CERTAIN ASPECTS OF ECOLOGY AND BEHAVIOUR OF THE SATYR TRAGOPAN, (*Tragopan satyra*) IN THE SINGHALILA NATIONAL PARK, DARJEELING, INDIA

THESIS

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CERTIFICATE

This is to certify that Miss Sarala Khaling has worked out the thesis entitled **"Certain aspects of ecology and behaviour of the Satyr Tragopan, *Tragopan satyra* in the Singhalila National Park, Darjeeling, India"** under our joint supervision and that she has fulfilled the requirements of the regulations relating to the nature, period of research as per rules of the North Bengal University. It is also certified that the said thesis incorporates the results of the original investigations made by Miss Sarala Khaling in our laboratory and field research station under our joint and actual supervision throughout. The thesis submitted is in partial fulfillment of her Ph.D. (Science) degree in Zoology of the North Bengal University, has not been submitted previously anywhere for any degree whatsoever either by her or anyone else. We are forwarding this thesis for the award of Ph.D. degree in Zoology of North Bengal University.

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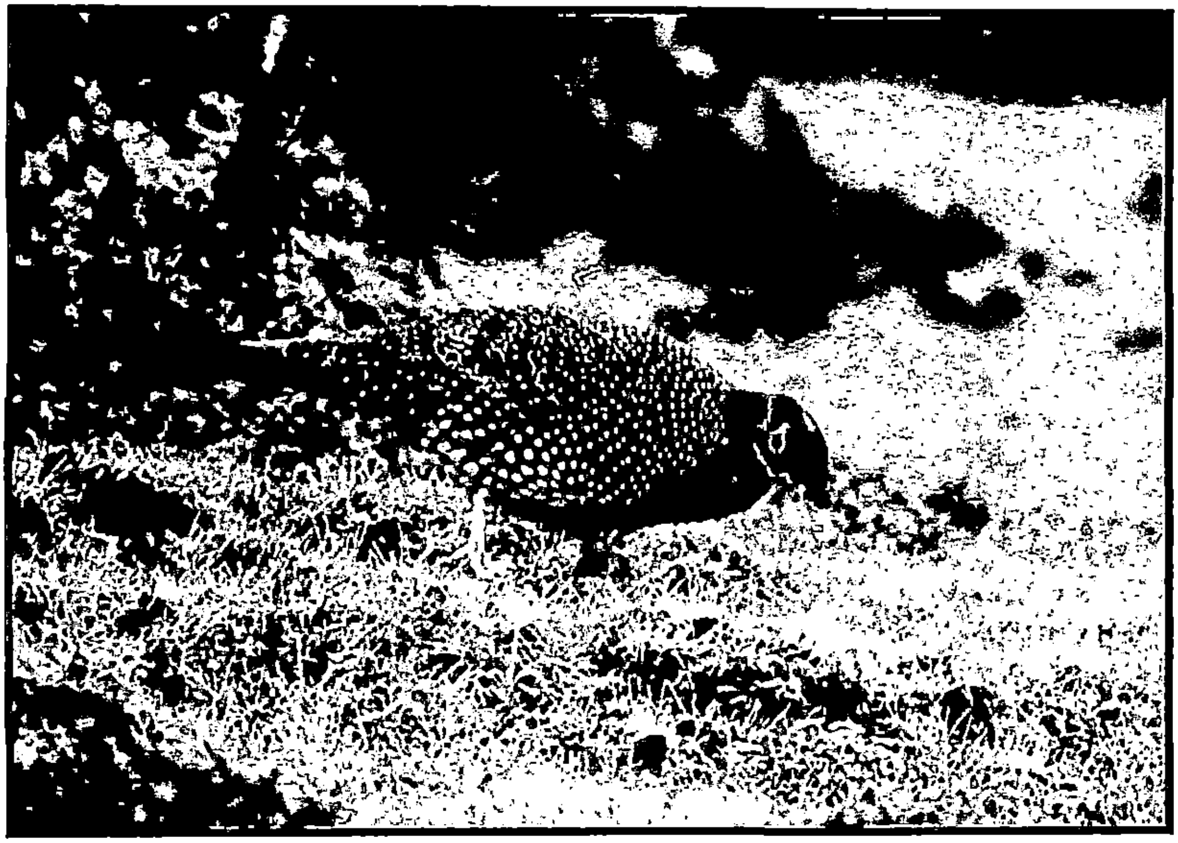

