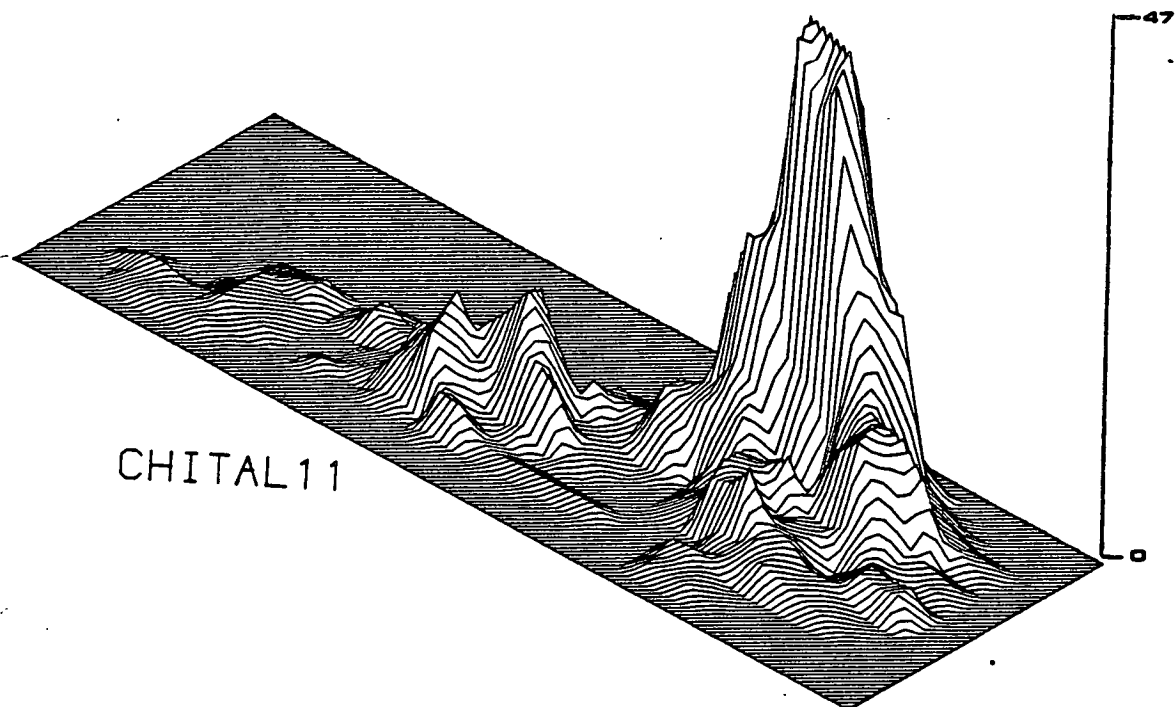
APPENDIX



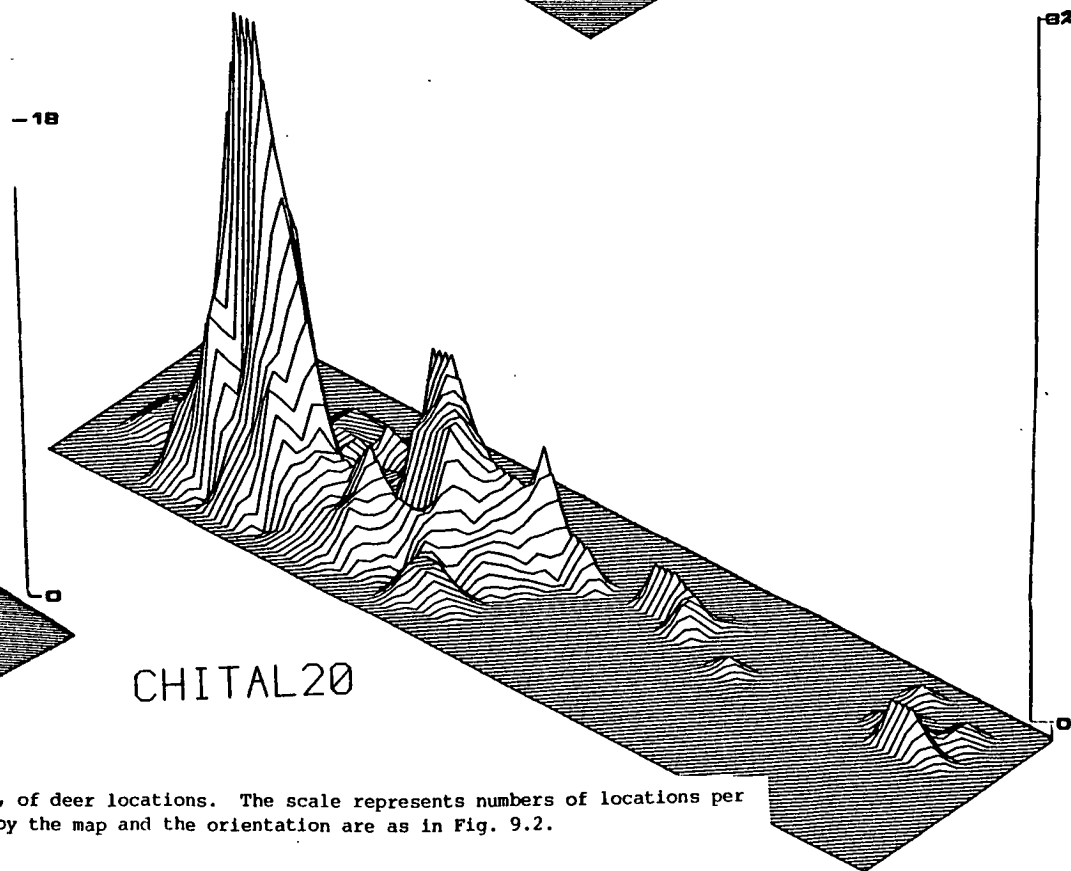
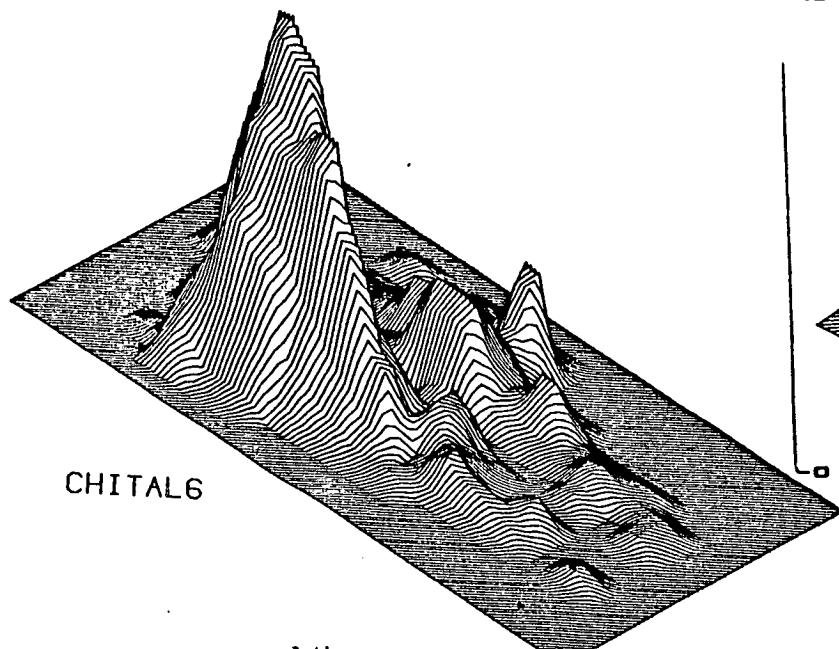
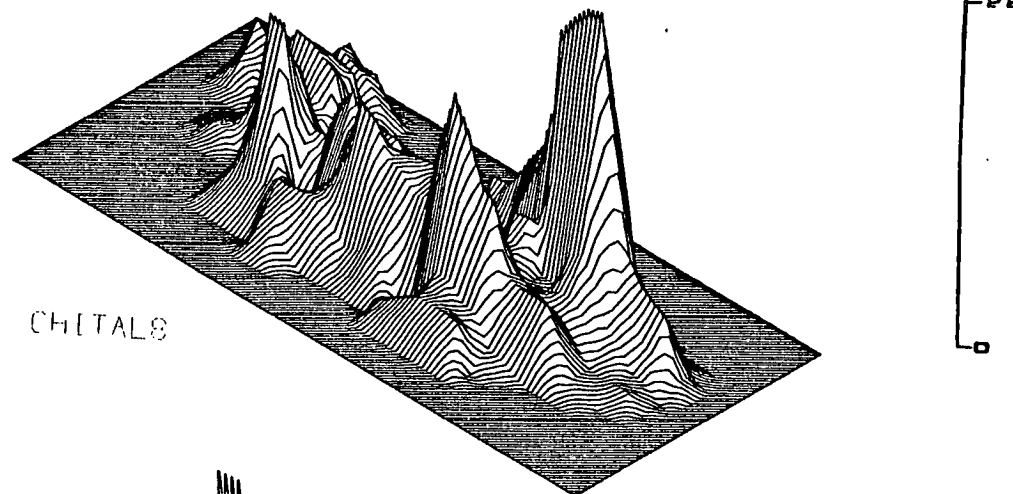
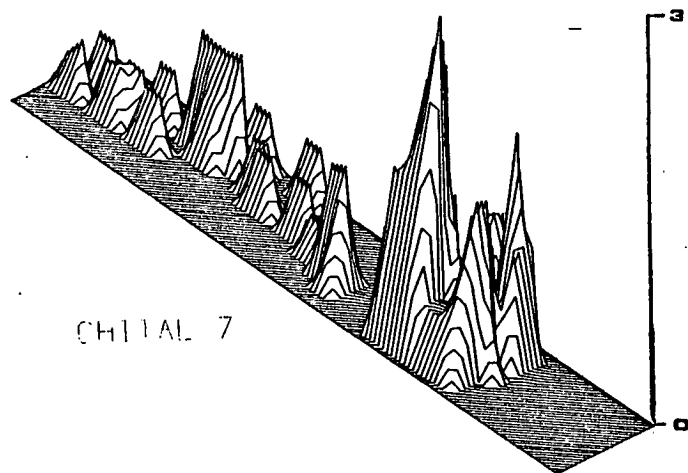
A three-dimensional map generated by SYMVU, of deer locations. The scale represents numbers of locations per quadrats of size 2ha. The area covered by the map and the orientation are as in Fig. 9.2.



