POPULATION SIZE AND STRUCTURE AND HABITAT RELATIONS OF THE BARASINGHA (*CERVUS D. DUVAUCELI*) IN SUKLA PHANTA WILDLIFE RESERVE, NEPAL

By

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Fisheries and Wildlife

1978

ABSTRACT

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Population organization and habitat relations of the barasingha (*Cervus d. duvauceli*) were studied between April 1974 and May 1976 in Sukla Phanta Wildlife Reserve, Nepal.

Total population counts in March when barasingha were most concentrated on southern grasslands in the reserve yielded 805 animals in 1975 and 908 in 1976. Aerial surveys confirmed barasingha distribution, and showed that they frequented Indian territory bordering the reserve before human settlement began there in 1975. Fecal-pellet counts in March 1976 gave estimates of 1,295 barasingha, 273 hog deer (*Axis porcinus*) and 341 chital (*Axis axis*). For barasingha, this was an estimate of maximum population size because they were concentrated on the grasslands. Hog deer and chital numbers represented only the grassland populations, since both species were more widespread in March.

The population comprised 16.4-32.7% stags, 35.2-48.6% hinds, 7.1-16.1% yearlings and 9.20-7.7% fawns. An apparent 12.8% increase in minimum population occurred in 1975-76. The large proportion of

hinds indicated that potential population increase was greater than observed. Comparison with Kanha National Park barasingha data suggested that mortality and not poor breeding success caused the low increase. The population before 1968 and 1972, when flash floods drowned many animals reportedly was larger than that observed in 1975-76. Habitat thus may be available to support more barasingha before carrying capacity is reached, and further population increases can be expected.

Habitat surveys during the year indicated that barasingha remained mostly on dry grasslands while forests and savannas were avoided or used to an intermediate degree. Hog deer showed greater preference for seasonally-wet grassland, while chital mostly frequented forests and savannas. Fecal-pellet distributions indicated that lowland grasslands and savannas were frequented similarly by the three deer during the premonsoon season, when environmental conditions and young forage grasses caused habitat preferences to be less defined.

The grasses Imperata cylindrica, Narenga porphyrocoma, Phragmites karka, Saccharum bengalense and Saccharum spontaneum were eaten by barasingha. The relative abundance of these species on the southern grasslands, and availability of water there during the dry season, influenced habitat selection.

"Increaser" plant species found on village grazing grounds were absent on southern reserve grasslands, despite local heavy grazing by livestock. A high water table promoted grass growth,

helping to maintain carrying capacity even during the dry season, while flooding, water-logged soils and fire maintained grassland habitats.

Barasingha avoided livestock on southeastern reserve grasslands during the premonsoon season. As livestock grazing declined there annually, drinking water and fresh grass attracted barasingha to the areas vacated. Elimination of livestock from these grasslands will free additional habitat for deer.

Aside from the annual congregation of the largest herds in March, barasingha in Sukla Phanta moved little in response to seasonal change. Some 32 km^2 of lowland grassland, savanna and marsh supported the population year-round. Future increases in barasingha numbers in less-preferred habitats could indicate disturbance on the southern grasslands, or that carrying capacity there had been exceeded.

Recommendations for barasingha conservation include continued annual population counts and investigation of additional specified research questions. Disturbance in the form of grass-cutting and gathering in the reserve should be eliminated. Re-establishment or introduction of barasingha into other reserves should be considered. An international reserve to include Sukla Phanta and 10 km^2 of adjacent Indian territory is proposed.

ACKNOWLEDGMENTS

Many persons helped to plan and execute this study, and their names and contributions are too numerous to list all of them here, though I am grateful to each one. I would like to express my gratitude especially to the following individuals: the members of my Guidance Committee, Drs. George A. Petrides (Chairman), Leslie W. Gysel, Rollin H. Baker, and Victor J. Rudolph; to Mr. and Mrs. Kirti M. Tamang, Col. (ret.) and Mrs. Hikmat B. Bisht and their family, Mr. Arjan Singh, Mr. and Mrs. Balram Singh, Dr. Robert Fleming, Sr., Dr. and Mrs. Robert Fleming, Jr., Mr. Clifford Rice, Mr. Will Weber, Dr. Irving Wyeth, Dr. Collin W. Holloway, Dr. Charles E. Cress, Dr. Stanley Zarnoch, Dr. Gary A. Dawson, Mr. John Blower, Mr. and Mrs. Frank Poppleton, and Maj. (ret.) B. Chhetri. I also thank the numerous officers and staff of the Office of National Parks and Wildlife Conservation, and of the Forest Ministry, His Majesty's Government of Nepal, for obtaining permission for me to do the study, and for their subsequent cooperation and assistance. I am grateful, too, for the use of a United Nations aircraft and the services of pilot G. Fuerer in making aerial deer counts. For generous financial support of the study, I am grateful to the World Wildlife Fund (U. S. and International Appeals), the New York Zoological Society, the Zoological Society of San Diego, the

San Francisco Zoological Society, and the Fauna Preservation Society. Special thanks go to my mother, Mrs. M. Schaaf, who provided extra personal financial aid when it was most needed, and to my mother-in-law, Mrs. J. Le Blanc, who gave us a home in which to live and work once the field study was completed. Perhaps most important of all, I owe a debt of gratitude to my wife Cherie, who assisted me ably in the field and afterwards, and whose unfailing patience and encouragement were always a source of inspiration.

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INTRODUCTION

Extant Wild Barasingha Populations

The barasingha or swamp deer (Cervus duvauceli) is one of the world's endangered large mammals (IUCN Secretariat, 1976). Native to the northern and central portions of the Indian subcontinent, the species has declined drastically in recent decades due to the loss of habitat and other pressures exerted by an ever-increasing human population (Schaller, 1967; Schaller and Simon, 1970; Holloway, 1973; Singh, 1973; Schaaf and Singh, 1977).

The largest populations still extant in the wild are in three reserved areas in India and one in Nepal. In sequence according to declining estimated sizes of barasingha populations, these are Dudhwa National Park in Uttar Pradesh, Sukla Phanta Wildlife Reserve in southwestern Nepal, Kaziranga National Park in Assam, and Kanha National Park in Madhya Pradesh. The estimated minimum population of Dudhwa is 1,200 animals (Holloway, 1973; Schaaf and Singh, 1977), while that of Sukla Phanta is approximately 1,000 (present study). Lahan and Sonowal (1973) reported 520 head in Kaziranga, and it is thought that the population there has since increased (K. Patar, personal communication). Panwar (in press) reported an estimated minimum population of 283 animals in Kanha, where restorative measures have resulted in an increase from the lowest population size of 55 animals counted by Schaller in 1965.

The Northern and Southern Subspecies of Barasingha

Barasingha are divided into two subspecies (Ellerman and Morrison-Scott, 1951), Cervus d. duvauceli Cuvier 1823 and Cervus d. branderi Pocock 1943. The latter occurs in east central India north of the Godavari River, and today is confined for all practical purposes to the Kanha National Park. The northern subspecies is represented by larger populations and occurs mainly in the other reserves, while a few remnant populations of uncertain status survive outside the reserved areas. The former range of this subspecies includes the alluvial plains of the great river systems of north India, the Indus, Ganges and Brahmaputra.

The naturalist Dunbar-Brander (1927) first drew attention to the possibility of there being two subspecies. Pocock (1943) distinguished between them on the basis of museum specimens he examined and Dunbar-Brander's descriptions of animals observed in north and central India. It was noted that the northern deer are more nearly true swamp dwellers since they inhabit alluvial plains which are at least seasonally wet, while the southern animals live in the central Indian highlands on dry ground, though in the vicinity of water. Dunbar-Brander reported that the hooves of the latter population are ". . . hard and well knit, (like those) of (animals) accustomed to gallop on hard ground. . . ." The northern deer are said to have splayed, "spongy" hooves, the better to support them in their wet habitat. The northern deer also were judged to be larger and paler in color than their southern cousins. Measurements of ten

skulls (seven from north India and three from central India) made by Pocock tend to confirm the size difference, yet it is noteworthy that the largest antlers were carried by specimens from central India, the biggest measuring 41 inches (104 cms.) around the outside curve (Dollman and Burlace, 1922).

General descriptions of the barasingha have been given by Schaller (1967) and Prater (1971). A large stag may weigh 170-180 kgs. and stand 135 cms. at the shoulder (Prater, 1971). Published weights of hinds (Crandall, 1964) include those of two captive animals which weighed 305 and 320 lbs. (138 and 145 kgs.). Perhaps the heaviest specimens on record were two stags of 563 and 588 lbs. (256 and 267 kgs.) reported by the Maharaja of Cooch Behar (1908).

During the warm months (April-September), barasingha have sleek, reddish coats in which pale spots are sometimes evident. These spots are not composed of white hair, but appear rather like watermarks on stationery, as Dunbar-Brander (1927) noted. During the cool season (October-February) the pelage is greyish-brown and shaggy, and longer on the neck. Mature stags are noticeably darker at that time of year than other members of the population.

The term "barasingha" means "12-horned" and refers to the 12-tined antlers typically carried by mature males. However, many stags have a larger or smaller number of tines, the usual range being 10-14. "Barasingha" is also a vernacular name in India for the Kashmir stag (Cervus elaphus hanglu), and this common name thus

may be a source of confusion when one reads the older literature on these different species.

Barasingha in Nepal

Barasingha inhabit the terai, an extension of the north Indian Gangetic Plain, which fringes the southern edge of otherwise-mountainous Nepal. As late as the 1950s, barasingha were still widespread in the districts of Banke, Bardia, Kailali, and Kanchanpur, or approximately the western third of the terai from about 25 kms. east of Nepalganj to the western border with India, just beyond the Mahakali River (K. M. Tamang, personal communication).

In 1957, barasingha were also reported "in large numbers" in the Chitawan Valley of south-central Nepal. They were found in the then-extensive marshy grasslands north of the Rapti River, just outside the area which is now the Chitawan National Park (K. M. Tamang, personal communication). According to Schaller (1967), a few animals survived in that valley as late as 1963. None occurs there today. The grasslands where they formerly lived have been settled and are now under cultivation.

At present three barasingha populations are known to survive in Nepal, each isolated from the others by distance and/or agricultural development. Dinerstein (1976) reported "no more than 20" animals from the 348 km^2 Karnali-Bardia Wildlife Reserve in Bardia District. Some 110 kms. further west a population of unknown size and status exists in the 37 km^2 Dhaka Shikar (Hunting) Reserve in Kanchanpur District. About 4 kms. west of Dhaka, Sukla Phanta

Wildlife Reserve (147 km^2) harbors about 1,000 animals, the largest population in Nepal, and the subject of the present study.

Previous Studies

Schaller (1967) obtained the first systematically collected data on the biology of the barasingha, working with the southern form in 1963-65 in the Kanha National Park. In addition to his observations on ecology and behavior, he summarized much of what had been written by earlier observers, mainly sportsmen-naturalists from the days of the British Raj, about the distribution, habits, and natural history of both subspecies. Schaller's study provided a basis for further research, and drew attention to the precarious status of the southern barasingha and the continuing decline of the northern deer.

In 1969 an IUCN Study Group briefly visited Kanha to assess the proposed construction of a 74-acre protective enclosure in which a small breeding herd of barasingha could be established, free from predation and other disturbance. It was recommended that a qualified biologist oversee the project and further investigate barasingha ecology in the park (Binney et al., 1971).

Martin (1975) succeeded Schaller, studying barasingha ecology in Kanha during 1971-73. He concluded that the principal causes for the decline of this subspecies were loss of habitat and poaching, coupled with the deer's need for seasonal migration to satisfy requirements for food, water, and suitable fawning grounds.

During Schaller's study, barasingha were observed primarily on the Kanha Meadow, where they spent half the year, but from which they dispersed early in the monsoon season until the following winter. Martin concluded that their seasonal range extensions took them outside the park where they conflicted with man. He suggested that disturbance during the October fawning season, rather than disease, as suggested by Schaller, could have caused the low proportion of fawns observed in 1964-65.

An addition of land to the park in 1964 took in much of the northern monsoon-season range of the deer. In 1969 a forest village north of the Kanha Meadow was removed, and livestock grazing was eliminated from nearby clearings. By the early 1970s, the former village site and nearby meadows had become important monsoon-season range and fawning grounds for barasingha (Martin, 1975).

Securing additional habitat was one factor which improved conditions for the deer. In addition, controlled burning of grasses on the Kanha Meadow after the monsoon season increased the forage available during the dry season when chital (Axis axis) (Appendix A) and barasingha congregated there near water. Controlled buring also permitted certain perennial grasses to become re-established, since they were not as heavily grazed as when the entire meadow was burned annually, and ungulates concentrated on the subsequent flush of new growth. The practice of baiting tigers into the area had induced disproportionately high predation on the already-small barasingha herd. This practice was eliminated and tigers began to kill more chital. In response to these measures, the barasingha population

expanded, and continues to grow and occupy new areas in the park at present (Panwar, in press).

Holloway (1973), writing of the northern barasingha in Uttar Pradesh, noted that of 11 localities mentioned by Schaller in 1967 as having known or probable populations, eight could be struck from the list for all practical purposes by 1973. He indicated that an etho-ecological study was an immediate conservation need. This recommendation and subsequent proposals for a world-wide threatened deer conservation program (Cowan and Holloway, 1973, 1974) provided a rationale for the present study, which extended from April 1974 to May 1976 and was the first effort to collect data on the northern subspecies.

Objectives of the Present Study

As originally conceived, the study would have involved the two largest remaining populations, in Sukla Phanta Wildlife Reserve and the nearby Dudhwa National Park. The logistics involved and formal arrangements required to travel repeatedly between Nepal and India made this an impractical plan. The study was limited to the Sukla Phanta Reserve, with only a few comparative observations made in Dudhwa. The principal objectives were (1) to initiate collection of basic ecological data on the northern subspecies, particularly with respect to population size and structure, (2) to use these and environmental data to assess the current status of the deer and factors affecting its welfare, and (3) to make such recommendations

as might be needed to improve conservation of the barasingha through herd and habitat management.

THE STUDY AREA

Location

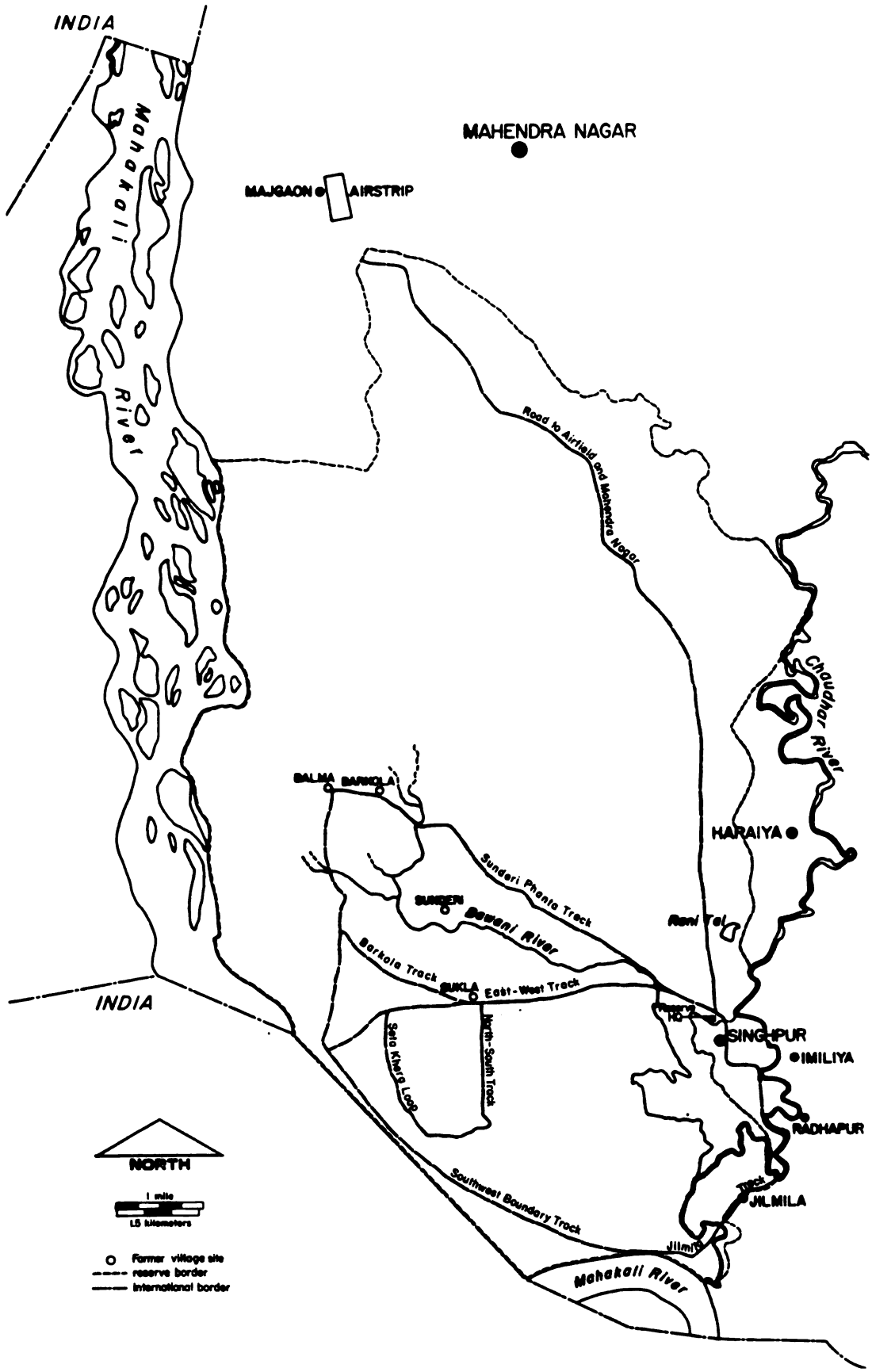
Sukla Phanta Wildlife Reserve is situated between 28°49' and 28°57' north latitude and 80°07' and 80°15' east longitude in the Kanchanpur District of southwest Nepal. For approximately 6 kms., its southern boundary coincides with the international border between Nepal and India. It is bounded on the west and along part of its southern boundary by a large tributary of the Ganges, the Mahakali River, or Sharda River, as it is called in India (Figure 1).