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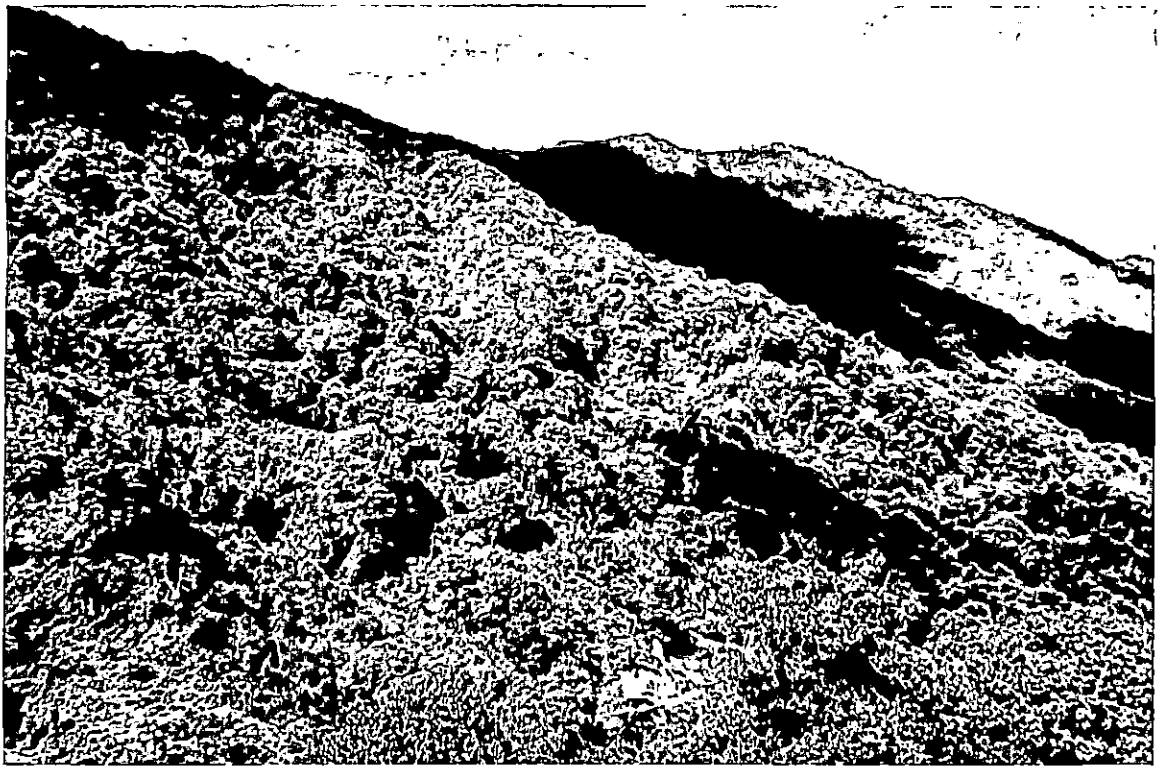
A male Satyr Tragopan



A general view of Singhalila National Park forests

Researchers on their routine monitoring work

PREFACE

The present study on the ecology and behaviour of Satyr Tragopan, *Tragopan satyra* Linn. was initiated as a research project to produce information on the species in particular as well as the Singhalila National Park in general. This protected area is one of the most important forest cover areas of the Darjeeling Himalaya and no other research activity to document the flora and fauna of this National Park had ever been conducted in the recent past.

The rare and threatened Satyr Tragopan is one of the most attractive species among pheasants. Very little quantitative data have been produced on the ecology of the species throughout its distributional range from Garhwal in the west to Arunachal Pradesh or southeast China in the far east. With this kind of background a study on the ecology of the Satyr Tragopan in the Singhalila National Park was launched in June 1994. The study period covered two years from June 1994 - August 1996, and another four months from March 1997 - June 1997.

Thesis layout: I have divided the thesis into 8 chapters.

Chapter 1. Introduction: Introduces the pheasants and reviews work done on pheasants at the global, Asian and Indian level. A small section on the review of work done on Satyr Tragopan has also been included. The last section of the chapter lists the main objectives of the thesis.

Chapter 2. Materials and methods: Describes the study area and the general methods adopted during the study. Details of methods are discussed in greater details along with each chapter separately.

Chapter 3 Distribution and abundance: Reviews the historical and current global distribution of Satyr Tragopan. I have also discussed the local distribution and abundance of the Satyr Tragopan in Singhalila National Park.