A three-dimensional map generated by SYMVU, of deer locations. The scale represents number of locations per quadrats of size 2ha. The area covered by the map and the orientation are as in Fig. 9.4



A three-dimensional map generated by SYMVU, of deer locations. The scale represents number of locations per quadrats of size 2ha. The area covered by the map and the orientation are as in Fig. 9.4



A three-dimensional map generated by SYMVU, of deer locations. The scale represents numbers of locations per quadrats of size 2ha. The area covered by the map and the orientation are as in Fig. 9.2.

SUMMARY

1. From 1978 to 1981 a study was carried out on the ecology and behaviour of the chital with comparative studies of the 3 sympatric species of deer namely, the hog deer, sambar and the barking deer, in the Royal Chitwan National Park, Nepal.

2. Chitwan is Nepal's first national park and formerly used to be a famous Shikar (Hunting) reserve. It is situated in southern Nepal in the sub-tropical region of the inner Terai. The habitat within the park is a complex mosaic of sal forest, riverine forest, grasslands and savannah.

3. Field techniques consisted mainly of systematic direct observations by traversing along set transects on trained domestic elephants, and of detailed monitoring of individually known radio-collared animals. Details are given of methods of capture of deer and the use of immobilising drugs.

4. The chital was a species of the riverine forest/grassland edge with prominent seasonal variations in choice of habitat in relation to plant growth, grass cutting and seasonal burning. In contrast the hog deer was mainly a species of the grassland and sambar and barking deer were mainly restricted to forest habitats.

5. Some breeding went throughout the year but each species had a peak breeding season. The peak breeding season was different for each species, although barking deer seemed to produce fawns throughout the

year. The chital came into rut during the dry pre-monsoon season (February - May) and produced most young during the cool months of December/January. In contrast the sambar had an opposite cycle and the hog deer fitted between these extremes.

6. Chital lived mostly in small herds the size of which varied according to season and habitat. Group composition was highly variable and dependent on season. Most noticeably there was a distinct sexual segregation which reached a peak in December/January. Sambar and barking deer were mainly solitary. Hog deer were mainly solitary or in very small groups but formed large groups in patches of grassland that had been cut and burned.

7. The mean yearly home range size of adult male chital was significantly larger than the range of adult females. In the course of the average days foraging adult chital covered only about 9 - 12 percent of their total home range. The total home range was used in a period of about 12 to 15 days. Home range size was larger during the pre-monsoon season (February - May) than at other times of the year. There were no significant seasonal movements of the deer.

8. Average annual mortality of adult chital was estimated to be 20.8 %. The only discernable cause of death was predation by Tiger and Leopard. No evidence of malnutrition was found. The anti-predator behaviour of each species of deer was described.

9. Suggestions are made for future biological research on deer in Chitwan and also for the management of the park in the light of existing scientific knowledge.