The term "phanta" means a grassy plain, or a grassy opening in the forest. Sukla Phanta is one of the largest grasslands in the area, and gives the reserve its name.

History

The aboriginal Tharus, agriculturalists and livestock herders (Bista, 1967), were until recently almost the sole inhabitants of the remote western terai, including what is now the reserve (local informants). During the relatively dry and cool winter months, the rulers of Nepal sometimes visited Kanchanpur District to hunt (Smythies, 1942), as the forests and grasslands of this region were noted for an abundance of big game.

Figure 1.--Sukla Phanta Wildlife Reserve, Nepal.


INDIA
MAHAKALI River
MAHENDRA NAGAR
MAJGAON
AIRSTRIP
Road to Airfield and Mahendra Nagar
Chaudhar River
BALMA
BARKOLA
HARAIYA
Sunderi Phanta Track
SUNDERI
Bawani River
Rani Tal
Barkola Track
SUKLA
East-West Track
INDIA
Seta Khet Loop
North-South Track
SINGHPUR
IMILIYA
RADHAPUR
JILMILA
Southwest Boundary Track
Jilmila
Mahakali River
NORTH
1 mile
1.5 kilometers
Former village site
reserve border
international border

In 1965-66, by decree of the late King Mahendra, some 131 km^2 surrounding Sukla Phanta became a Royal Shikar (Hunting) Reserve. Fair-weather tracks were cleared to facilitate the hunt and several villages were removed from the new reserve and the people resettled elsewhere (local informants; Singh, 1966). The eroded dikes of rice paddies, old plow furrows, groves of village mango (Mangifera indica) trees and other signs of former habitation still can be found. Cultivation and livestock grazing have influenced the condition of the habitat in and near Sukla Phanta for at least the past half century. Singhpur Village, for example, was founded in 1927 and still exists on the eastern boundary of the reserve (Figure 1).

In 1976 Sukla Phanta became a wildlife rather than a shikar reserve, and was added to a newly created system of national parks and nature reserves in Nepal. With a few alterations to its boundaries, it stands today much as demarcated in 1965-66. Additional fair-weather tracks have been cleared, and a permanent bridge built in the early 1970s across the Bawani River provides vehicular access to the southern part of the reserve from headquarters near Signhpur Village during the dry season. A special unit of the Nepal Army was assigned to protect the reserve early in 1976, replacing the forest guards formerly responsible. Administration and development are the duties of a warden and his staff.

Climate

No earlier climatological records were available for the study area, but records of temperture and precipitation at reserve headquarters were kept during the study. The highest daytime temperature recorded was 48° C on June 14, 1974, and the lowest nighttime reading was 2° C, on December 11 and 12, 1974, and January 26, 1975. The largest single rainfall of 128.5 mm occurred on July 12, 1975.

The premonsoon hot season or summer lasted from mid-March to mid-June and brought steadily-increasing temperatures with very little rain (Figure 2). Except in some permanent streams and marshes, surface water gradually evaporated.

The onset of a steady southeast wind bringing moist air from the Bay of Bengal signaled the beginning of the monsoon (Hagen, 1961; Ramdas, 1974). In Kanchanpur District monsoon rains began on about June 17, 1964, and June 23, 1975. Approximately 94 percent of the precipiation recorded at headquarters fell during the monsoon seasons.

In September-October the weather cleared and gradually cooled. Temperatures dropped into the cold season or winter and were lowest in December-January. Occasional light frosts were not unknown, though none occurred during the two winters of the study. Winter rains were infrequent and usually light. After mid-February, cool weather slowly gave way to premonsoon heat.

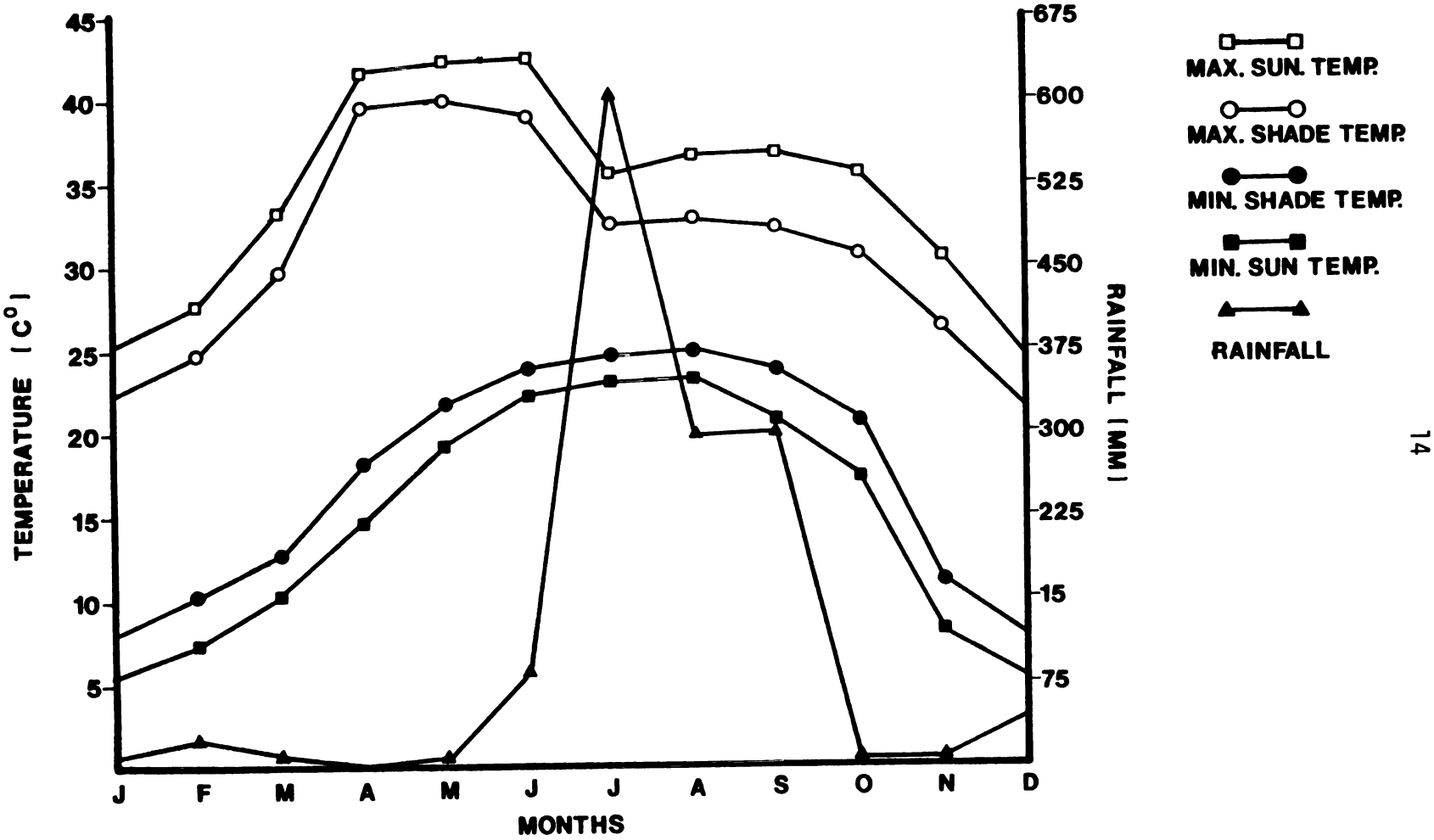


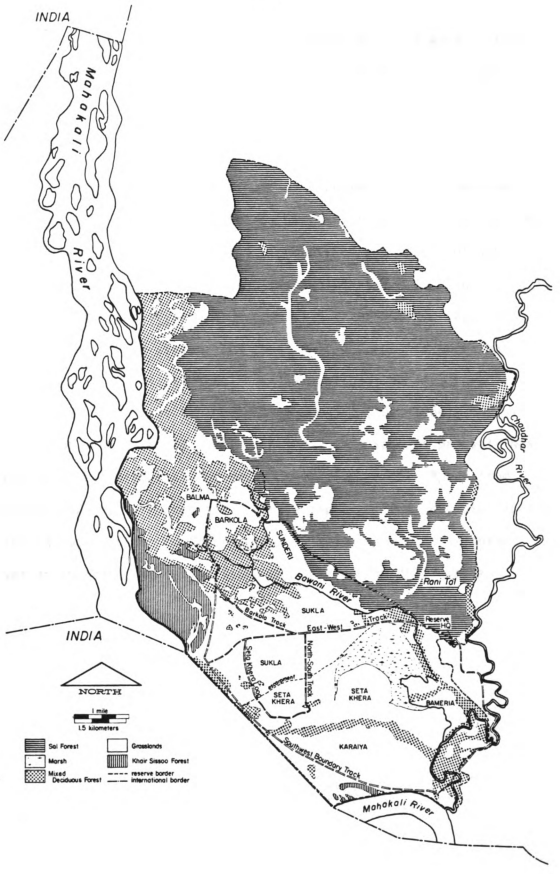
FIGURE 2. AVERAGE MONTHLY TEMPERATURE AND RAINFALL, 1974-76, RESERVE HEADQUARTERS, SUKLA PHANTA RESERVE, NEPAL.

Topography and Soils

The reserve is on a flat, gently undulating plain (elevation ca. 100-150 m above sea level) lying at the base of the Siwalik Hills, and sloping gradually south. Soils of the north-Indian plains and Nepalese terai are alluvial, and were laid down by the great north-Indian river systems and their numerous tributaries (Raychaudhury and Rajan, 1971; Mani, 1974). The alluvium was brought down from the Siwaliks and the Himalayan ranges where the large rivers arise, and varied from fine silts and clays to pebbles or larger rocks. This material was deposited as the rivers meandered across the land, and the process continues today.

Mani (1974) stated that the older or Pleistocene alluvium called bhangar occupies higher ground than the newer khadar which grades into the most recent delta silts. Champion and Seth (1968) noted that sal (Shorea robusta) forests on the plains tend to be confined to the older alluvium. In this study, sal forest in the northeast part of the reserve was seen to be on higher ground than the grassland and mixed deciduous forest to the south. The break in elevation between these two kinds of vegetation was often sharply defined, and ran roughly from southeast to northwest, from the north side of the Singhpur Village fields, along the north bank of the Bawani River and the east side of Sunderi Phanta, and thence north of the Balma-Barkola grasslands (Figure 3). In general, with the exception of seasonal streams and depressions, sal forest soils in the reserve appeared to be sandier and better drained than the

Figure 3.--Vegetation types, Sukla Phanta Reserve, Nepal.


INDIA
MONAKOTI
RIVER
INDIA
BALMA
BARKOLA
GUNDER
Bowoni River
Rani Tal
SUKLA
Forest Track
East - West
Reserve
SUKLA
North - South Track
SETA KHERA
SETA KHERA
RAMERIA
KARAIYA
Mahakali River
NORTH
1 mile
1.5 kilometers
Sal Forest
Grasslands
Marsh
Khair Sissoo Forest
Mixed Deciduous Forest
reserve border
international border

heavier southern-grassland soils. However, areas of sandy soils occurred also in the southern grasslands, notably in Sukla and Karaiya Phantas.

Fauna

Several large mannals have disappeared from the reserve in the past 5-20 years, according to local informants. These included blackbuck (Antilope cervicapra), four-horned antelope (Tetracerus quadricornis), dhole or wold dog (Cuon alpinus), wild (Canis lupus), and striped hyena (Hyaena hyaena). Wild water-buffalo (Bubalus bubalis) also were present but apparently disappeared more than 20 years ago. The western terai also lies within the former range of the Indian rhinoceros (Rhinoceros unicornis) (Gee, 1964), but since it is not remembered by local villagers, this species probably has not occurred in or near the reserve for many years. Apart from mammals (Appendix A) and birds (to be reported in a separate paper), the various species of other groups of animals were not recorded; yet an abundant and varied fauna was observed in the reserve.

THE HABITAT

Vegetation Types

Observations on vegetative physiognomy and species composition made during the study were the basis for distinguishing eight vegetation types. Sal forest and savanna were found on the upland portion (80.5 km^2) of the reserve, while the remaining six types were on the lowlands to the south and west (Figure 3). Aerial photos (1:12,000, made during a USAID Forest Resources Survey in 1964) provided information on the extent of large blocks of vegetation which could not be surveyed on the ground.

Sal Forest

This type occupied the largest continuous area in the reserve, ca. 70.4 km^2. Unlike the mixed deciduous forest to the south, sal forest was more extensive than associated grasslands, and thus included them.

Sal forest generally is characterized by the dominance of *Shorea robusta*, which is highly gregarious and may form almost pure stands (Champion and Seth, 1968). Other common sal forest trees in the reserve included *Lagerstroemia parviflora*, *Emblica officinalis*, *Terminalia belerica*, *T. alata*, *Syzygium cerasoideum* and *Wrightia tomentosa*. Some stands had closed canopies and little ground cover other than fallen leaves, while elsewhere trees were more widely

separated with an understory of grasses, including Eulaliopsis binata, Narenga porphyrocoma, Themeda arundinacea, Saccharum bengalense, S. spontaneum, Desmostachya bipinnata and Eulalia spp.

Sal Savanna

According to Whyte (1974), savannas are generally understood to be grasslands containing some woody vegetation. For purposes of this study, grassland in which the tree canopy cover was about 10-30% (ocular estimate), and/or including low-growing woody vegetation such as coppicing trees or shrubs, was classified as savanna.

Sal savannas comprised roughly 10.1 km^2 of the uplands. A small part was seasonally wet, principally where seasonal streams flowed. Tree and grass species on the savannas were similar to those in the sal forest.

Sal trees at various stages of development in virtually all the drier savannas suggested that they were part of a seral continuum between the mature Shorea robusta forest climax (Champion and Seth, 1968) and more open grassland resulting from disturbance of the forest, mainly by fire and grazing. Many of the large upland phantas contained extensive stands of coppicing sal no taller than the grasses, and subject to annual burning which presumably prevented advanced growth.

Mixed Deciduous Forest

Mixed deciduous forest occupied about 20.5 km^2 on the 66.8 km^2 lowlands. Typically, mixed deciduous forest does not

contain sal as a dominant species (Champion and Seth, 1968), and sal was entirely absent from this forest in the reserve.

Ground cover was variable, consisting only of fallen leaves where the canopy was dense. Elsewhere broad-leaved plants such as Ageratum sp. or ferns predominated, and grass was found infrequently. Common tree and shrub species were Trewia nudiflora, Syzygium cuminii, Celtis australis, Ficus spp., Bombax ceiba, Albizzia sp., Cedrela toona, Holarrhena antidysenterica, Mallotus philippinensis and Murraya koenigii. The trailing, spiny palm Calamus tenuis was common in wet places.

Khair-Sissoo Forest

Khair (Acacia catechu) and sissoo (Dalbergia sissoo) are pioneer species which thrive on unstable riverine sites (Champion and Seth, 1968). Sissoo formed almost pure stands on the banks and gravel bars of the Mahakali River. Understory grasses included Narenga porphyrocoma, Apluda mutica and Phragmites karka, among species identified. While sissoo was limited mainly to the banks of the Mahakali, khair was scattered about the grasslands on moist sites, and occasional specimens occurred in the mixed forest. Khair-sissoo forest occupied only about 4.7 km^2 in the southwest corner of the reserve.

Lowland Grasslands

Most of the reserve west and south of the Bawani River and south of the forest bordering the north edge of Sukla Phanta proper

was grassland (Figure 3). It was divided into the four types described below. Grasslands outside the principal southern phantas were not known well enough to classify them similarly. Lowland grasslands covered about 38.5 km^2.

Dry Grassland.--Dry grassland was only seasonally well-watered. Soils in some places were sandy, facilitating percolation of water and drying of surface layers. Central Sukla Phanta proper, west Seta Khera, part of east Seta Khera bordered on the north by marsh, and parts of Karaiya Phanta met these criteria. Grass heights varied, depending on species and enviornmental conditions. Dominant grasses were Narenga porphyrocoma, Imperata cylindrica, Saccharum bengalense, S. spontaneum and Desmostachya bipinnata. Dry grassland occupied an estimated 9.9 km^2.

Seasonally-Wet Grassland.--This type lay at lower elevations where it was flooded by the Bawani River and monsoon rains, and where topography and soils favored retention of surface water. Some areas remained marshy for up to 6 months after the rains ended. Grasses reached heights of 150 cms. or more. Dominant species included Narenga porphyrocoma, Imperata cylindrica, Saccharum spontaneum, Vetiveria zizanioides, and in eastern Seta Khera, Sclerostachya fusca. Sedges of the genera Cyperus and Scleria also were found. Northeast Sukla, Bameria and most of Seta Khera and Sunderi Phanta supported wet grasslands. About 8.8 km^2 in or adjacent to the main southern phantas were covered by this type.

Lowland Savanna.--This savanna extended over an estimated 9.5 km^2 on the southern phantas, including portions of Sukla and Seta Khera and most of Karaiya. Savanna occupied dry and seasonally-wet sites, but was found primarily on the former. The main tree species represented were Butea monosperma, Acacia catechu, Dalbergia sisso (in Karaiya Phanta), Ficus religiosa, Bombax ceiba, Cedrela toona and Sterculia villosa. Grasses were the same species mentioned above.