Chapter 4. Habitat studies: This chapter discusses the habitat use of the species on a seasonal basis and attempts to identify the habitat variables important to the Satyr Tragopan.

Chapter 5 Food and feeding ecology: Deals with results obtained from faecal analysis and attempts to list the food items identified from the droppings of Satyr Tragopan. I have also attempted to identify preference-avoidance of food items in Singhalila National Park on a seasonal basis.

Chapter 6. Calling behaviour and social organisation: Not much data could be generated on this chapter . Attempts have been made to study the different aspects of calling behaviour and the probable functions associated with calling. The social organisation has attempted to address the group size and crude sex ratio of the species.

Chapter 7 Threats: Deals with the general socio-economic conditions of the settlements situated in the fringe area of Singhalila National Park. Attempts have been made to identify activities which may be potential threats to the species as well as its habitat. Based on the results a few recommendations which may help in formulating management techniques have been proposed.

Chapter 8. General discussion: Discusses and tries to interrelate the various chapters which have up to now been dealt in isolation. This section also discusses the outcome of the work.

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I thank Mr. Manoj Nandi, I.F.S., for initiating this kind of a project in Singhalila National Park. Mr. S.S. Rasaily I.F.S. encouraged my interest in wildlife and nature and it was his encouragement, which saw me taking up this work. Mr. A. Raha I.F.S. Conservator of Forests, Mr. Ravikant Sinha, I.F.S, Mr. N. Singhal, I.F.S., Mr. L.G. Lepcha I.F.S. and Mr. P.R. Pradhan W.B.F.S. all contributed in either to get the project started or to run it smoothly till the end. Mr. J.N. Roy provided his government quarters to be used as a field station and was of immense help in everything. Mr. Bhuwan Giri B.O. was like my local guardian and provided transport, accommodation and co-operation. It was he who took me all around the National Park and got me acquainted with all the Forest Department staff. Mr. Pravin Katwal the former B.O. of Singhalila Range helped me to familiarise myself with the study area by providing useful information and suggestions. Mr. B. Lepcha B.O. Singhalila Range provided all help and logistics whenever I was working in the Sandakphu area.

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Sarala Khaling

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CHAPTER 1

INTRODUCTION

1.1 Background

The Galliformes is a group of birds, which are popularly known as "Game birds" and have formed a valuable food resource for man from ancient times. Birds belonging to this group are terrestrial in habit with stout unfeathered legs usually with spurs. The Majority of these birds ~~is~~ are ground nesting with nidifugous young. Pheasants, partridges, quails, megapodes, cracids, turkeys, grouse and guinea fowls belong to this group of birds. Pheasants are a group of terrestrial birds with a plump body, short stout bill, short, rounded wings and short or very long tail. The plumage in the male of most pheasants is striking while the females are cryptic. Facial adornments in the form of crests, wattles, ruffs and hackles are present in pheasant males. Many of the pheasant species have been kept in captivity because of their spectacular plumage patterns (males) and have also been considered as "ornamental" birds.

1.1.1 Taxonomy: One of the earliest to attempt taxonomy of this group was Beebe (1914a) who used the sequence of moulting in the retrices (tail feathers) as the main criterion of generic groupings. According to this criterion *Ithaginis* (Blood Pheasants) and *Tragopan* (Tragopan pheasants) along with partridge like species were included in the subfamily Perdicinae (centrifugal moulting pattern) while the typical pheasants were included in Phasianinae (centripetal moulting pattern). The typical peafowls (moulting beginning from the second retrices from the outermost, with outermost moulting before the inner ones) and Peacock and Argus pheasants (moulting beginning with third from central and proceeding outward and inwards simultaneously) were exceptions to this and were placed in the group Pavoninae and Argusianinae respectively. Peters (1934) included all the Old World partridges, their relatives and the typical pheasants in the subfamily Phasianinae. Delacour (1977) included the New World quails also in the subfamily Phasianinae and though he found *Ithaginis* and *Tragopan* related to the partridges he considered them sufficiently pheasant-like. Verheyen (1956) proposed a new classification based on measurements of the skeleton. According to his classification the pheasants were included in three subfamilies - Phasianinae which included most of the pheasant like species, Afropavoninae which included the Congo Peafowl and Pavoninae which included the peafowls. Wetmore (1960) placed pheasants as a separate family Phasianidae under the superfamily Phasianoidea. Sibley and Ahlquist (1972) suggested the typical pheasants to be included in a separate subfamily Phasianinae. Johnsgard (1973, 1986) classified pheasants as a separate subfamily Phasianinae under the broad family Phasianidae. This subfamily was further classified into the tribe Phasianini that included the pheasants exclusively. Wolters (1975-1982) considered the guinea fowl to be one of the 15 subfamilies of the family Phasianidae and proposed that the typical pheasants be divided into eight separate subfamilies. This is the most widely used form of classification of pheasants. More recently Sibley and Monroe (1990) classified the pheasants and the Old World partridge, quail and francolin species under family Phasianidae.