Marsh.--Marsh was characterized by the presence of surface water the year round, or by soils which were water-logged and muddy all year. Dense Phragmites karka, Saccharum spontaneum and Sclerostachya fusca comprised the dominant vegetation. An estimated 3.1 km^2 were covered by marsh east of Sukla Phanta and north of eastern Seta Khera. Additional smaller areas were on the northeast edge of Karaiya Phanta, in south-central Sunderi, and in the Khair-sissoo forest.

Influence of Fire in the Habitat

Fires annually burned over much of the reserve. Probably all were man-made, and many were started by grass-cutters who entered the reserve each winter to collect thatching material. Some were started by passers-by, or by livestock graziers wishing to hasten new growth. The earliest fires were recorded in Karaiya Phanta on November 29, 1974, and December 4, 1975. By the end of December each year most of the south-central grasslands had burned,

although burning continued in peripheral areas and on the uplands until well into the premonsoon season. The first extensive fires in the sal forest and savannas were recorded on March 12, 1975, and about April 15, 1976. On occasion, fires started in India also may have swept across the southern border into the reserve.

Within a few days after a burn, the first new grass appeared and soon attracted wild ungulates. By clearing senescent vegetation and stimulating new growth, fire encouraged the annual congregation of barasingha in large herds on the southern phantas. Chital and hog deer (Axis porcinus) also were attracted to the new grass. Burning thus influenced the seasonal distribution of animals, in addition to maintaining the grasslands by preventing forest regeneration.

Availability of Water

Water was abundant everywhere during and after the monsoon. Some of it remained in temporary ponds until late in the following dry season. Seven ponds were found in southern Sukla and adjacent Seta Khera Phanta. All but two were dry by May each year, and even these disappeared by the end of that month. After May, drinking water was to be found only in the Bawani and Mahakali Rivers, and in the marshes bordering the main phantas. The Chaudhar River dried during the last month of the hot season. Being located peripherally, this stream probably was of less importance to wildlife, in particular to barasingha, even when flowing. The Mahakali River, too, may have been a less important source of drinking water since it also is on the periphery of the reserve. Only once, in May, 1974,

tracks of two barasingha were found on the Mahakali where it adjoins Karaiya Phanta, and the same day a lone hind was spotted leaving the river bed for the grassland.

Dew-falls were recorded in the dry season as late as mid-April, and these also provided water for grazing animals. Additional moisture was present in the green forage, especially on the seasonally wet grasslands, where grass was kept fresh by the relatively high water table (Singh, 1966).

In the sal forest and savannas, two ponds about 1.5 kms. northeast of Sukla Phanta also contained water into May. Permanent water was found on the periphery of the sal forest and savannas in Sunderi Phanta, the Bawani River and Rani Tal, a small lake on the east side of the reserve (Figure 1). Since grass fires occurred later in the season in the sal forest region, and because the water table was not as high as in the lowlands, less green forage was available before the onset of the monsoon rains than on the southern grasslands. Furthermore, leaf-drop by sal trees in March and the simultaneous growth of new leaves may have resulted in draw-down of the water table and enhanced drought conditions on the uplands, in a manner similar to that reported by Martin (1975) from Kanha National Park.

POPULATION SIZE

Methods

Barasingha congregated annually to the greatest extent on the recently burned grasslands of Sukla and Seta Khera Phantas between February and mid-April. They then afforded the best opportunity to attempt total population counts. Both aerial surveys and ground counts were made. An additional estimate of population size was obtained from fecal-pellet counts.

Aerial Surveys

Aerial surveys were conducted when the United Nations plane based in Kathmandu became available, and for this reason, the first survey on May 2-3, 1974, was somewhat after the season of maximum deer concentration, while the second on March 26-27, 1975, took place at the appropriate time of year. Flights using the Swiss Pilatus Porter single-engine STOL aircraft were made on the afternoon of the first day after 1500 hrs., and the following morning before 1000 hrs. during each two-day period. Flights proceeded from the southeast corner of the reserve on a series of east-west, west-east transects. The courses flown also enabled views of about 10 km^2 of Indian territory adjoining the southern border of the reserve and lying between the Mahakali River, where it turns briefly south before swinging back to Nepal, and the international boundary.

Transects extended between the Mahakali and Chaudhar Rivers, and continued as far as the northern tip of Sunderi Phanta. The same two observers participated in all four flights, one person recording barasingha from each side of the plane. The numbers of animals seen in large groups were estimated or partially counted and then estimated. With the straight-and-level flight pattern employed, observers alternately viewed from the north and south sides of the plane, and duplicate sightings of deer were possible. Since sightings were not numerous, however, and the area covered was small (ca. 70 km^2), duplicate counts were eliminated by comparing the data recorded by both observers immediately after flights. When duplicates occurred, the larger figure was included in the count, and sightings of small groups by one observer overlooked by the other were added to the total.

Ground Counts

Ground counts were conducted along a standardized route which gave the greatest coverage to the areas frequented by barasingha during the period of maximum deer concentration and visibility. Counts were made in the morning before 0900 hrs. and/or in the afternoon after 1600 hrs. An observer sitting on top of the cab of a vehicle driven slowly along the route tallied all deer seen, stopping carefully to count large herds with 7 x 35 binoculars or a 20x telescope. The route comprised the East-West Track, beginning where it enters Sukla Phanta proper, up to and including the Seta Khera Loop, and the North-South Track (Figure 1). In

addition, two short extensions were made, one to the south from the east end of the East-West Track and approximately 500 m long, the other to the southeast about 300 m just as the Seta Khera Loop turns onto the North-South Track. These extensions gave added coverage to east-central Seta Khera and southeast Sukla Phanta proper.

Fecal-Pellet Counts

Fecal-pellet counts were used to estimate the numbers of barasingha as well as hog deer and chital present on Sukla and Seta Khera Phantas during the 1976 premonsoon season. As noted previously, all three deer species were attracted to new grass growth after winter grass fires, and they frequently shared common grazing grounds at that time of year.

In February, 56 50-m^2 plots were laid out at 300 m intervals along transects 500 m apart in Sukla Phanta and in western and central Seta Khera Phanta. All pellets were removed from them, and they were re-examined 60 days later. Lack of rain and little insect activity meant that most pellets dropped during the interim remained *in situ* and undamaged. Pellets were identified by size and shape (Eisenberg, et al., 1970). Those of barasingha tended to be the largest and were barrel-shaped. Chital pellets were narrower and longer relative to barasingha pellets, and hog deer pellets were smaller and more uniformly round than the others.

Barasingha frequently defecated while walking, making it difficult to distinguish pellet groups, especially where pellet densities were high. Taber (in press) reported similar behavior

for captive chital. For this reason, total numbers of pellets for each species, rather than pellet groups (Bennett et al., 1940; Neff, 1968) were counted when plots were re-examined.

Results

Aerial Surveys and Ground Counts

The May 1974 aerial survey yielded lower totals than the one in March 1975 (Table 1). Using the Spearman rank correlation coefficient (Steel and Torrie, 1960), a high inverse correlation was found between the number of sightings and group size, i.e., the fewer groups seen, the larger the group size (r_s = 0.800). A "group" or "herd" consisted of one animal or more.

A significant correlation also existed between few groups and large group size during 1975 ground counts (r_s = 0.708, $p < 0.05$) (Figure 4). A similar significant correlation between these variables was not found on ground counts in 1976, though, when r_s = 0.346.

During ground counts in both years, the highest total numbers of deer were recorded in March, followed by declines in the latter half of April. In 1975, the abrupt drop from 800 to less than 200 animals between April 11 and 19 may have been caused by visiting royalty on April 13, when a helicopter and a large number of vehicles and personnel were active on Sukla Phanta proper, and could have scattered the herds. A more gradual decline in barasingha numbers was seen in 1976 in the absence of such disturbance (Figure 4).

TABLE 1.--Barasingha numbers estimated from aerial surveys made in Sukla Phanta Reserve, Nepal, May 1974 and March 1975

Date	Time	Number of Transects	Approximate Distance Between Transects (m)	Approximate Altitude (m)	Number of Sightings	Range of Group Size	Total Animals Seen
May 2 1974	1600-1650	10	720	170	13	6-120	575
May 3 1974	0800-0845	10	720	170	26	1-130	349
Mar. 26 1975	1550-1630	13	550	170	4	95-300	795
Mar. 27 1975	0820-0910	10*	550	70	5	2-800	884

*The three southernmost transects were not repeated since the area they covered had been heavily used by livestock, and no deer were seen there the previous day.

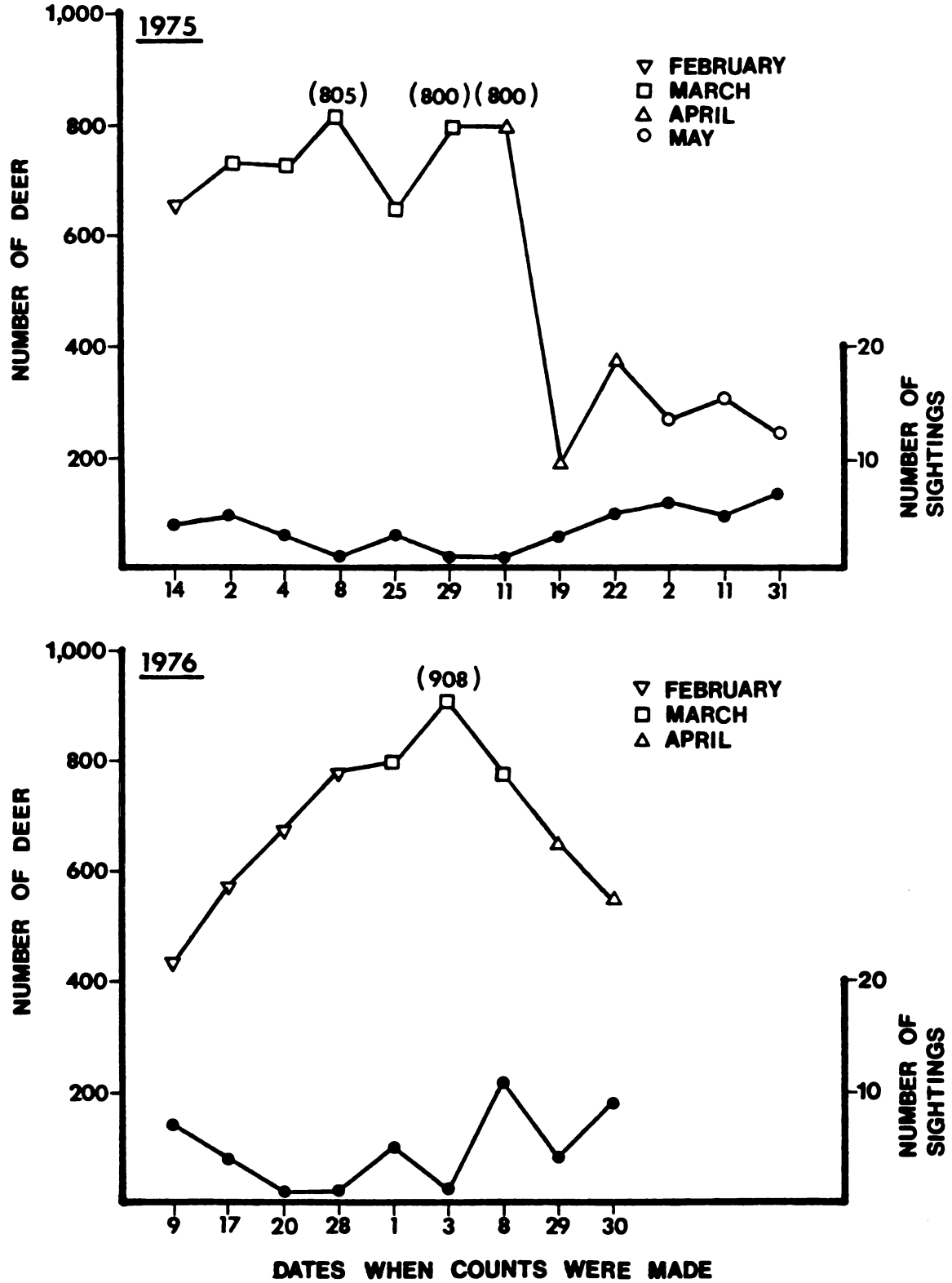


FIGURE 4. GROUND COUNTS OF BARASINGHA DURING THE PREMONSOON SEASONS, 1974-76, SUKLA PHANTA RESERVE, NEPAL.

Fecal-Pellet Counts

Five of the 56 plots were lost during the 60-day interim because markers were removed by passers-by, or could not be relocated in grasses which had grown during that time. The total number of pellets for each species was divided by the average number of pellets per group, calculated from 195 complete pellet groups found (Table 2), to obtain the number of pellet groups represented by the total pellet counts. The results were converted to pellet groups per km^2 and divided by 13, the assumed number of groups deposited per day. This figure was used by Eisenberg et al., (1970) to calculate chital numbers in the Wilpattu National Park of Ceylon (now Sri Lanka). The same figure was used for this study because it approximated defecation rates for several other deer species (e.g., McCain, 1948; Van Etten, 1959; Julander et al., 1963; Neff et al., 1965) and, in the absence of more precise data, was believed to be a reasonable estimate for barasingha and hog deer as well. Dividing again by 60, the number of days between clearing and re-examination of the plots, produced estimates of deer per km^2. These figures were multiplied by 12.3 km^2, that portion of Sukla and Seta Khera Phantas represented by the sample plots. Estimated population sizes were 1,295 barasingha, 273 hog deer, and 341 chital (Table 2).

Discussion

The results obtained from aerial surveys were considered less accurate than ground counts because they were based in part on

TABLE 2.--Population estimates of three deer species derived from fecal-pellet counts on Sukla and Seta Khera Phantas, February-April 1976, Sukla Phanta Reserve, Nepal

	A. Total No. of Pellets[a]	B. No. of Complete Pellet Groups	C. Mean No. of Pellets/Group (± S. E.)	D. No. of Pellet Groups in Plots (A/C)	E. No. of Pellet Groups/ km^2[b]	F. No. of Deer-Days per km^2[c]	G. No. of Deer per km^2[d]	H. Population Estimates[e]
Bara-singha	13,359	59	63.78 ± 4.28	209.45	82,137.91	6,318.30	105.31	1,295
Hog Deer	8,183	83	62.24 ± 3.44	131.47	17,284.36	1,329.57	22.16	273
Chital	8,420	53	57.23 ± 3.14	147.13	21,647.24	1,665.17	27.75	341
Totals	29,962	195	--	--	121,069.51	9,313.04	155.22	1,909

[a] on 51 x 50 m^2 plots = 2,550 m^2

[b] Conversion factor = 392.16

[c] E/13 pellet groups/deer/day

[d] F/60 days

[e] G x 12.3 km^2

estimates of groups size instead of complete counts. Moreover, estimates made by the two observers differed by as much as 14% for the largest groups. It was observed also that small groups of barasingha (less than 10-15) might not have been distinguished correctly in every instance from hog deer and chital when viewed from the plane, and this could have influenced survey results. These considerations did not apply to ground counts, where time could be taken to study animals with field glasses and to count all individuals.

Aerial surveys tended to confirm the assumption derived from observations made on the ground, however, that barasingha were most concentrated on the grasslands of Sukla and Seta Khera Phantas during the mid-premonsoon season. None were seen from the air in March or May in the upland phantas north of Sukla Phanta proper. The relatively small number of animals seen during the May surveys indicated that the largest herds had broken up by then, and scattered smaller groups probably were overlooked more easily.

During the May 3 survey, 21 animals were seen either on the Indian side of the southwestern border or close to it in Nepal, indicating that at the time, the deer may have used habitat available in India. Human settlement had not begun in the 10 km^2 Indian territory mentioned above, but by March 1975 settlers were present and no deer were seen there. Although the absence of deer from this area might be expected when the animals had congregated on the grasslands to the northeast, it is unlikely that they would have returned

to the then-settled Indian territory following the April-May break-up of the large herds.

The inverse correlation between herd size and the number of barasingha herds or groups seen, and a lack of sightings except on the south-central grasslands of the reserve, were indications that during the season of maximum deer concentration a high proportion of the total barasingha population may have aggregated into the largest herds seen. Close agreement among the three maximum ground counts in 1975 also indicated that perhaps few animals remained uncounted. The highest ground counts in 1975 (805) and 1976 (908), therefore, were regarded as the minimum barasingha population each year.

With respect to fecal-pellet counts, factors which may affect pellet-group deposition rates have been summarized by Neff (1968) and Nootong (1975). Young deer are known to defecate more often than adults, and green forage like that present on the southern phantas when counts were made also increases defecation rates. The actual rate for each species thus may have been more than 13 groups per day, and population estimates based on the true rates then would have been somewhat smaller than those given in Table 2.

Since hog deer and chital were known to be more widespread in the reserve than barasingha during the premonsoon seasons, population estimates for those species apply only to the grasslands sampled. The observed relative abundance of hog deer and chital,

however, may indicate their abundance in the reserve as a whole. Judging from the available habitat in which hog deer were seen regularly, they probably were the least abundant of the three deer. Chital being the most widespread were likely to be more abundant than barasingha, and therefore, were the most numerous wild ungulates in the reserve. In comparison, estimates of chital density in Wilpattu National Park were 44.4-57.9 per km^2 in suitable habitat (Eisenberg et al., 1970; Eisenberg and Lockhart, 1972), approximately twice as many as were present on the southern phantas of the reserve.

While an unknown portion of the barasingha population of Sukla Phanta Reserve was not observed during deer counts, it may be assumed that the entire population present on the southern phantas contributed to the number of fecal pellets counted. The population figure derived from pellet counts (1,295) therefore may be taken as an approximation of maximum barasingha population size in the first quarter of 1976.