Sixteen genera (Delacour 1977) and 51 species (69 taxa) of pheasants are known to science and out of these 50 species are endemic to Asia (McGowan and Garson 1995). Only one species, the Congo Peafowl, *Afropavo congensis* is native to Zaire in Central Africa (Crowe *et al.* 1986). Several species of native pheasants have been introduced to various parts of Europe and USA and the globally distributed domestic fowl, is believed to be derived from the Red Jungle Fowl, *Gallus gallus* (Wood-Gush 1959). Silver Pheasant, *Lophura nycthemerus* and Golden Pheasant, *Chrysolophus pictus* were introduced around 1865 and 1932 respectively by captive breeding in a farm and released in Kuar Islands between 1907 and 1914. The Lady Amherst Pheasant, *Chrysolophus amherstiae* was released in Ohau, Hawaii in 1933. However all these species failed to survive (Caum 1933). One of the most common and wide spread pheasants introduced in Europe and North America is the Chinese Ring-necked pheasant, *Phasianus colchicus.*

In Asia, pheasants are distributed from Indonesia at 8° S through to northeastern China at 50° N and from 45° E in the Caucasus to 145° E in Japan. Along their distribution pheasants are found in diverse habitats like lowland tropical forests (Mountain Peacock Pheasant, *Polyplectron inopinatum*), temperate coniferous forests (Western Tragopan, *Tragopan melanocephalus*), subalpine scrub (Blood Pheasant, *Ithaginis cruentus*), alpine meadows (Chinese Monal, *Lophophorus lhuysii*), montane grass scrub (Cheer Pheasant, *Catreus wallichii*), broad-leaved evergreen forests (Kaleej Pheasant, *Lophura* spp. and Koklass Pheasant, *Pucrasia macrolopha*) to name a few.

According to McGowan and Garson (1995), there is very little basic ecological information available on 47 taxa (68%) of pheasants. Most of the pheasant distribution areas in Asia are remote and inaccessible and most of the species are secretive and silent often rendering surveys a time and labour intensive exercise. Even the most vocal species show strong seasonal fluctuation and cannot be easily detected. Of the 69 taxa of pheasants 4 (6%) are critically endangered with extinction, 16 (23%) are endangered, 24 (35%) are Vulnerable, 19 (27%) are categorised as safe from extinction and 6 (9%) are considered to be insufficiently known to be assigned a threat category (Fig1.1). Threats that affect most pheasants along their distribution range are in the form of habitat loss and fragmentation, poaching for food sport and trade, hybridisation and use of pesticides.

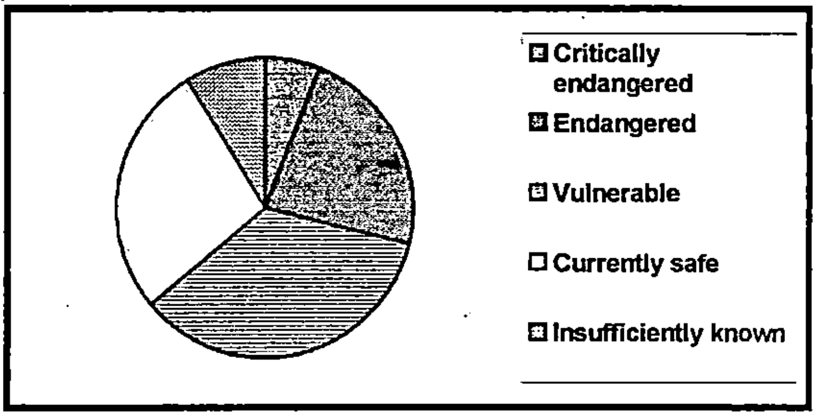


Fig. 1.1 Showing the threat categories of 69 pheasant taxa

Of the 51 species of pheasants 17 species occur in India. These are mentioned below. Adjacent to each species their threat categories are given in parenthesis.