Of the methods employed to census deer, direct counts made at the appropriate time of year along the ground route described above were relatively quickly done with the least expense, and provided an index to barasingha population size. Ground-count data could be accumulated over several years by reserve personnel and used to monitor changes in barasingha abundance.

REPRODUCTION

Timing of the Rut and Distribution of Rutting Stags

Martin (1975) found that the highest rate of rutting calls or "bugling" by stags among the Kanha deer coincided with the observed peak of mating there in the latter half of January. In Sukla Phanta, calling was used as an indicator of mating since barasingha rarely could be seen in the rank post-monsoon grasses. The largest group recorded in the cold season before the grasses burned was 12 animals. Larger "breeding herds" like those observed in Kanha (Schaller, 1967; Martin, 1975) were not seen to form in Sukla Phanta.

Rutting calls were heard primarily after 1600 hrs. and intermittently throughout the night in Sukla Phanta. Calling usually ended in the morning before 0900 hrs. The earliest call of the season was heard on August 31, 1975. That same day the first mature stag in hard antlers was seen. The latest call recorded was on April 18, 1974. Subsequent observations showed that mature stags began to drop antlers in early March, and apart from the instance referred to, calling was not heard in April.

Methods

To determine the peak mating period and to locate rutting areas, calls and their direction from the observer were recorded in

the early morning and evening from four "listening posts," located as follows: (1) the guard post at the former Barkola Village site, (2) midway along the side of Sunderi Phanta and 100 m east of that grassland, (3) at a lone Butea monosperma tree 400 m south along and 150 m west of the North-South Track, and (4) in Karaiya Phanta south of (3), at the edge of the forest separating Karaiya and Seta Khera. The Sukla post was monitored 19 times between September 22 and December 13 during the 1974-75 rutting seasons. The others each were monitored one morning and one evening in November 1974, except Sunderi, which was visited two mornings and evenings. During one morning at Sunderi and each morning at Barkola and Karaiya, calls were recorded simultaneously by another observer at Sukla.

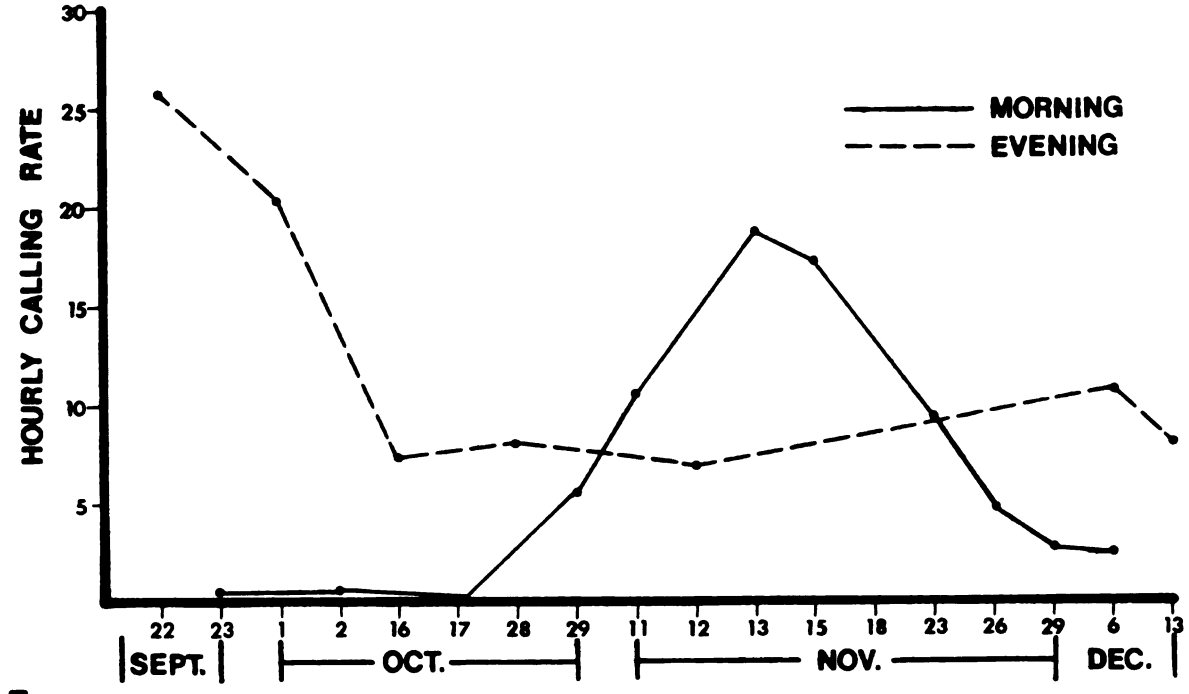
Results

Data for 1974-75 from the Sukla post were combined since the rut followed roughly the same schedule each year. Evening calling rates declined from mid-October and remained approximately at the same level until mid-December (Figure 5a). Morning rates peaked in mid-November and were markedly lower at other times. Of 498 calls recorded at Sukla, most came from the southwest and southeast, and the least calling was heard from the north (Figure 5b).

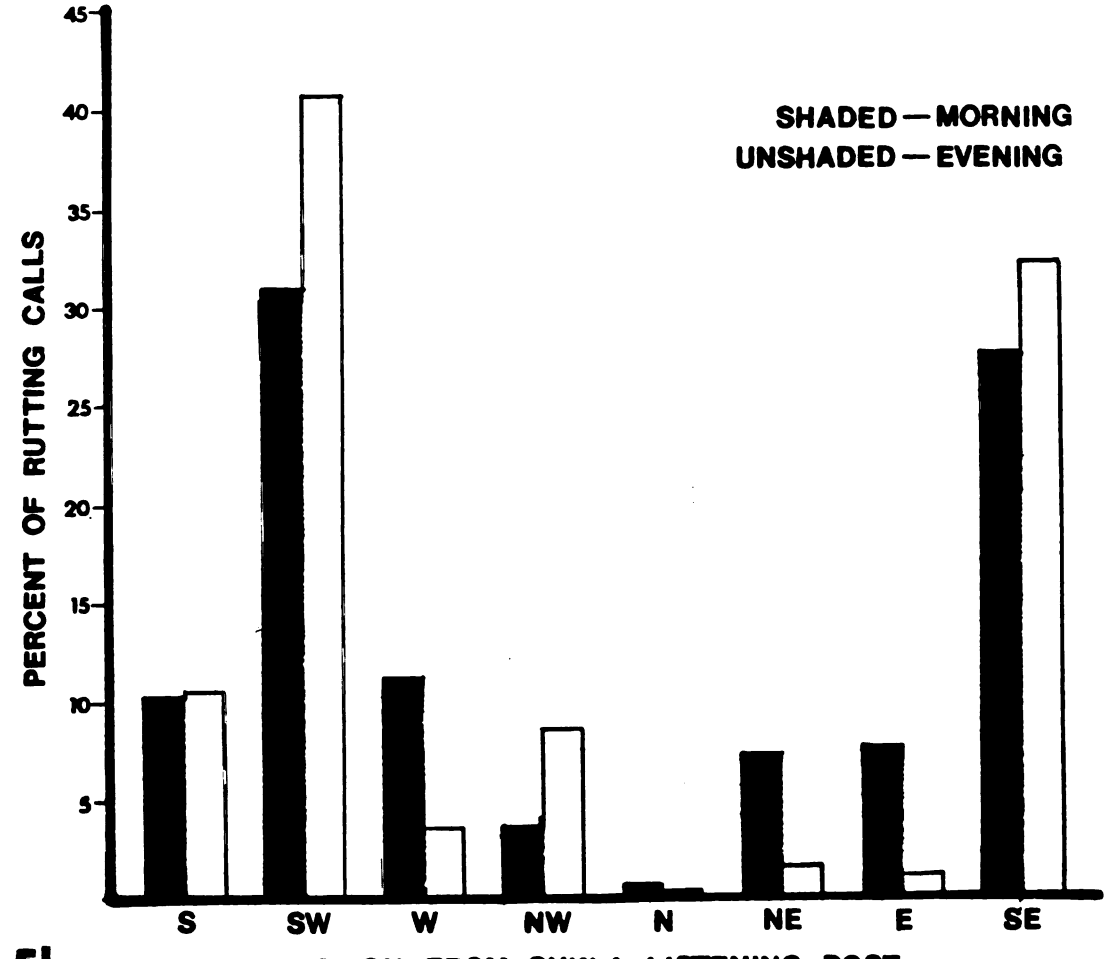
Morning calls at two posts were fewer than those simultaneously recorded at Sukla (Table 3). The least activity was noted at Barkola, with nine calls scattered around the post. Morning and

Figure 5.--(a) Morning and evening hourly rutting call rates in Sukla Phanta proper, 1974-75

(b) Percentage of total calls heard from various directions in Sukla Phanta proper, 1974-75, Sukla Phanta Reserve, Nepal.


HOURLY CALLING RATE
30
25
20
15
10
5
MORNING
EVENING
22 23 1 2 16 17 28 29 11 12 13 15 18 23 26 29 6 13
SEPT.
OCT.
NOV.
DEC.
CALENDER DATES

5a.


PERCENT OF RUTTING CALLS
45
40
35
30
25
20
15
10
5
SHADED — MORNING
UNSHADED — EVENING
S
SW
W
NW
N
NE
E
SE
DIRECTION FROM SUKLA LISTENING POST

5b.

TABLE 3.--Morning and evening rutting calls counted at three listening post, compared with morning counts made simultaneously in Sukla Phanta proper, November 1974, Sukla Phanta Reserve, Nepal

	Barkola	Sunderi	Sunderi	Karaiya	Totals
Three posts, PM	4	12	17	16	49
Three posts, AM	5	3	3	14	25
Sukla, AM	28	40	--	14	82

evening calls at Karaiya came mainly from Seta Khera to the north-east and northwest.

Discussion

The reason for the difference in pattern between morning and evening calling rates (Figure 5a) is not known. Possibly the high number of September evening calls represented pre-rut activity as stags challenged one another to establish dominance hierarchies. Behavior of this kind was noted among red deer (Cervus elaphus), where dominant stags were more likely later to establish harems (Lincoln et al., 1970). Although barasingha do not maintain harems, dominant stags have priority in access to estrous hinds (Schaller, 1967; Martin, 1975). Since the gestation period in barasingha is 240-250 days (Kenneth, 1953; Asdell, 1964), the peak of new fawns appearning from late June into August (see beyond) indicated that the high number of rutting calls in Mid-November probably reflected the peak of mating.

The frequency and location of calls indicated that rutting activity was greatest in southern Sukla Phanta proper and adjacent Seta Khera. Five permanent wallows used by rutting stags each year of the study were found in southeast Sukla Phanta and north-central Seta Khera. Similar wallows were not found elsewhere, though apparently suitable wet, grassy places were present in the lowlands during the rut. Fidelity to rutting areas was found among the Kanha deer (Schaller, 1967; Martin, 1975), and is known to occur in other species as well (Darling, 1937; Murie, 1951; Ueckermann and Hansen, 1968). Use of certain rutting areas may be traditional among the Sukla Phanta barasingha as well.

Each year local people were permitted to cut grass for thatch in the reserve for one month in November-December, during and just after the height of the rut. Since the tall, dense grasses in southern Sukla Phanta and environs were particularly desired, the disturbance caused by large numbers of people and draft animals in the main rutting area may affect population mating success.

Age of Hinds at First Breeding

Schaller (1967) and Martin (1975) found no evidence that yearling hinds participated in the rut in Kanha. Schaller believed that hinds first mate when just over 2 years old and bear fawns at about 3 years of age. Barasingha hinds at Woburn Deer Park in England do not mate until 28-30 months old (D. G. Talbot, personal communication). There was no indication that yearlings in Sukla Phanta took part in the rut and it is likely that most, if not all,

of the annual fawn crop was produced by hinds which mated first at 2 years or older.

Fawning

Owing to the dense vegetation in Sukla Phanta, the wariness of the deer, and the tendency of young fawns to remain hidden, no data could be obtained on the ratio of hinds to new-born fawns. Fawns counted in March (see beyond) had survived the first months of life when mortality was likely to be high. The proportion of the annual crop lost between the June-August fawning season and the following March is unknown.

The earliest new fawns were observed on June 28, 1974, shortly after the onset of the monsoon rains. One of four fawns seen on that date was flushed after its mother revealed its hiding place. The other three were with groups of older animals, indicating that they had completed the "hiding phase" common among new-born cervids (Lent, 1974). The estimated age of these three animals was 10-14 days, based on the assumptions that they were among the first-born of that season and that the hiding phase had lasted about a week. Conception of these early fawns then would have occurred in mid-October, roughly a month earlier than the estimated peak of the rut.

New fawns were seen 36 times during the 1974 monsoon season, either alone, with their mothers, or in the company of other deer. In 1975, the first new fawn of the season was seen on July 6 in a

small group of animals. Thereafter, new fawns were observed 22 times during July and August.

Schaller (1967) found no records of twinning in barasingha, and apparently did not observe it among the Kanha deer. Hinds were sometimes seen with two fawns at heel in Sukla Phanta, but this could not be taken as firm evidence of twinning, since one or two fawns sometimes even trailed after stags.

POPULATION SEX AND AGE STRUCTURE

Sex and age composition counts were made several times between November and May during both years of the study. Figures obtained in March during the season of maximum deer concentration were judged best to approximate actual population structure because the largest counts were obtained, and visibility was better than at other times of year.

Methods

All counts took place in Sukla Phanta proper, save one in Dudhwa National Park, and were made with binoculars and telescope. The most favorable circumstances for accurate counts occurred when herds were moving slowly, roughly in single file and at right angles to the direction of observation. Individuals then could be distinguished and classified as adult males, adult females, yearlings, or fawns on the basis of relative body size and the presence of antlers or antler pedicels. Though yearling males carried short, unbranched antlers or "spikes," these were not always visible in the field, and yearlings were tallied only as such, without regard to sex.

Since deer could not be closely examined, the classes most difficult to identify were females, yearlings (males as well as females, if spikes were not evident) and well-grown fawns. In April-May 1974, no distinction was made between yearlings and fawns

of the previous monsoon season, since insufficient skill had been attained at that time in separating the two classes.

Results

In Sukla Phanta, adult males comprised 16.4-32.7% of animals counted, adult females 35.2-48.6%, yearlings 7.1-16.1%, and fawns 9.2-17.7% (Table 4). The three largest March counts (one in 1975 and two in 1976) included 30-40% of the minimum population in each instance. The smallest March count in 1975 contained an unusually low number of fawns, while the Dudhwa count included a larger proportion of immature animals than counts made in Sukla Phanta at the same time of year.

Discussion

Variations in proportions of deer observed in four sex and age classes were due to differences in visibility and deer distribution at different times of year. As expected, numbers of unclassified deer were greatest in November-December before the grasses were burned. Variation between counts was greatest for adult males, although they usually were easiest to recongize because of their antlers. This variation may be caused by the tendency of stags to wander and to be more widespread during the rut (Schaller, 1967) as well as segregation of adult males from other members of the population for part of the year. Martin (1975) found that stags left females and young during the premonsoon season, with segregation by sex reaching a peak in May. Segregation was noted in Sukla Phanta

TABLE 4.--Numbers (and percentages) by sex and age of barasingha tallied in Sukla Phanta Reserve, Nepal, and Kakraha Block, Dudhwa National Park, India

	April-May 1974	Nov.-Dec. 1974	March 1975	March 1975	Nov.-Dec. 1975	March 1976	March 1976	April[a] 1975
Adult Males	53 (29.9)	23 (20.4)	33 (27.7)	104 (32.7)	11 (16.4)	97 (32.7)	123 (30.8)	28 (16.3)
Adult Females	86 (48.6)	47 (41.6)	56 (47.3)	112 (35.2)	31 (46.3)	115 (38.7)	158 (39.6)	50 (29.1)
Yearlings	34 (19.2)[b]	8 (7.1)	19 (16.0)	51 (16.1)	9 (13.4)	42 (14.1)	40 (10.0)	61 (35.5)
Fawns	--	20 (17.7)	11 (9.2)	38 (11.9)	11 (16.4)	39 (13.1)	62 (15.5)	33 (19.2)
Unclassified	4 (2.3)	15 (13.3)	--	13 (4.1)	5 (7.5)	4 (1.4)	16 (4.0)	--
Fawns/ 100 adult females	--	42.6	19.6	33.9	35.5	33.9	39.2	66.0
Source[c]	177 animals, various herds	113 animals various herds	119 animals, 1 herd	318 animals, 1 herd	67 animals, various herds	297 animals 1 herd	399 animals, 1 herd	172 animals, 1 herd

[a]Kakraha Block, Dudhwa National Park

[b]Includes fawns

[c]A herd was defined as 1 or more animals.

only when subgroups of stags were seen in the large herds in March-April, but it also may account for the low number of males counted in the Kakraha Block of Dudhwa in April. Deer there were occupying land freed from livestock grazing in 1974. Additional habitat could have promoted breeding success and contributed to the high fawn/female ratio observed, but it is possible that part of the adult population simply was absent from the herd counted.

Realized and Potential Population Increase

The observed increase in the minimum barasingha population of Sukla Phanta from March 1975 to March 1976 was 12.8%. Since about 40% of the total population were adult females, the potential rate of increase was somewhat higher. Whether the difference between the observed and potential increase was the result of mortality or low breeding success, or a combination of the two, could not be accurately determined.

In Kanha (Martin, 1975), composition counts were made when fawns were slightly younger than those counted in Sukla Phanta in March (6-9 vs. 8-10 months old). Adult female percentages were the same in both populations, but fawns/100 adult females were higher in Kanha (30.0 in 1971, 46.7 in 1972, and 43.1 in 1973) and permitted an 18-20% annual population increase there. Since adult female percentages and fawns/100 females ratios were similar on the two areas, higher mortality was a probable cause of the lower observed increase in Sukla Phanta. Data thus far obtained in Sukla Phanta will provide the basis for comparison with future counts.