a. Blood Pheasants (Safe): A single species *Ithaginis cruentus* and three subspecies represent this group. The *I.c. affinis* is distributed in Sikkim, *I.c. tibetanus* in central Arunachal Pradesh and *the I. c. kuseri* in central to eastern Arunachal Pradesh.

b. Tragopan pheasants (Endangered and Vulnerable): These include four species, the Western Tragopan, *Tragopan melanocephalus* distributed in the western Himalaya, Satyr Tragopan, distributed in Garhwal, Kumaun, Darjeeling hills, Sikkim and Arunachal Pradesh, Blyth's Tragopan, *T. blythii blythii* distributed in Assam, Mizoram and Manipur and Temmick's Tragopan, *T. temmickii* distributed in Arunachal Pradesh.

c. Koklass Pheasants (Safe): These are found in the western Himalaya and are represented by a single species - *Pucrasia macrolopha* and two subspecies. The Kashmir Koklass, *P.m. biddulphi* is found in northern Kashmir and Himachal Pradesh while the Common Koklass, *P.m. macrolopha* is found from southern Kashmir to Garhwal.

d. Monal Pheasants (Safe): This group of pheasants is represented by two species, the Himalayan Monal, *Lophophorus impejanus* found along the Himalaya from west to the east and the endangered Sclater's Monal, *L. sclateri* found in the northern fringes of Arunachal Pradesh.

e. Jungle Fowls (Safe): Are represented by two species. The Red Jungle Fowl, *Gallus gallus* is represented by two subspecies, the Indian Red Jungle Fowl, *G.g. murghi* which is found along the Himalayan foothills and up to 2000m from Kashmir to Arunachal Pradesh and southwards in parts of Uttar Pradesh, Madhya Pradesh, Bihar, Orissa, West Bengal and Assam. The other subspecies, Burmese Red Jungle Fowl, *G.g. spadicus* is confined to eastern Mishmi hills in Arunachal Pradesh. The Grey Jungle Fowl, *G. sonnerati* found in peninsular India which includes southern Rajasthan, Madhya Pradesh, Gujrat, Maharashtra, Tamil Nadu and Kerala represents the second species of Jungle Fowl found in India.

f. Kaleej Pheasants (Safe): This is represented by one species, *Lophura leucomelana* and four subspecies - White Crested Kaleej Pheasant, *L. l. hamiltonii* found in the western Himalaya, Blackbacked Kaleej Pheasant, *L.l. melanota* found in east-central Himalaya, Blackbreasted Kaleej Pheasant, *L. l. lathami* found in Arunachal Pradesh, hills adjoining Myanmar and Manipur and William's Kaleej Pheasant, *L.l. williamsi* distributed in southeast Manipur and hills of Mizoram contiguous with the Chin hills of Myanmar.

g. Eared-pheasants (Endangered): In India this genus of pheasants is represented by the endangered Tibetan Eared-pheasant, *Crossoptilon harmani* found in northern areas of Arunachal Pradesh.

h. Cheer Pheasant (Vulnerable): *Catreus wallichii* is the only representative of its genus and is distributed in the Himalaya from Kashmir through Garhwal to Kumaun in India.

i. Hume's Pheasant (Endangered): This is represented by a single subspecies, *Symatricus humiae humiae* distributed in Manipur, Patkai, Naga and Mizo hills of northeast India.

i. Peacock Pheasants (Safe): This group is represented by a single species, the Bhutan Peacock Pheasant, *Polyplectron bicalcaratum bakeri* distributed in Sikkim, North Bengal, Arunachal Pradesh, Assam, Manipur and Nagaland. There is a possibility of the occurrence of another subspecies of Peacock Pheasant, the Burmese Peacock Pheasant, *P.b. bicalcaratum* in southern Mizoram adjoining the Chittagong hill tracts of Bangladesh.

j. Peafowls (Safe and Endangered):There are two species of peafowls in India. The common Indian Peafowl, *Pavo cristatus* distributed up to 1800m throughout the country and the rare and endangered Green Peafowl, *Pavo muticus spicifer* is suspected to be distributed in the areas lying adjacent to southeastern Bangladesh.

Tragopan or horned pheasants are medium sized montane pheasants in which the sexes are highly dimorphic. Five species and four subspecies are recognised in the genus *Tragopan* all ~~of that are~~ are endemic to south Asia. Four species of Tragopan pheasants occurring in India have been mentioned in the preceding pages and the fifth species is the Cabot's Tragopan with two subspecies, *T caboti caboti* and *T. c. guangxiensis* which are endemic to China.

The males of Tragopan pheasants have strikingly bright plumage colours with a red or black head and colourful face and lappet. The body is red or crimson with spots and ocelli on the back, breast and wings. The female plumage is comparatively dull with colours like brown, creamy buff and rufous predominant (Johnsgard 1986). In the Satyr Tragopan male, the face and throat are thinly feathered. The general plumage pattern according to Finn (1911) is "rich red on the neck and below and mottled black and brown above with round white spots edged with black all over. The head and tail are black with the tail having a black band. The bend of the wing is red with red patches on the mottled brown plumage of the rest of the wing and rump. The bill is blackish brown, the horns sky-blue, skin of face and throat rich deep blue, the bib blue, with large red lateral spots when expanded, the eyes are dark and the legs are flesh coloured". The female Satyr Tragopan is rich brown, with paler underparts grizzled and mixed with black and buff. The beak is dark horn-colour and the legs are fleshy grey. Plumage colour in young birds is similar to the females but distinctly streaked with buff. Male Satyr Tragopan weighs from 1600-2100 g (Ali and Ripley 1978) and has a wingspan of 245-285 mm and a tail of 250-345 mm. The females weigh 1000 - 1200 g (Ali and Ripley 1978) and have a wingspan of 215-235 mm and a tail of 195 mm.

The Tragopan pheasants are distributed from Indus Kohistan in Pakistan through the Himalayas in India, Nepal and Bhutan to Hunan in the Yunan Province in eastern China. The Western Tragopan is found in oak and coniferous forests or moist/dry forests (Johnsgard 1986, Islam and Crawford 1987) at 2000 - 3600m. Satyr Tragopan is known to inhabit oak- rhododendron or mixed broad-leaved forests with dense ringal understorey (Lelliott and Yonzon 1980, Young and Kaul 1987, Inskipp and Inskipp 1993a & b, Kaul *et al.* 1995). Blyth's Tragopan is found in Rhododendron forest at 2400-2600m with dense undergrowth of ringal bamboo and ferns (Ali *et al.* 1973 in press). The Temmick's Tragopan is known to occur in evergreen or deciduous broad-leaved mixed forests at 1600 - 2700m (Li Xiangtao and Lu Xiaoyi 1989) whereas the eastern most species the Cabot's Tragopan is found to inhabit evergreen broad-leaved forests at 800- 1400m (Young *et al.* 1991). Males of the genus *Tragopan* are vocal particularly during the breeding season in which they give out a very distinctive advertisement or breeding call (Johnsgard

1986, Islam and Crawford 1996). This call has been used effectively to count the species in their habitat ((Lelliott and Yonzon 1980, Sharma and Panday 1989, Duke 1990, Kaul *et al.* 1995, Ghose 1997, Kaul 1998).

Out of the five species of Tragopan pheasants four are considered threatened in their respective distribution range. The Temmick's Tragopan is considered safe, the Satyr, Western and Cabot's Tragopan as 'Vulnerable' species and the Blyth's as 'Endangered' according to the Mace-Lande threat categories (McGowan and Garson 1995). Except for the Cabot's Tragopan the other four Tragopan pheasants are distributed along the Himalayas in Pakistan, India, Nepal and Bhutan. Of the four Tragopan pheasants found in India, the Western Tragopan is restricted to the western Himalaya, the Satyr Tragopan is an east-central species while the Blyth's Tragopan and the Temmick's Tragopan are strictly eastern in their distribution. In the eastern Himalaya the range of the Satyr Tragopan and the Temmick's Tragopan are suspected to overlap and may form a sympatric population in certain areas. Very little is known about the ecology of Tragopan pheasants. Most of the attempted studies on this genus have provided sketchy accounts of the species probably as a result of difficulties imposed by remote areas of their distribution and the rugged terrain inhabited by them while their shy and elusive nature compounds this problem.

All along their distribution in the Himalaya the Tragopan pheasants have been closely associated with the local human population. They are much admired for their aesthetic value and form an integral part of the culture (Nepal, Himachal Pradesh, Pakistan), in some parts of their distribution they are protected for religious reasons (Bhutan) whereas they are also hunted for meat in most areas. Over the last century the increase in human population has put severe pressures on our natural resources. This increased consumption has resulted in severe threats to the survival of most of these pheasant species. One of the main threats is habitat destruction and fragmentation through deforestation, conversion of land for agricultural purposes, excessive livestock grazing and firewood and fodder collection. It has also been suggested that removal of medicinal plants especially in Western Himalaya might have serious consequences on the Western Tragopan populations (Garson and Gaston 1992). Tragopan pheasants are also threatened by poaching for meat, sport and sale.