FACTORS AFFECTING SURVIVAL

Poaching

Poaching was widespread in the reserve during the study. Between April 1974 and May 1976, 70 incidents related to poaching were recorded. These included shots heard, armed persons seen, hunting camps found, and encounters reported between forest guards and poachers. Although the total kill by poachers could not be determined, it was assumed that the most frequently taken large mammals were chital, because of their relative abundance and wide distribution. One instance of hog deer poaching was noted, and two unsuccessful attempts to kill barasingha also were observed. Since barashingha meat was the least desired as food by local people (local informants), the presence of hog deer and chital may have decreased hunting pressure on barasingha. Local authorities believed that my presence deterred would-be barasingha poachers, but no evidence was found to support this view. Since law enforcement in the reserve was improved in 1976 with the arrival of the Nepal Army, poaching today may be less prevalent than it once was.

Predation

The remains of 50 deer were found on Sukla, Seta Khera, and Karaiya Phantas during the study. Twelve were identifiable as barasingha, but only two adult hinds definitely could be identified

as tiger (Panthera tigris) kills. Tigers were the only carnivores in the reserve known to prey upon adult barasingha. Leopards (Panthera pardus), although present, were not known to be common and frequented forests where barasingha were less often found. The several other species which may have preyed on deer in the past (wolf, wild dog, hyena) no longer exist in the reserve.

Jackals (Canis aureus) were common, and circumstantial evidence indicated that they could be important predators on new-born fawns and even older animals. Once two jackals were observed chasing a hog deer doe. One was in close pursuit while the other lagged behind, implying a cooperative hunting effort. In Africa, C. aureus brings down adult gazelles (Gazella thomsoni) and their fawns (Van Lawick-Goodall, 1971; Kruuk, 1972), and jackals undoubtedly take some barasingha fawns each year in the reserve. As in the case of tigers, the impact of jackals on the deer population is not known.

Diseases and Ectoparasites

Barasingha mortality from disease was not observed. Mange or dermatitis affected a few animals. Schaller (1967) reported a similar skin disorder among the barasingha of Kanha National Park. In Sukla Phanta Reserve, dark, discolored skin patches were seen during the premonsoon and monsoon seasons, when the hair was short. Afflicted animals showed no signs of discomfort, however, and appeared to function normally. Skin disorders were not observed among hog deer and chital in Sukla Phanta.

In March 1976, a disease diagnosed as rinderpest (C. Rice, personal communication) broke out among local village livestock and caused heavy mortality. Wild ungulates were not observed to be infected, though many species are susceptible to the rinderpest virus (Scott, 1970). The tendency of barasingha to avoid areas used by livestock (see beyond) could be important in preventing the spread of livestock diseases.

Ectoparasite loads (ticks, lice, louse flies) observed on poached animals and predator kills were light. Ectoparasites probably did not affect deer survival significantly, though their importance as potential vectors of disease cannot be discounted (see also Appendix B).

Floods

The Mahakali River formerly flooded portions of the reserve lowlands, but since 1928 an irrigation dam northwest of the reserve has diverted some of its flow to India. Thereafter, monsoon floods in the reserve were caused mainly by accumulated rain water in poorly drained areas, and overflow from the Bawani River. Even when the Mahakali had flooded regularly, the water usually rose gradually enough so that large animals could move to higher ground. In 1968 and 1972, however, exceptional monsoon rains breached the earthen dikes of the irrigation system and caused flash floods. Local informants reported that humans and many domestic and wild animals drowned. Barasingha were reported to have begun recovering their numbers only recently. Exceptionally heavy floods may become

an increasing threat as catchment areas in the hills continue to be deforested and overgrazed, and as stream bed levels rise due to siltation (Robbe, 1954; Sterling, 1976).

In the Sathiana Block of Dudhwa National Park, by comparison, principal barasingha habitats are flooded almost every year, forcing the deer south out of the park into areas increasingly occupied by subsistence farmers. There they remain for up to 7 months until attracted back into the park by new grass growth which follows after winter fires.

Drainage of flood water in Sathiana is retarded by road and railway beds which act as dikes. When early-season rains are heavy, as they were in June 1975, the rapidly-accumulated flood water almost certainly drowns some new-born barasingha fawns (Schaaf and Singh, 1977).

HABITAT PREFERENCES

The preferred habitats of barasingha, hog deer, and chital were determined, since these species shared the same range for part of each year. Among the remaining ungulates in the reserve (Appendix A), only wild boars (Sus scrofa) occurred regularly in the same areas frequented by barasingha, but in such small numbers that they were considered an insignificant part of the total ungulate population. Data on habitat preferences were obtained from counts of the deer as well as their fecal pellets.

Methods

Deer Counts

Observations were made from the back of a domestic elephant along 15 permanent transects varying between 1.2 and 4.6 kms. long, and located in the lowland grasslands and forest as well as in the sal forest and savannas northeast of Sukla Phanta proper. The elephant penetrated dense vegetation where a person on foot could not go, and elevated the observer enough to see over the tall grasses. Transects were covered in March 1975 (late winter-early hot season), May-June (late hot season), August-September (late monsoon), and December (mid-winter). The March count was repeated in 1976.

Parallel transects were laid out at approximately 500 m intervals and spanned all vegetation types except the khair-sissoo forest and marsh, which were inaccessible even by elephant. When deer were sighted, the species, group size, estimated distance from the observer, and vegetation type were recorded. For each deer species, the average sighting distance in a vegetation type was doubled to yield the transect strip width. This figure was then multiplied by the distance traveled in that type to provide an estimate of area covered. In each season, a set of transects was completed in about 14 days.

For each survey, the observed number of animals was compared with the number which would be expected in each vegetation type if all deer tallied had been randomly distributed. Detection of a significant difference between observed and expected numbers using a chi-square test indicated that selection occurred, but did not of itself suggest which types were selected or avoided. For this purpose confidence intervals on the observed proportions of deer in each type were calculated to determine if expected proportions lay within the range of significance. Thus, if observed proportions were significantly greater than expected (i.e., more deer observed than expected), habitat preference was indicated. The reverse relationship (significantly more expected deer than observed) indicated habitat avoidance (Neu, et al., 1974).

Fecal-Pellet Counts

Fecal-pellet counts used to determined deer population size also provided information on habitat preferences. Kruskal-Wallis comparisons (Hollander and Wolfe, 1973) of ranked data (numbers of pellets in each plot) were used to determine whether pellets of any one deer species were significantly more numerous in dry grassland, seasonally-wet grassland or lowland savanna, the three vegetation types included in fecal-pellet counts during the 1976 premonsoon season on Sukla and Seta Khera Phantas. Similar comparisons were made within each vegetation type to determine if the relative abundance of pellets differed significantly among three deer species. In the latter comparisons, to compensate for differences in population densities among deer species, and possible species differences in numbers of pellets defecated per individual, proportions of pellets in each plot instead of actual numbers were compared. As noted before, it was assumed that pellet group deposition rates were approximately the same for all species.

Results

Deer Counts

Grass-cutting in winter and floods during the monsoon season sometimes prevented counts from being completed. In March 1976, half of one transect could not be covered due to wild elephants in the work area. Another transect on dry grassland also was omitted then so that barasingha herds being observed there for another purpose would not be disturbed. Since many of the deer were along the

transect omitted, not including them in the count caused barasingha totals in March 1976 to be much lower than in March 1975 (Tables 5, 9). Nevertheless, since data analysis depended on proportions of deer and not on equal coverage of each vegetation type, it was judged that each type was covered sufficiently each season to enable valid comparisons to be made.

Chi-square tests of data from deer counts indicated that there was a highly significant distribution for all species during each data collection period, except for hog deer in December 1975. The number of expected observations then was too small to warrant use of the chi-square method. For all other data collection periods the smallest calculated chi-square was 26.981, compared with a table value of 16.750 ($df = 5$, $p < 0.005$).

Barasingha preferred dry grasslands in every season (Tables 5-10). As the hot season advanced, however, seasonally-wet grassland also was preferred. At all times, mixed deciduous forest, sal forest and sal savanna were avoided, or were used without preference being demonstrated.

Hog deer habitat preferences were similar to those of barasingha (Tables 5-10). Seasonally-wet and dry grasslands were most frequented in March. By May-June, hog deer were found most often in seasonally-wet grasslands, and during the monsoon season, they moved onto dry grassland. Forests and sal savannas were avoided, or frequented without a clear preference being shown. During December hog deer may have been more scattered, and the number of

TABLE 5.--Occurrence of three deer species in six habitats, March 1975, Sukla Phanta Reserve, Nepal

Habitat	Species	Area Surveyed (Ha.)	Proportion of Total Area (= Expected Proportion of Deer, p_e)	Number Observed	Number Expected	Proportion Observed, p_o	Confidence Interval on Observed Proportion, p_o
Seasonally wet grassland	barasingha	525	.268	23	310	.020	$.010 \leq p_o \leq .030$*
	hog deer	166	.252	33	14	.611	$.453 \leq p_o \leq .769$**
	chital	386	.288	89	88	.292	$.230 \leq p_o \leq .354$
Dry grassland	barasingha	634	.324	884	375	.765	$.736 \leq p_o \leq .794$**
	hog deer	200	.304	10	16	.185	$.058 \leq p_o \leq .312$
	chital	467	.349	4	106	.013	$.003 \leq p_o \leq .029$*
Lowland savanna	barasingha	699	.357	249	413	.215	$.186 \leq p_o \leq .244$*
	hog deer	252	.383	10	21	.185	$.058 \leq p_o \leq .312$*
	chital	394	.294	201	90	.659	$.594 \leq p_o \leq .724$**
Mixed deciduous forest	barasingha	24	.012	0	14	.000	--
	hog deer	15	.023	1	1	.019	--
	chital	31	.023	10	7	.033	$.009 \leq p_o \leq .057$
Sal savanna	barasingha	41	.021	0	24	.000	--
	hog deer	12	.018	0	1	.000	--
	chital	27	.020	0	6	.000	--
Sal forest	barasingha	35	.018	0	21	.000	--
	hog deer	13	.020	0	1	.000	--
	chital	33	.025	1	8	.003	$.000 \leq p_o \leq .009$*
Totals	barasingha	1,958	1.000	1,156	1,157	1.000	
	hog deer	658	1.000	54	54	1.000	
	chital	1,338	0.999	305	305	1.000	

*p_o significantly < p_e, avoidance indicated ($p < 0.10$).
**p_o significantly > p_e, preference indicated ($p < 0.10$).

TABLE 6.--Occurrence of three deer species in six habitats, May-June 1975, Sukla Phanta Reserve, Nepal

Habitat	Species	Area Surveyed (Ha.)	Proportion of Total Area (= Expected Proportion of Deer, p_e)	Number Observed	Number Expected	Proportion Observed, p_o	Confidence Interval on Observed Proportion, p_o
Seasonally wet grassland	barasingha	162	.102	129	44	.301	$.248 \leq p_o \leq .354$**
	hog deer	82	.143	13	4	.448	$.228 \leq p_o \leq .668$**
	chital	133	.123	1	9	.013	--
Dry grassland	barasingha	634	.398	265	170	.619	$.564 \leq p_o \leq .674$**
	hog deer	200	.348	5	10	.172	$.005 \leq p_o \leq .339$*
	chital	467	.430	2	32	.027	$.001 \leq p_o \leq .091$*
Lowland savanna	barasingha	699	.438	18	187	.042	$.081 \leq p_o \leq .066$*
	hog deer	252	.439	9	13	.310	$.104 \leq p_o \leq .516$
	chital	394	.363	3	27	.040	$.002 \leq p_o \leq .120$*
Mixed deciduous forest	barasingha	24	.015	16	6	.037	$.015 \leq p_o \leq .059$
	hog deer	15	.026	2	1	.069	--
	chital	31	.029	11	2	.147	$.049 \leq p_o \leq .245$**
Sal savanna	barasingha	41	.026	0	11	.000	--
	hog deer	12	.021	0	1	.000	--
	chital	27	.025	45	2	.600	$.464 \leq p_o \leq .736$**
Sal forest	barasingha	35	.022	0	9	.000	--
	hog deer	13	.023	0	1	.000	--
	chital	33	.030	13	2	.173	$.068 \leq p_o \leq .278$**
Totals	barasingha	1,595	1.001	428	427	0.000	
	hog deer	574	1.000	29	30	0.999	
	chital	1,085	1.000	75	74	1.000	

*p_o significantly < p_e, avoidance indicated ($p < 0.10$).
**p_o significantly > p_e, preference indicated ($p < 0.10$).

TABLE 7.--Occurrence of three deer species in six habitats, Aug.-Sept., 1975, Sukla Phanta Reserve, Nepal

Habitat	Species	Area Surveyed (Ha.)	Proportion of Total Area (= Expected Proportion of Deer, p_e)	Number Observed	Number Expected	Proportion Observed, p_o	Confidence Interval on Observed Proportion, p_o
Seasonally wet grassland	barasingha	79	.087	7	9	.071	$.009 \leq p_o \leq .133$
	hog deer	40	.105	0	16	.000	--
	chital	65	.076	0	14	.000	--
Dry grassland	barasingha	259	.286	70	28	.714	$.604 \leq p_o \leq .824$**
	hog deer	132	.346	123	54	.794	$.718 \leq p_o \leq .870$**
	chital	213	.250	4	47	.021	$.004 \leq p_o \leq .051$*
Lowland savanna	barasingha	232	.256	19	25	.194	$.098 \leq p_o \leq .290$
	hog deer	89	.233	18	36	.116	$.054 \leq p_o \leq .178$*
	chital	294	.345	0	65	.000	--
Mixed deciduous forest	barasingha	22	.024	0	2	.000	--
	hog deer	14	.037	3	6	.019	$.002 \leq p_o \leq .052$
	chital	29	.034	107	6	.572	$.486 \leq p_o \leq .658$**
Sal savanna	barasingha	153	.169	0	17	.000	--
	hog deer	46	.120	4	19	.026	$.004 \leq p_o \leq .064$*
	chital	99	.116	51	22	.273	$.194 \leq p_o \leq .352$**
Sal forest	barasingha	161	.178	2	17	.020	$.001 \leq p_o \leq .065$*
	hog deer	61	.160	7	25	.045	$.004 \leq p_o \leq .086$*
	chital	152	.178	25	33	.134	$.074 \leq p_o \leq .194$
Totals	barasingha	906	1.000	98	98	0.999	
	hog deer	382	1.001	155	156	1.000	
	chital	852	0.999	187	187	1.000	

*p_o significantly < p_e, avoidance indicated ($p < 0.10$).
**p_o significantly > p_e, preference indicated ($p < 0.10$).

TABLE 8.--Occurrence of three deer species in six habitats, Dec. 1975, Sukla Phanta Reserve, Nepal

Habitat	Species	Area Surveyed (Ha.)	Proportion of Total Area (= Expected Proportion of Deer, p_e)	Number Observed	Number Expected	Proportion Observed, p_o	Confidence Interval on Observed Proportion, p_o
Seasonally wet grassland	barasingha	162	.166	8	17	.076	$.014 \leq p_o \leq .138$*
	hog deer	82	.198	3	2	.250	--
	chital	133	.155	0	8	.000	--
Dry grassland	barasingha	259	.266	72	28	.686	$.587 \leq p_o \leq .794$**
	hog deer	132	.318	2	4	.167	--
	chital	213	.249	2	12	.041	$.000 \leq p_o \leq .149$*
Lowland savanna	barasingha	128	.131	17	14	.162	$.076 \leq p_o \leq .248$
	hog deer	50	.120	4	1	.333	$.001 \leq p_o \leq .862$
	chital	163	.190	13	9	.265	$.114 \leq p_o \leq .416$
Mixed deciduous forest	barasingha	24	.025	0	3	.000	--
	hog deer	15	.036	0	0	.000	--
	chital	31	.036	5	2	.102	$.008 \leq p_o \leq .281$
Sal savanna	barasingha	211	.217	8	23	.076	$.014 \leq p_o \leq .138$*
	hog deer	64	.154	2	2	.167	--
	chital	138	.161	12	8	.245	$.099 \leq p_o \leq .391$
Sal forest	barasingha	190	.195	0	20	.000	--
	hog deer	72	.173	1	2	.083	--
	chital	179	.209	17	10	.347	$.184 \leq p_o \leq .510$
Totals	barasingha	974	1.000	105	105	1.000	
	hog deer	415	0.999	12	11	1.000	
	chital	857	1.000	49	49	1.000	

*p_o significantly < p_e, avoidance indicated ($p < 0.10$).
**p_o significantly > p_e, preference indicated ($p < 0.10$).