1.2 Literature Review

1.2.1 Overview of pheasant studies in Europe and America:

The Chinese Ring-necked Pheasant or the common pheasant, *Phasianus colchicus* is the most common gamebird in Britain and breeds in every county (Sharrock 1976). It is an introduced species, which has been resident since at least the eleventh century (Yapp 1983) in Britain. Although attempts to introduce pheasants in America were not successful in the initial years of introduction, by 1900 the pheasant had spread over most of United States of America. By 1920 with the increase in the rates of stocking and release, hunting of pheasants as game became a common activity (Mctee 1945, Allen 1956 in Warner and Eatter 1986). In Britain the bird is widely hunted for sport and to ensure high densities for shooting, a large number of hand reared birds are released each summer (Hill and Robertson 1988, Robertson and Dowell (1990). With the establishment of introduced pheasants in

Europe and America studies on almost all aspects of the Ring - necked Pheasant ecology and behaviour have been conducted over the years with over 600 references of published papers available on the species (Carroll 1988).

1.2.1.1 Habitat and cover use: Gates and Hale (1974) using radio collars studied distribution patterns of Wisconsin Pheasants during winter. Since high mortality was reported in winter the studies made recommendations for winter management of the pheasants. Habitat studies by Guthery and Whitesade (1984) revealed that the Ring-necked Pheasant used reed fringed wetland scrub in America when woodlands were absent. Robertson (1985) studied the winter habitat use of the Common Pheasant in Ireland and found that scrub land and woodland with scrub underlayer were selected. Woods with bare grassy under layer; hedge-groves or open fields were avoided. There was differential habitat selection among male and female birds. Hill and Robertson (1988b) observed that the Common Pheasant showed seasonal variation in habitat use. Woodlands were used extensively during winter and the birds moved out into growing crops during spring and summer. Ditches and dykes were used in treeless farmland. The females in southern Wisconsin preferred food patches and brush and avoided pastures and croplands (Gatti *et al.* 1989). In southern Idaho Common Pheasants preferred sagebrush, wetland and herbaceous cover types to grassland as their winter habitat in agricultural cover types (Leptich 1992). Robertson *et al.* (1993) studied the winter density of the Common Pheasant in the U.K. Woodlands with a high proportion of shrubby cover and the provision of supplementary food were associated with high pheasant densities.

1.2.1.2 Cover: Alfalfa was the most extensively used cover during night and day in all months by Common Pheasants in east central Dakota (Hanson and Progulske 1973). Warner (1979) also studied the use of cover by pheasant broods in eastcentral Illinois and found that broods roosted mostly in oats and hay. Use of cover did not change in response to weather conditions but appeared to be more of a function of brood age than of crop phenology or harvest. Snyder (1984) in his studies on the nesting ecology of pheasants in northeastern Colorado found that winter wheat and post harvest stubble were the dominant nesting cover in spring. The height and density of this cover was affected by the amount of precipitation accumulated in the soil. In their studies on the use of cover types by Common Pheasant broods in Oregon (Myers *et al.* 1988) observed that the survival of broods was related to cover types and in some cover types survival was a function of the age of the brood.

1.2.1.3 Population studies: Errington and Hammerstrom (1937) studied the nesting losses and juvenile mortality of Ring-necked Pheasants, while Green (1938) analysed the importance of food and cover relationships in the winter survival of pheasants in northern Iowa. Eklund (1942) studied the mortality factors affecting the nesting of pheasants in the Willamette Valley while Bach (1944) studied the population fluctuations of pheasants in North Dakota. Arnold (1951) worked on red fox predation of ring-necked pheasants, Buss *et al.* (1952) assessed the significance of adult pheasant mortalities in spring to autumn while Gondahl (1953) studied winter behaviour of pheasants with relation to winter cover in Winnebago country. Blouch (1955) analysed the factors affecting pheasant populations in Michigan.