TABLE 9.--Occurrence of three deer species in six habitats, March 1976, Sukla Phanta Reserve, Nepal

Habitat	Species	Area Surveyed (Ha.)	Proportion of Total Area (= Expected Proportion of Deer, p_e)	Number Observed	Number Expected	Proportion Observed, p_o	Confidence Interval on Observed Proportion, p_o
Seasonally	barasingha	394	.208	0	56	.000	--
wet	hog deer	125	.194	9	10	.180	$.051 \leq p_o \leq .309$
grassland	chital	290	.221	0	53	.000	--
Dry	barasingha	431	.227	92	62	.339	$.270 \leq p_o \leq .408$**
grassland	hog deer	136	.212	27	11	.540	$.373 \leq p_o \leq .707$**
	chital	317	.241	106	58	.442	$.366 \leq p_o \leq .518$**
Lowland	barasingha	653	.344	179	93	.661	$.592 \leq p_o \leq .730$**
savanna	hog deer	235	.365	14	18	.280	$.129 \leq p_o \leq .431$
	chital	368	.280	78	67	.325	$.253 \leq p_o \leq .397$
Mixed	barasingha	17	.009	0	2	.000	--
deciduous	hog deer	11	.017	0	1	.000	--
forest	chital	23	.017	0	4	.000	--
Sal	barasingha	211	.111	0	30	.000	--
savanna	hog deer	64	.100	0	5	.000	--
	chital	138	.105	9	25	.038	$.009 \leq p_o \leq .067$*
Sal	barasingha	190	.100	0	27	.000	--
forest	hog deer	72	.112	0	6	.000	--
	chital	179	.136	47	33	.196	$.134 \leq p_o \leq .258$
Totals	barasingha	1,896	0.999	271	270	1.000	
	hog deer	643	1.000	50	51	1.000	
	chital	1,315	1.00	240	240	1.001	

*p_o significantly < p_e, avoidance indicated ($p < 0.10$).
**p_o significantly > p_e, preference indicated ($p < 0.10$).

TABLE 10.--Summary, seasonal occurrence of three deer species as observed year-round in six habitats, Sukla Phanta Reserve, Nepal

	Seasonally Wet Grassland	Dry Grassland	Lowland Savanna	Mixed Deciduous Forest	Sal Savanna	Sal Forest
Barasingha						
March 1975	-	+	-	-	-	(-)
May-June	+	+	-	0	(0) or (-)	(0) or (-)
Aug-Sept	0	+	0	(0)	(-)	-
December	-	+	0	(0)	-	(-)
March 1976	(-)	+	+	(0)	(-)	(-)
Hog deer						
March 1975	+	0	-	(0)	(0)	(0)
May-June	+	-	0	(0)	(0)	(0)
Aug-Sept	(-)	+	-	0	-	-
December	(0)	(0)	0	(-)	(0)	(0)
March 1976	0	+	0	(0)	0	(0)
Chital						
March 1975	0	-	+	0	(0)	-
May-June	(-)	-	-	+	+	+
Aug-Sept	(-)	-	(-)	+	+	0
December	(0) or (-)	-	0	0	0	0
March 1976	(-)	+	0	(0)	-	0

+ = Habitat preference indicated ($p_o > p_e$).

- = Habitat avoidance indicated ($p_o < p_e$).

0 = Habitat neither preferred nor avoided (p_e lies within confidence interval on p_o).

( ) = Confidence intervals could not be calculated because no animals were observed, or observed proportions were so small that the lower limit was less than zero. In such cases, the magnitude of the difference in the raw data (expected vs. observed numbers) was compared with differences of similar magnitude (for each species and season) which had proved significant.

sightings was small. They then demonstrated no preference for any of the six vegetation types.

Chital were more clearly animals of the forest types (Table 10). They frequented lowland grasslands in March, but later in the year preferred the mixed deciduous forest and sal forest and savannas avoided by the other species (Tables 5-10). Chital avoided the seasonally wet grassland. Like hog deer, in December they showed no preference for any one vegetation type.

Fecal-Pellet Counts

As indicated previously five of the 56 fecal-pellet plots were lost during the 60-day interim between clearing and re-examination. Thirty-three plots remained to be examined in dry grassland, eight in seasonally-wet grassland and ten in savanna. For each deer species, there was no significant difference in the numbers of fecal pellets in the three vegetation types ($H = 4.007$, 1.799, and 4.453 for barasingha, hog deer and chital, respectively; $X^2 = 4.605$, $p < 0.10$). Barasingha pellets were significantly more abundant in dry grassland, however, than those of hog deer or chital (Table 11).

Discussion

Replication was possible only for deer counts made in March. Slight variations in preferences between 1975 and 1976 (Table 10) may have resulted from the similarities among lowland grassland types at that time of year. Grasses were uniformly short, and neither drought nor monsoon conditions prevailed. Since the three deer

TABLE 11.--Results of Kruskal-Wallis comparisons to detect significant differences in fecal pellet numbers from three deer species in dry grassland, seasonally-wet grassland, and lowland savanna, February-April 1976, Sukla Phanta Reserve, Nepal

	Dry Grassland	Seasonally-wet Grassland	Lowland Savanna
All species compared in:	4.875*	0.064	0.809
Barasingha vs. hog deer in:	15.910**	--	--
Barasingha vs. chital in:	11.546**	--	--
Hog deer vs. chital in:	4.364	--	--

*$X^2 = 4.605$, $p < 0.10$

**$|R._u - R._v| > 7.772$, $p < 0.10$

species are primarily grazers, food preferences probably influenced habitat selection less then because young grasses were higly palatable, and a larger variety of forage species was likely to be acceptable than later in the year (Bor, 1960; Heady, 1964; Martin, 1975). Deer thus moved more freely between grassland types than during other seasons. Fecal pellet distributions supported this interpretation, indicating that the three deer species frequented the three grassland types nearly equally until the end of April. Barasingha were the exception, and as indicated by their fecal pellets, occurred more commonly on dry grassland than hog deer or chital. While deer counts showed habitat preferences at the moment they were made, pellet counts reflected deer movements over a 60-day

period, including nocturnal movements. These may well have differed from movements observed during the day. Chital, for example, were seen venturing further onto the open grassland of Sukla Phanta proper at night than during the day.

Schaller (1967) noted that while barasingha utilize a variety of vegetation types, including open forest where grasses are present, historically their greatest abundance was reached in the sandy and marshy riverine grasslands of north India. Of the several vegetation types in the reserve, the southern grasslands are most similar to this environment. In central India, on the other hand, the southern barasingha exist entirely in a sal forest environment. Martin (1975) found that the deer in Kanha National Park infrequently entered the forest but confined themselves largely to meadows associated with this type (cf. sal savanna in Sukla Phanta Reserve). The Kanha deer migrated between seasonal ranges some 7 kms, apart in response to changing availability of water and food. Martin suggested that seasonality is more markedly felt in the central Indian highlands, which lack the alluvial flats of north India, where green forage and water are available even in the dry season. In Sukla Phanta where both lowland grasslands and upland sal forest environments exist, barasingha remained largely in the former, and moved little to satisfy seasonal requirements.

FACTORS INFLUENCING HABITAT SELECTION

Feeding Habits

Methods

Barasingha are primarily grazing animals (Schaller, 1967; Martin, 1975), and an attempt was made to identify food plants and to assess their distribution. Grasses and sedges were collected from 116 10-m^2 plots regularly placed at 300 m intervals along transects 500 m apart. Sixty plots were in central and western Seta Khera Phanta and in Sukla Phanta proper. The remaining 56 were located in the sal forest and savannas northeast of Sukla Phanta. Plots were examined after the monsoon season in October and early November, 1974-75, when the majority of grasses were in flower or fruit and therefore identifiable. Frequency of occurrence of grass and sedge species was recorded, and an ocular estimate of the area covered by each species in each plot was made.

Feeding observations were made during the premonsoon and monsoon seasons in Sukla and Seta Khera Phantas. Because of the wariness of the deer, and due to vegetation density during the monsoon, few opportunities to see directly what barasingha ate were possible. The presence of two other deer species prevented the identification of grazed or browsed plants as barasingha foods, even when livestock was absent (see beyond).

Results

Fifty-four grasses and sedges were collected in the reserve and at reserve headquarters (Appendix C). Twenty-three species were in the sample plots (Table 12); the remainder were collected outside the areas sampled. Perennial grasses constituted the dominant vegetation of the grasslands sampled. By using a species-area curve (Braun-Blanquet, 1932), it was estimated that most of the common species were collected (Figure 6).

The lowland (Sukla and Seta Khera Phantas) and upland (sal forest and savanna) environments each yielded 17 species in the areas sampled, with ten common to both. Of all species collected in the reserve, 35 occurred in the lowlands and 23 in the uplands with 12 common to both regions (Appendix C). Sterile (usually unidentifiable) grasses were found more frequently in the sal forest and savannas, as were bare ground, forbs, and coppicing woody vegetation. Very little nongrass vegetation was found in the lowlands, and bare ground occurred only on the more xeric sandy sites. The grasses Ophiuros exaltatus and Mnesithea laevis were not identified as separate species (Table 12) until specialists had examined the collection.

Five grasses which barasingha were observed consuming were Imperata cylindrica, Narenga porphyrocoma, Phragmites karka, Saccharum bengalense and Saccharum spontaneum (Table 13). One instance of browsing on Acacia catechu was observed. Barasingha also ate aquatic vegetation, plunging their muzzles into seasonal

TABLE 12.--Frequency of occurrence and estimated average percent[1] cover of 23 common grasses and sedges in 116 plots in Sukla Phanta Reserve, Nepal

Species	Sukla & Seta Khera		Sal forest & Savanna	
	Frequency	Cover	Frequency	Cover
Apluda mutica	.08	1-10	--	--
Cymbopogon sp.	.33	1-10	.04	1-10
Desmostachya bipinnata	.22	20-30	.34	1-10
Dicanthium bladhii	.12	1-10	.30	1-10
Eragrostiella bifaria	.10	20-30	--	--
Eulalia leschenaultiana	--	--	.20	10-20
Eulalia trispicata	--	--	.11	1-10
Eulaliopsis binata	.02	10-20	.48	10-20
Fimbristylis sp.	.18	20-30	--	--
Hemarthria compressa	.03	1-10	--	--
Heteropogon contortus	--	--	.04	1-10
Imperata cylindrica	.40	60-70	.11	30-40
Mnesithea laevis[2] Ophiuros exaltatus[2]	.13	1-10	.36	1-10
Narenga porphyrocoma	.63	50-60	.39	1-10
Ophiuros megaphyllus	--	--	.02	1-10
Phragmites karka	.03	1-10	--	--
Saccharum bengalense	.33	30-40	.07	10-20
Saccharum spontaneum	.53	20-30	.38	1-10
Scleria alta	.03	1-10	--	--
Sorghum nitidum	--	--	.11	1-10
Themeda arundinacea	--	--	.39	1-10
Vetiveria zizanioides	.02	1-10	.02	40-50
Unidentified sterile grass	.12	60-70	.55	30-40
Forbs, coppicing woody vegetation	.08	1-10	.86	10-20
Bare ground	.10	10-20	.64	10-20

[1]Ocular estimate on a scale of 1-10, e.g., 1 = 1-10% of plot area, 2 = 11-20%, etc.

[2]Not treated as separate species in the field (see text).

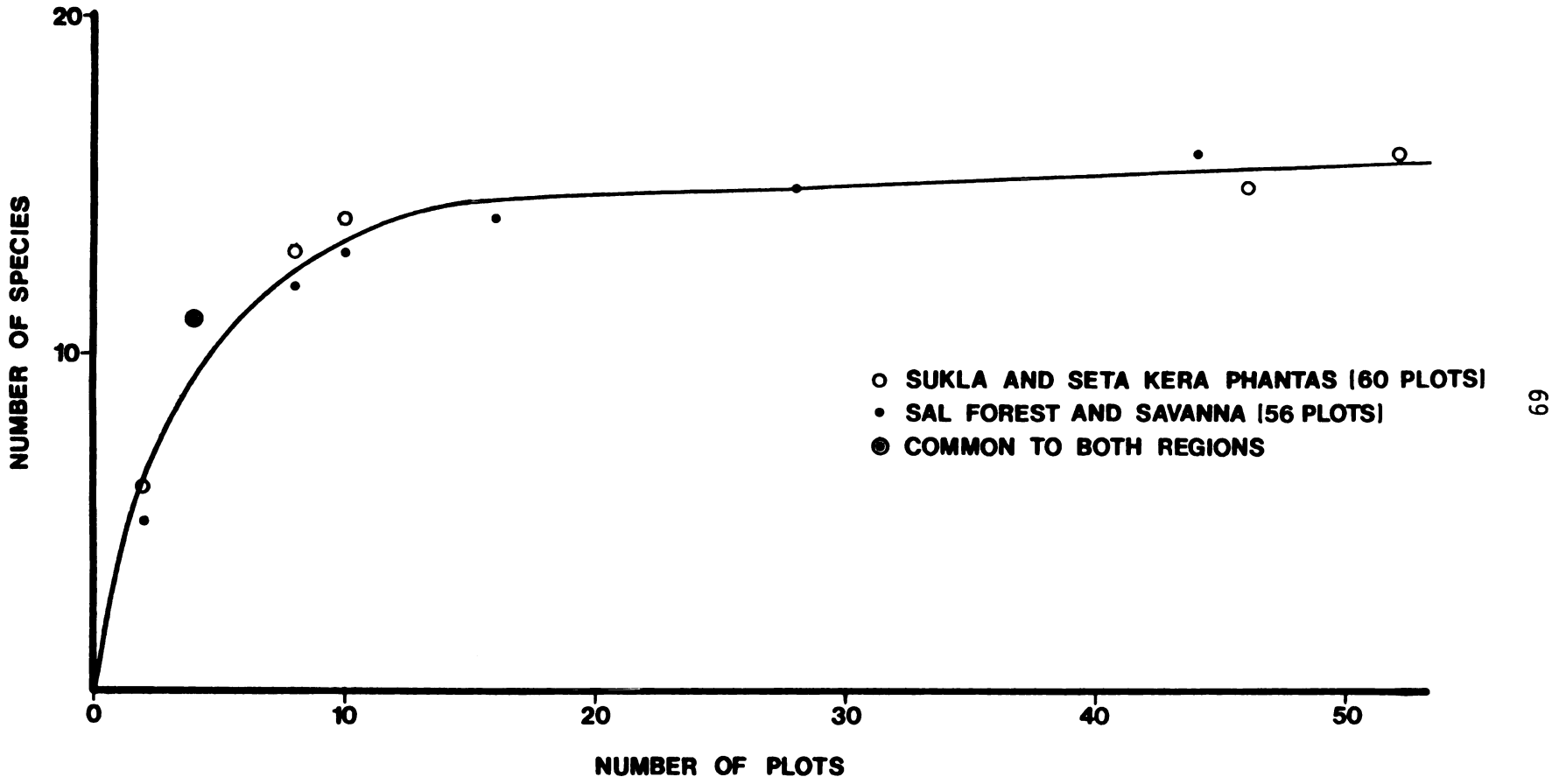


FIGURE 6. SPECIES-AREA CURVE FOR GRASSES AND SEDGES COLLECTED IN SUKLA PHANTA RESERVE, NEPAL, DURING OCTOBER-NOVEMBER 1974-75 (SEE TEXT).

TABLE 13.--Grazing incidence on several grasses and sedges by three deer species in Sukla Phanta Reserve, Nepal, during the premonsoon and monsoon seasons, 1974-76.

Species	Barasingha Instances Grazed[a]		Hog Deer Instances Grazed		Chital Instances Grazed	
	Premonsoon	Monsoon	Premonsoon	Monsoon	Premonsoon	Monsoon
Cynodon dactylon			2			
Imperata cylindrica	>10	>10	2	5	>10?[b]	
Narenga porphyrocoma	3			1?[b]		
Phragmites karka	5					
Saccharum bengalense		3				
Saccharum spontaneum		10				
Cymbopogon sp.[c]		x		x		x
Desmostachya bipinnata[c]		x		x		x
Fimbristylis sp.[c]	x	x	x	x	x	x
Hemarthria compressa[c]	x	x	x	x	x	x
Scleria alta[c]		x				
Themeda arundinacea[c,d]		x		x		x
Vetiveria zizanioides[c]	x		x		x	

[a]An observed bout of grazing by one animal was one instance.

[b]Circumstantial evidence, animals present where grass was freshly grazed, but grazing not actually observed; or species grazed in doubt.

[c]Species showing signs of grazing, possibly grazed as indicated, but the herbivore(s) responsible not actually observed.

[d]Possibly grazed by livestock in sal forest and savannas during the monsoon season.

ponds up to their eyes to reach it. The species taken in this manner were not identified, but possibly they belonged to the genus Naias (Schaller, 1967; Martin, 1975).

Repeated annual burning of I. cylindrica causes it to produce a form with tender foliage which is relished by grazing animals (Dabadghao and Shankarnarayan, 1973). This form grew abundantly on Sukla and Seta Khera Phantas (Table 12) and was seen to be grazed by barasingha more often than other grasses (Table 13). Coarse grasses such as N. porphyrocoma, S. bengalense and S. spontaneum were eaten by barasingha even after early growth, at which stage they would have been most palatable to livestock (Bor, 1960). The sharp-edged leaves of S. bengalense were pulled until broken and pieces 50-60 cms. long were consumed. The distal 10-20 cms. of S. spontaneum leaves were nipped off, or leaves up to 100 cms. long growing near the bases of plants were removed and consumed.

Although not common in the lowland areas sampled, P. karka was abundant in wet areas in eastern Seta Khera. It also occurred on the banks of some seasonal ponds in central Seta Khera, where the normally tall plants were hedged by grazing during the premonsoon season. Proximity to water may have increased grazing pressure on grasses near ponds as the dry season advanced (Stoddart et al., 1975). Since domestic animals were present in east and central Seta Khera during the premonsoon season, hedging of P. karka could not be attributed entirely to wild ungulates.

With the exception of P. karka, which occurred only in the lowlands, the five forage grasses known as food for barasingha grew

both on the lowlands and uplands, but the extent of their occurrence in the two regions differed. In the lowland areas sampled, the four species common to both regions were more abundant and widespread than in the upland plots (Table 12).

Discussion

While species other than the known forage grasses undoubtedly also were eaten, if the five forage grasses were preferred barasingha food items, their relatively greater abundance on the lowlands must have influenced habitat selection. Forage preference values could not be assessed, but I. cylindrica, for example, was judged to be a major item in the barasinghas' diet. Ngampongsai (1977) found that this grass was the most important food of sambar (Cervus unicolor) in the Khao-Yai National Park of Thailand where it comprised 67% of available forage and 88% of all food eaten. In Kanha National Park, however, it was rare, occurring in fewer than 0.1% of sample plots, and was not recorded as being eaten by barasingha (Martin, 1975).

In further comparison to barasingha food habits in Sukla Phanta, Martin (1975) found that eight of 26 common grasses on the Kanha Meadow were regularly eaten by barasingha. Intake of five of these was "high" or "medium" (these terms were not defined). Intake of N. porphyrocoma, however, was "low." P. Karka was said to be heavily grazed in Kanha while in flower after the monsoon season, and intake was described as "medium." S. spontaneum was one of two important forage species (intake "high") during the

winter and premonsoon seasons. S. begalense is a north Indian grass (Bor, 1960) and does not occur in Kanha. While three of the known forage grasses from Sukla Phanta were also consumed in Kanha, I. cylindrica may not have been recorded as being eaten simply because it was encountered so infrequently by grazing deer.

Schaller (1967) and Martin (1975) also noted that barasingha sometimes consumed dry grass in winter even with green forage available. This was not observed in Sukla Phanta. Six browse species were recorded in Kanha, but as in Sukla Phanta, browsing was rarely observed, and grasses obviously formed the bulk of the barasinghas' diet.

Effect of Livestock Grazing on Habitat Use by Barasingha

Seasonal grazing by cattle and domestic buffalo (Bubalus bubalis) within the reserve was observed in the phantas south of the forest bordering the north side of Sukla Phanta proper. Herds entered this area illegally from nearby villages to the east, notably Jilmila and Radhapur (Figure 1). Animals from Singhpur grazed in village fields south and west of their home. When in the reserve, they fed in sal forest north of the village, and also in Bameria Phanta. Occasional incursions by small groups of stock from India also took place along the southwestern reserve boundary.

After winter fires, livestock grazing began on new grass in Karaiya and Bameria Phantas and also on eastern Seta Khera. From the latter area, the herds sometimes wandered as far west as the

Seta Khera Loop. All of Bameria and Karaiya Phantas were grazed but Sukla Phanta proper was avoided by herdsmen, probably because this was the area most likely to be visited by reserve personnel.

On one occasion, 1,450 head of cattle and buffalo were counted in one day during the 1975 premonsoon season in Karaiya, Bameria, and eastern Seta Khera Phantas. The heaviest grazing was observed near points of entry into the reserve. Graziers did not drive their animals to fresh areas at once, but let them wander daily over previously-grazed ground. This caused local overgrazing with livestock trails and exposed bare soil with scattered clumps of severely cropped grass.

Livestock grazing on the southern phantas declined beginning in May each year. Among factors responsible were (1) a reduction in forage quality as grasses grew coarse and less palatable, (2) the recovery of village grazing grounds outside the reserve sufficient to permit renewed grazing, and (3) increased difficulty of movement and vision for herdsmen on foot where grasses had grown tall and rank.

When monsoon rains began, livestock no longer grazed regularly on the southern phantas. Flooding and dense grasses effectively barred both cattle and herdsmen. Domestic buffalo, however, were better adapted to wet habitats than cattle and continued to wander unattended during the rains onto Karaiya Phanta in small groups.

As livestock numbers decreased in eastern Seta Khera during the premonsoon season, barasingha increased in that area. There was

a corresponding decline in barasingha numbers on western Seta Khera and on Sukla Phanta proper (Figure 7). Recently-dropped antlers and fresh fecal pellets found in early March in eastern Seta Khera showed that a few deer at least frequented the area well before livestock use declined. They may have been present only at night, when livestock and graziers returned to the villages, or they may have remained hidden during the day. Nonetheless, reduced numbers of livestock and humans as well as the availability of water and perhaps more succulent forage on the seasonally-wet grasslands of the east side of the reserve caused barasingha to move eastward as the premonsoon season advanced.

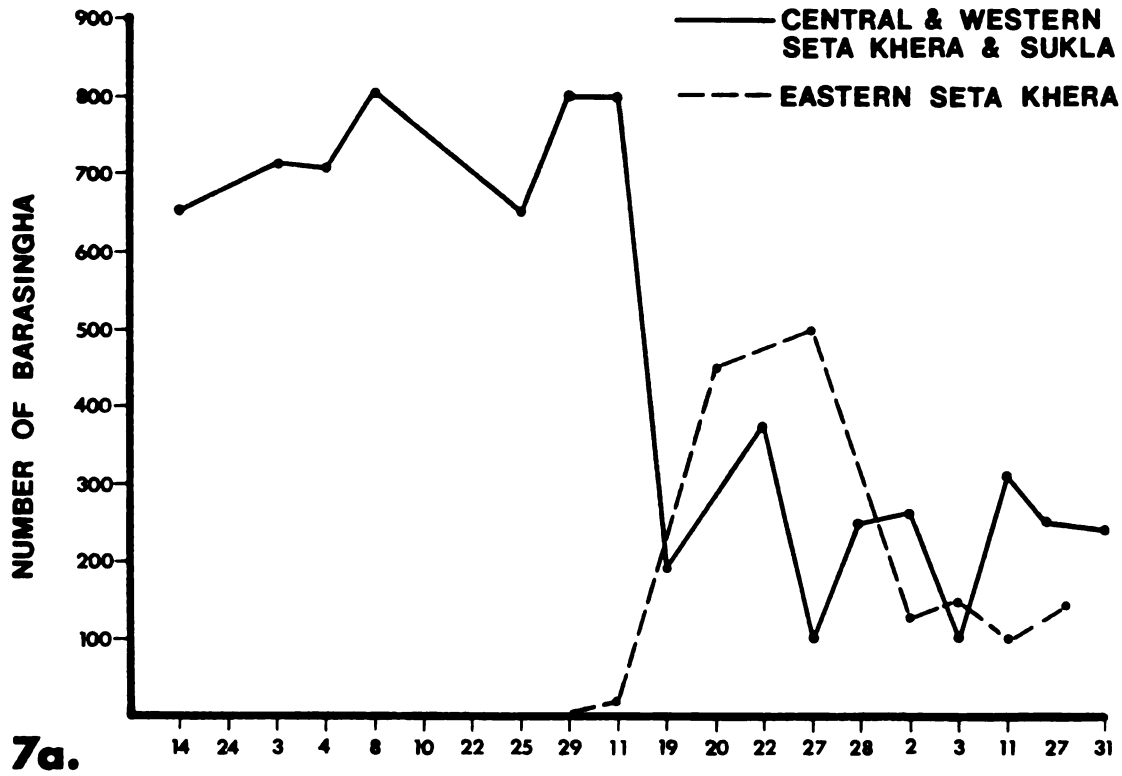
Additional evidence indicating that barasingha avoided livestock and graziers was found in the Kakraha Block of Dudhwa National Park. During the 1973 premonsoon season with livestock present, only 16 barasingha were seen in Kakraha. A year later after the removal of domestic animals and herdsmen, there were 150-200 deer, and during the same season in 1975, 276 barasingha were counted (Schaaf and Singh, 1977).

Livestock grazing was seen to occur in most of Sukla Phanta Reserve during the study, but its extent and duration outside the southern phantas was not well observed. On the upland savannas and in the sal forests, grass fires were started later, and grazing therefore began later too. On these areas livestock continued to graze during the monsoon season because extensive floods did not occur and vegetation was not as dense as in the lowlands.

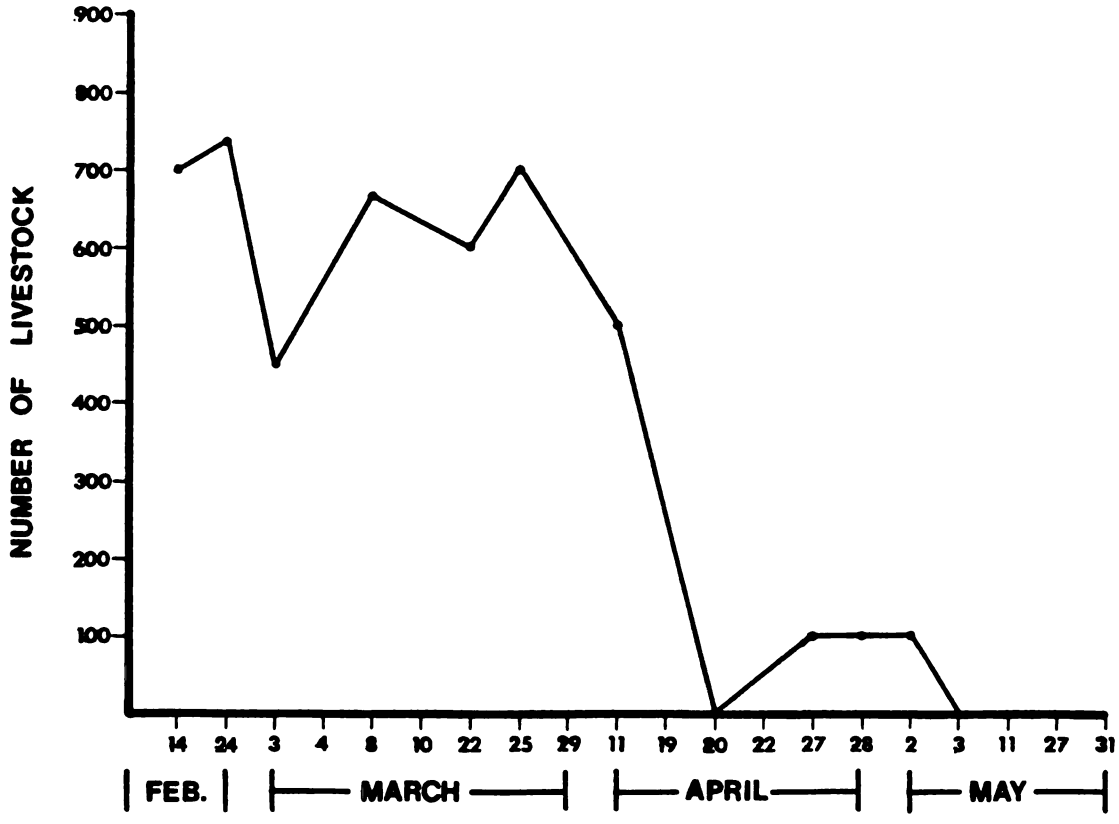
Figure 7.--Avoidance by barasingha of areas used by livestock and graziers:

(a) barasingha numbers on central and western Seta Khera Phanta and on Sukla Phanta (livestock grazing slight or absent) compared with numbers of eastern Seta Khera Phanta (livestock grazing seasonally intensive), February-May 1975, and

(b) livestock numbers on eastern Seta Khera Phanta, February-May 1975, Sukla Phanta Reserve, Nepal.



7a.



7b.

CALENDER DATES

Effects of Grazing and Fire on the Grasslands of the Southern Phantas

Climate favors forest as the natural climax vegetation in the Sukla Phanta region. Where grasslands occur, they are caused by fires, or exist on sites too wet for forest development (Seth, 1954; Bor, 1960; Champion and Seth, 1968).

Most of the southern grasslands in the reserve belong to the Phragmites-Saccharum-Imperata cover type (Whyte, 1968; Dabadghao and Shankarnarayan, 1973) and occur on poorly-drained soils. Grazing, cutting, and burning induce a gradual drying of the habitat, and a change to communities dominated by Imperata cylindrica, Saccharum spontaneum, and Sclerostachya fusca on wet sites, and by Imperata cylindrica, Desmostachya bipinnata and Saccharum bengalense where it is drier.

Annual burning caused the development of a sward in which the form of I. cylindrica favored by grazing animals predominates. Such a sward is able to tolerate "a considerable amount of hard grazing" (Dabadghao and Shankarnarayan, 1973), and this grass, with emergent specimens of D. bipinnata, was distributed widely over Sukla Phanta proper and central Seta Khera Phanta. It was kept closely grazed during the premonsoon and monsoon seasons by barasingha, the only ungulates present then in sufficiently large numbers to accomplish it.

Under continuous burning and grazing pressures, the Imperata-Desmostachya association can give way to a Sporobolus-Paspalum-Chrysopogon grassland (Whyte, 1968). Chrysopogon

aciculatus is one of the most resistant to trampling and grazing of the Indian grasses and is considered to be noxious since it is not a desirable forage, and because the sharp seed calli are able to injure grazing animals (Bor, 1941, 1960). Along with the unpalatable forb Cassia tora, Chrysopogon aciculatus was common outside the reserve on the meadows near reserve headquarters (Appendix C), where heavy livestock grazing regularly occurred. Thus, under continuous heavy grazing pressure, the possibility for change to grasslands dominated by or containing Chrysopogon and other less desirable grasses exists also in the reserve. Elimination of livestock from the southeastern portion of the reserve would reduce grazing pressure there.

Controlled burning also can affect grassland condition (Daubenmire, 1968). During the study, all of the southern phantas were burned annually. Whether under a reduced burning regime, such as biennial fires, other species would increase in an established I. cylindrica grassland, or whether an important source of forage would be lost if I. cylindrica then took on a more robust form, are relevant questions which cannot be answered without further study.

It has already been noted that many of the perennial grasses in the reserve are more desirable forage in the early stages of growth after a fire. Cattle in particular are more selective as the vegetation grows older and more fibrous (Bor, 1960). Burning induces the rhizomes to send up fresh shoots, but if grazing is too heavy or prolonged, the rhizomes weaken, and plants may die or assume a depauperate form (Whyte, 1957; Panwar, in press).

Before restorative measures were begun on the Kanha Meadow of Kanha National Park, fire followed by concentrations of chital and other ungulates caused the decline of certain perennial species, e.g., Themeda triandra, Sorghum halpense, and Phragmites karka. The grasses which remained then were grazed quickly, or dried each year before the end of the premonsoon season when fodder was in short supply (Martin, 1975; Panwar, in press).

Similar conditions did not occur in Sukla Phanta, where a high water table benefitted growing rhizomatous perennials. Except on the more xeric sites, grasses in Sukla Phanta continued to grow rapidly even during the driest time of year. Signs of local overgrazing by livestock (severely cropped stubble, trampled and exposed soils) were found only on the driest sites, such as seasonally droughty parts of Karaiya Phanta. Even there, once grazing by cattle had been halted by monsoon conditions, tall, dense grasses grew in each year of the study. Although grazing impact in terms of ungulate density may have been greater on the Kanha Meadow than on the southern phantas of the reserve, the more favorable soil moisture relations in Sukla Phanta may bring about a higher ungulate carrying capacity there during the premonsoon dry season than on the Kanha Meadow and similar grasslands in Kanha National Park.

CONCLUSIONS

In the Sukla Phanta Wildlife Reserve, northern barasingha inhabited early successional grasslands, mainly on alluvial flood plains. Preferred habitats on those sites were dry and seasonally-wet grasslands. Including the less-utilized adjacent areas of lowland savanna and marsh (the latter frequented to an undetermined extent), some 32 km^2 supported from 908 to approximately 1,295 animals in March 1976, or about one-third of the world's extant wild barasingha population.

Based on these population figures, there were approximately 28-40 barasingha per km^2 in the reserve over the 32 km^2 lowland habitats. Density on the central grasslands of Sukla and Seta Khera Phantas reached about 74-105 animals per km^2 during the pre-monsoon season of maximum barasingha concentration.

Aside from the annual congregation of herds on the newly-grassed phantas following winter fires, barasingha moved little in response to seasonal changes. A few animals, however, were found in the sal forest and on the sal savannas during the monsoon and in early winter when green grass and water were widespread. During the rut also, individual interactions and restlessness occasioned by the mating season caused some animals, especially stags, to leave the southern grasslands temporarily. To a large extent, the yearly

cycle of barasingha life, including the rut and fawning, was carried out entirely on or immediately adjacent to the southern phantas. Factors of importance in determining preference for these grasslands were the relative abundance of forage grasses such as Imperata cylindrica and the presence of drinking water during the premonsoon dry season.

Although the sal forest grasslands were not preferred habitat, in the Kakraha Block of Dudhwa National Park barasingha retreated into sal forests when disturbed by graziers. In the future, if increased barasingha numbers are observed in the sal forests and savannas of the Sukla Phanta Reserve, it could indicate either that human or other disturbances had occurred on the lowlands, or that carrying capacity there had been exceeded, causing the animals to move into less-preferred habitats.

Seasonal flooding, water-logged soils and fire maintained a grassland disclimax (Oosting, 1956) favorable to barasingha on the lowlands of the reserve. So long as present conditions prevail, no successional changes would likely occur to reduce the habitat area used by barasingha. A decrease in the incidence of burning may be desirable to improve grassland quality, but the most judicious use of fire in managing the vegetation has yet to be determined.

Where barasingha and two other deer species occurred without domestic animals on the south-central grasslands of the reserve, there was no indication that the present populations caused the vegetation to be over-utilized. Less-palatable "increaser"

species (Petrides, 1975; Stoddart et al., 1975) found on village grazing grounds around reserve headquarters did not occur on lowland grasslands in the reserve. Removal of domestic animals from the southeast portion of the reserve would eliminate local overgrazing there, and make available additional habitat for barasingha during the premonsoon season.

Barasingha numbers in Sukla Phanta increased during the study, when 25-28% of the March 1975-76 population comprised fawns and yearlings. Forest guards and villagers stated on several occasions that barasingha had been even more numerous before the 1968 and 1972 floods. It is possible, therefore, that the habitat is capable of supporting larger numbers of barasingha before carrying capacity is reached, and that further population growth can be expected.

RECOMMENDATIONS

In May 1968, it was announced that Sukla Phanta Reserve is to be expanded eastward to include the Dhaka Shikar Reserve and parts of adjacent forest blocks (L. Fleming and C. Holloway, personal communications). The new reserve will be approximately double the size of the existing one. This most welcome development obviates certian planned recommendations, such as the relocation of Jilmila Village (Figure 1) on the east side of the reserve (in addition to the relocation of Haraiya and Singhpur, plans for which existed prior to this study). It is assumed also that livestock grazing and poaching have been eliminated from the reserve since 1976, with the advent of improved law enforcement. The following additional recommendations are offered for consideration by the Nepalese authorities, to assist in efforts to protect the barasingha and the habitat on which it depends.

1. Before the present study ended, recommendations to eliminate grass-cutting in the reserve over a two-year period were submitted to the Office of National Parks and Wildlife Conservation. The two-year period would provide time for local people to find alternative ways to roof their houses. Tiles, for example, already are made locally and used by some.

In the event that more extensive tile manufacture proves to be impractical and that grass-cutting continues in the reserve,

then first, grass-cutting must be eliminated both south of the East-West Track in Sukla Phanta proper and from all of Seta Khera Phanta (Figure 3), and second, grass-cutting should not be permitted before December 15 each year, to insure that the peak of the barasingha rut has passed.

2. Counts of barasingha population size and sex and age composition should be continued each March by reserve personnel, following the procedures and the ground route described. Personnel should be trained to do this work and supplied with binoculars and any other needed equipment. Provided that identical procedures are followed on similar dates, changes in barasingha numbers and reproductive rates may thus be determined and related to changes in the environment.

3. An inventory should be made to obtain more detailed descriptions of vegetation types in the reserve, especially in the proposed extension. The objective should be to prepare a vegetation map for the entire new reserve, and to document the present location and species composition of various vegetation types. Several permanent transects could be established to measure vegetative and habitat changes, using the "three-step" method (Parker, 1954), which includes making a permanent photographic record of key range areas.

4. The following additional areas of investigation are considered to be of immediate importance, and should receive priority over other research:

a. A study of barasingha food preferences using fecal-pellet analyses and observations of feeding by tame animals, if carried out in conjunction with similar studies on hog deer and chital, would show how these sympatric species utilize food resources, and whether competitive exploitation of forage occurs. Knowledge of food preferences also could be used to assess range condition and trend (Petrides, 1975).

b. Range carrying capacities for barasingha, hog deer, and chital should be determined. Insuring that populations always remain slightly below carrying capacity will help to maintain the health of both the deer and the habitats which support them (McCullough, in press).

c. The effects of fire and grazing on the grassland vegetation should be studied using exclosure plots. It is possible that reduced burning would allow the increase of desirable forage species, or improve the quality of forage. Conversely, protection from fire may cause the decline of presently-utilized food plants, such as the tender, preferred form of Imperata cylindrica described earlier.

d. Areas of potential barasingha habitat in the proposed reserve extension should be identified. The opportunity should not be lost to study the manner of location and colonization of these areas by the deer. Such information may be useful in re-establishing or introducing barasingha in other reserves (see below).

5. The causes of the decline in the Karnali-Bardia Reserve barasingha population should be investigated, and if conditions

warrant it, the population still extant there should be secured, perhaps through the introduction of additional stock from Sukla Phanta. Introduction into Chitawan National Park also could be considered if studies of environmental conditions there indicate that the area is suitable, and especially if any portion of that park proves to have been part of the species' former range. Establishing several barasingha populations would be added insurance against the species' extinction in Nepal. Where introductions are made, only animals in good health and free of disease should be used.

6. Consideration should be given to creating an international reserve between India and Nepal, to include the Sukla Phanta Reserve and the 10 km^2 of Indian territory adjoining it south of the international boundary and north of the Mahakali River. That territory is part of a natural unit to which Sukla Phanta belongs, and the border between the two areas is identified on the ground only by widely-spaced stone boundary markers. Before human settlement began there in 1975, the Indian area was observed to harbor barasingha, hog deer, chital, tigers, and a few remaining wild elephants. A joint reserve would help to secure the entire area and to protect the endangered species living there. Such international reserves have been successful in other countries, and it is believed that the one here proposed would be the first in South Asia. It could stand as a Peace Park and symbol of cooperation between the two nations.

SUMMARY

The northern subspecies of barasingha or swamp deer was studied between April 1974 and May 1976 in the Sukla Phanta Wildlife Reserve of Nepal. The main study objectives were to initiate collection of basic ecological data, and to use these as well as data on environmental conditions to assess barasingha status.

Total population counts were made when barasingha were seasonally congregated during March on the south-central grasslands of Sukla and Seta Khera Phantas. When the largest herds formed, the smallest number of sightings were made. This observation and close agreement among maximum herd counts in 1975 indicated that the largest herds tended to approach total population size, with perhaps few animals remaining uncounted. Thus, minimum populations of 805 deer in 1975 and 908 in 1976 were counted along a standardized ground route covering the area of barasingha concentration.

Aerial population counts were less accurate since large herds were estimated rather than counted, and because small barasingha groups could have been confused with hog deer or chital from the air. Aerial counts confirmed that barasingha concentrated on the south-central grasslands in March, and showed that prior to human settlement on the Indian side of the border in 1975, they occurred also in Indian territory adjacent to the reserve.

Fecal-pellet counts in March 1976 indicated that 1,295 barasingha, 273 hog deer, and 342 chital occupied the south-central grasslands. Although some barasingha were missed during deer counts, the entire population present on the grasslands contributed to pellets counted, and 1,295 deer therefore approximated maximum population size in the first quarter of 1976. Hog deer and chital numbers represented only animals present on the grasslands when pellet counts were made. Both species were more widespread in the reserve than barasingha during March. Judging from the habitat where hog deer were regularly seen, they were the least numerous of the three deer. Chital were the most widespread and probably the most abundant ungulates in the reserve.

Since barasingha in Sukla Phanta did not form large "breeding herds" and were infrequently seen during the rutting season, mating activity was monitored by recording stag rutting calls. Most activity occurred on the southern grasslands. A November peak in calls during the 1974-75 rutting seasons corresponded to the peak in mating activity, since new fawns were seen the following July-August after a 240-250 day gestation period. A September calling peak may have represented pre-rut activity, when stags competed for dominance and determined their access to estrous hinds.

The population comprised 16.4-32.7% adult males, 35.2-48.6% adult females, 7.1-16.1% yearlings, and 9.2-17.7% fawns. The largest and most complete sex and age counts, which were judged best to represent population structure, were obtained in March on the

southern grasslands, when up to 30-40% of the minimum population at a time were classified.

The minimum barasingha population showed an apparent increase of 12.8% in 1975-76. The large proportion of hinds (about 40%) indicated that the potential increase was higher than that observed. Comparison with barasingha population data from Kanha National Park where an 18-20% annual increment was reported during 1971-73 suggested that higher mortality rates rather than poor breeding success caused the lower increase observed in Sukla Phanta Reserve.

Barasingha were preyed upon by tigers, and some new-born fawns were undoubtedly taken by jackals. Poaching also occurred, but as in the case of predation, its effect on the population could not be assessed. Mortality caused by disease or ectoparasites was not observed. Flash floods on the Mahakali River in 1968 and 1972 reportedly drowned large numbers of barasingha. The danger of recurrent severe floods remains a threat to the present day.

Habitat preferences of barasingha, hog deer, and chital were determined from transect counts in six vegetation types in the reserve. Barasingha occurred mostly on dry grassland throughout the year and avoided forested areas. Their preferred habitats in the reserve closely resembled habitats on the north-Indian alluvial plains, where this subspecies once attained its greatest abundance. Hog deer habitat preferences were similar to those of barasingha, but hog deer showed a greater affinity for seasonally-wet grasslands

until monsoon flooding caused them to move to dry grasslands. Chital frequented forests and savannas more than the other deer.

All three deer species occurred on the southern grasslands during the premonsoon season, and fecal-pellet distributions indicated that for each species, dry grassland, seasonally-wet grassland and lowland savanna were equally frequented. When deer species were compared within each of these types, barasingha pellets were more abundant than the others on dry grassland. While deer counts revealed distribution at the time they were made, fecal-pellet distributions were a record of deer movements over a 60-day period. It is believed, therefore, that physical similarities among the three habitats and an abundance of new forage caused preferences on the southern grasslands to be less strictly defined than at other seasons.

Forty-six grasses and sedges were collected in the reserve, and an additional eight species were found outside near reserve headquarters. Barasingha were observed to eat five common perennial grasses, Imperata cylindrica, Narenga porphyrocoma, Phragmites karka, Saccharum bengalense and Saccharum spontaneum. These forage species attained their greatest abundance on the southern grasslands of the reserve. The distribution of these grasses and the availability of drinking water during the premonsoon season were important factors in determining habitat selection.

Barasingha tended to avoid the southeastern portion of the reserve where livestock grazed during the premonsoon season.

Livestock grazing declined by the end of May each year as domestic animals moved to village grazing grounds. Barasingha then occupied the grasslands vacated, attracted there by drinking water and more succulent forage growing where soil moisture was greater.

Signs of local overgrazing on the southern grasslands occurred where livestock grazed during the premonsoon season, but were absent where wild ungulates grazed alone. "Increaser" species such as Chrysopogon aciculatus and Cassia tora, common on heavily-grazed village lands, were not found on reserve grasslands. A high water table provided favorable growing conditions for perennial grasses even during dry periods, and may have helped increase carrying capacity relative to seasonally-droughty areas such as Kanha National Park.

Fire, seasonal flooding, and water-logged soils maintained reserve grasslands. Annual burning caused the development of a tender form of the common grass Imperata cylindrica, believed to be an important barasingha forage. Exclusion of fire could alter the form of this grass, thereby decreasing forage supplies. As long as existing environmental conditions prevail, however, successional changes leading to loss of barasingha habitat are not likely to occur.

The annual cycle of barasingha life took place largely on the southern grasslands of the reserve, where approximately 32 km^2 supported about one-third of the world's remaining wild barasingha population. The deer moved little in response to seasonal change,

and future increases in their numbers in less-preferred habitats in the reserve may indicate disturbance, or that carrying capacity on the southern grasslands had been exceeded.

During the study an apparent population increase was observed. Since the population before the 1968 and 1972 floods was said to have been larger than that in 1975-76, the habitat may be capable of supporting even greater barasingha numbers, and further population increases can be expected before carrying capacity is reached. Removal of livestock from the southeastern reserve grasslands would free additional premonsoon season habitat.

Recommendations are offered to assist in barasingha conservation in the reserve and to answer reserach questions of immediate concern. The latter include food preference studies, determination of range carrying capacities, studies of the effects of fire and grazing on the grassland vegetation, and observations on the colonization of new habitats by barasingha in a proposed reserve extension. Other recommendations include elimination of grass-cutting on the southern reserve grasslands, continuation of population counts by reserve personnel, securing the barasingha population of the Karnali-Bardia Reserve, investigating possible barasingha introduction into Chitawan National Park, and considering the creation of an international reserve to include Sukla Phanta and a section of Indian territory on its southern boundary.

APPENDICES

APPENDIX A

MAMMALS

APPENDIX A

MAMMALS

TABLE A-1.--Mammals noted during barasingha study (April 1974 to May 1976) in Sukla Phanta Reserve, Nepal

Common Name[1]	Scientific Name[1]	Estimated Relative Abundance[2]
Rhesus macaque	Macaca mulatta	common
Common langur	Presbytis entellus	common
Tiger	Panthera tigris	present[3]
Leopard	Panthera pardus	rare[4]
Jungle cat	Felis chaus	common
Small Indian civet	Viverricula indica	common
Common mongoose	Herpestes edwardsi	common
Jackal	Canis aureus	common
Indian fox	Vulpes bengalensis	present[3]
Sloth bear	Melursus ursinus	present[3,4]
Smooth Indian otter	Lutra perspicillata	present[3]
Grey musk shrew	Suncus murinus	common
Fivestripped palm squirrel	Funambulus pennanti[5]	present[3]
Common house rat	Rattus rattus	common
Indian porcupine	Hystrix indica	present[3,4]
Indian hare	Lepus nigricollis	common
Indian elephant	Elephas maximus	rare

TABLE A.1.--Continued

Common Name[1]	Scientific Name[1]	Estimated Relative Abundance[2]
Nilgai (blue bull)	Boselaphus tragocamelus	present[3]
Barasingha (swamp deer)	Cervus duvauceli	common
Sambar	Cervus unicolor	rare[4]
Hog deer	Axis porcinus	common
Chital (spotted deer)	Axis axis	common
Barking deer	Muntiacus muntjak	present[3]
Wild boar	Sus scrofa	present[3]

[1]Arrangement and nomenclature after Prater (1971).

[2]Applies only to the reserve, and does not indicate abundance in the surrounding country, where most of the larger species are altogether absent.

[3]Indicates that the species occurred in the reserve, but observations were not sufficient to estimate relative abundance.

[4]Presence detected from tracks, droppings, or calls; animals themselves not seen.

[5]Identification uncertain.

APPENDIX B

ECTOPARASITES AND BITING FLIES

APPENDIX B

ECTOPARASITES AND BITING FLIES

TABLE B-1.--Ectoparasites and biting flies collected in Sukla Phanta Reserve, Nepal.[1]

	Where Found	Remarks
IXODIDATE (Ticks)		
Dermacentor auratus	Human ankle	
Haemaphysalis bispinosa	Barasingha, Chital	
Rhipicephalus scalpturatus	Swept from grasses by passing vehicle	NEW DISTRIBUTION RECORD, previously known only from Assam
HAEMATOPINIDAE (Sucking Lice)		
Solenopotes sp.	Barasingha	NEW SPECIES
HIPPOBOSCIDAE (Louse Flies)		
Lipoptena axis	Barasingha Chital	First record of a louse fly on barasingha
Lipoptena saepes	Hog deer	A single male taken, male of this species previously undescribed

TABLE B-1.--Continued

	Where Found	Remarks
TABANIDAE (Deer or Horse Flies)		
Haematopota marginata	Free-living	
Haematopota sp.	Free-living	NEW SPECIES
Hippocentroides desmotes	Free-living	
Tabanus spp.	Free-living	One or more spp., identifications not received

[1]Ticks identified by H. Hoogstraal, NAMRU 3, Cairo; lice by K. C. Emerson, Department of the Army, Washington, D.C., and C. F. Weisser, Heidelburg University, Germany; louse flies by T. C. Maa, Taipei, Taiwan; tabanid flies by F. C. Thompson, U. S. National Museum, Washington, D.C., and J. F. Burger, Univeristy of New Hampshire, Durham, N. H.

APPENDIX C

GRASSES AND SEDGES

APPENDIX C

GRASSES AND SEDGES

TABLE C-1.--Grasses and sedges collected in Sukla Phanta Reserve, and near Reserve Headquarters, Nepal

Species	Where Collected			Annual, perennial, or short-lived perennial
	Low-lands[1]	Up-lands[2]	Head-quarters[3]	
Apluda mutica[4]	x			p
Arundinella bengalensis	x			p
Bothriochloa pertusa		x		p
Brachiaria ramosa	x		x	a
Chloris dolichostachya			x	p
Chrysopogon aciculatus			x	p
Cymbopogon flexuosus	x			p
Cymbopogon jwarancusa	x			p
Cymbopogon osmastonii	x			p
Cynodon dactylon	x		x	p
Cyperus iria	x			a[5]
Cyperus nivens	x			p
Cyperus rotundus	x			p[5]
Dactyloctenium aegyptium			x	a
Desmostachya bipinnata	x	x	x	p
Dichanthium bladhii	x	x		p
Digitaria granularis	x			a[5]
Digitaria violascens	x			a[5]
Eleusine indica			x	a
Eragrostiella bifaria	x			p
Eragrostis tenella			x	a

TABLE C-1.--Continued

Species	Where Collected			Annual, perennial, or short-lived perennial
	Low-lands[1]	Up-lands[2]	Head-quarters[3]	
Eragrostis unioloides		x	x	a or slp
Eulalia contorta		x		p
Eulalia fastigiata		x		p
Eulalia leschenaultiana		x	x	p
Eulalia trispicata		x		p
Eulaliopsis binata	x	x		p
Fimbristylis dichotoma	x			a
Fimbristylis ovata	x			a?
Hemarthria compressa	x		x	p
Heteropogon contortus		x		p
Imperata cylindrica	x	x		p
Kyllinga nemoralis			x	p
Mnesithea laevis	x	x		p
Narenga porphyrocoma	x	x		p
Ophiuros exaltatus	x	x		p
Ophiuros megaphyllus		x		p
Oplismenus burmanii			x	a
Panicum antidotale	x			p
Paspalidium flavidum			x	a
Perotis hordeiformis		x		a or slp
Phragmites karka	x			p
Saccharum bengalense	x	x	x	p
Saccharum ravennae	x			p
Saccharum spontaneum	x	x		p
Scleria alta	x			p
Scleria levis		x		p
Sclerostachya fusca	x	x		p

TABLE C-1.--Continued

Species	Where Collected			Annual, perennial, or short-lived perennial
	Low-lands[1]	Up-lands[2]	Head-quarters[3]	
Setaria pallide-fusca	x			a[5]
Sorghum nitidum		x		p
Sporobolus diander	x			p
Themeda arundinacea	x	x		p
Themeda villosa	x			p
Vetiveria zizanioides	x	x	x	p

[1]Dry grassland, seasonally wet grassland, lowland savanna.

[2]Sal forest, sal savanna.

[3]Headquarters is on an upland (sal forest) site adjacent to and north of the Singhpur Village fields.

[4]Identifications by T. A. Cope and W. D. Clayton, Royal Botanic Gardens, Kew, England, and K. R. Rajbandhari, Department of Medicinal Plants, Kathmandu, Nepal.

[5]Located only as apparent invaders on disturbed sites, where vehicular track improvement work had been done.

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