Comprehensive studies were conducted on the population ecology of Wisconsin pheasants between 1946-1961 (Wagner *et al.* 1965). Highest pheasant densities occurred in areas with 55-70% cultivated land and showed progressive decline in areas where either more or less than 55 - 70% land was cultivated. Population trends of pheasants were monitored throughout the year and the fluctuations were attributed to winter chick survival. Dumke and Pils (1973) used radio telemetry to study the mortality of pheasants and found that the maximum mortality occurred in winter when predation was highest. Gates and Hale (1974) studied the reproduction of Ring-necked Pheasant in central Wisconsin and found that harvesting operations were principally responsible for mortality of pheasants. Chicks from earlier season, which were older, were less vulnerable to mowing. Wollard *et al.* (1977) attributed the limited growth of a released population of South Korean pheasants, *Phasianus colchicus karpowi* in Missouri to the lack of suitable nesting cover. Dumke and Pils (1979) studied the renesting dynamics of pheasants in Wisconsin. Establishment of 31% nests was successful while 69% were disrupted. Of this 68% renested but 71% of the second clutches were terminated. 41% of females renested and produced 40% of the broods. Warner (1981) reviewed the population, ecology and distribution of pheasants in Illinois from 1900-1978. Greater population densities were attributed to high winter cover and more hay and small grain fields. Except for some areas there was a general decline in the population and for management purposes he suggested that efforts be directed towards establishment of habitat for nesting, brood foraging and improvement of habitat on agricultural lands.

1.2.1.4 Breeding: Hill and Robertson (1986) found that pheasants were polygamous with a harem size of 2.4±0.4 hens. Similar results have been obtained from Ireland

(Robertson 1986), Sweden (Goransson 1980) and America (Trautman 1982). In New Zealand the average number of hens per cock were just over one (Westerskov 1956). Koubek and Kubista (1990) studied the daily activity pattern of lekking pheasant males in Europe. The peak sexual behaviour occurred in the first ten days of April after which there was a distinct decline in May. Feeding and walking were the only behaviour that showed peak daily activity. Koubek and Kubista (1990) observed that in southern Moravia (Czechoslovakia) male *P.colchicus* preferred territories with activity centers having cover while open fields were avoided. Changes in the development of vegetation were proportionately reflected in the quality of individual pheasant territories (Koubek and Kubista 1991). Individual territories were divided into various activity centres. Male spacing, before females had initiated a clutch did not differ with male attractiveness and indicated that female choice might have affected the males' spacing behaviour (Grahn *et al.*1993). Ligon and Zwartjes (1995) tested the role of male plumage of Red Jungle Fowl in female mate choice. Though females discriminated between males, the plumage was not the target of female's attraction but males with larger combs were. Experiments and correlation data were used to investigate the role of male ornaments in male-male agonistic encounter (Mateos and Corranza 1997). Sexual selection traits did not have any effect. Head ornaments functioned as signals to rival males about readiness to fight, fighting ability and resource holding power. All the male-male conflict behaviourial traits were correlated with testosterone levels.

1.2.1.5 Feeding: Scwartz and Schwartz (1951) studied the food of an isolated population of Ring-necked pheasant in the Hawaiian Islands. From 191 crops and gizzards, 152 food types of food items were recorded and graded according to their importance. Kopischke and Nelson (1966) in their studies in Minnesota and South Dakota observed that laying hens consumed about 50 percent more grit by weight than nonlaying hens and they could selectively pick calcium- and magnesium bearing grit. Hill (1985) studied the feeding ecology and survival of pheasant chicks on arable farmland. Arthropods in the diet of the chicks were found to be important for their survival. Moreby (1987 and 1992) described methods to identify arthropod fragments in the diet of game bird chicks through diagnostic parts specific to certain groups of arthropods.

1.2.1.6 Management: The end of the war brought a complete change in agricultural practices in the USA with the availability of more efficient machinery, better quality crop hybrids and commercial fertilisers. With better crop yields many agricultural areas or farmlands were converted to urban development areas. Such a change in land use pattern adversely affected the pheasant population as lower harvesting returns indicated. Changing land use especially increased cultivation was once again responsible, but this time for the expansion (Hallett 1987) of the breeding range of the Ring-necked Pheasant in Missouri to 22,000km^2 in 1986 (30% increase from 1947). Robertson *et al.* (1988) surveyed butterfly numbers in a woodland in southern England. Areas managed for pheasants recorded significantly higher number and species of butterflies than unmanaged areas. Their studies suggested that woodland management for pheasants could benefit many of the declining butterfly species. Robertson *et al.* (1993) studied the effect of land use in breeding pheasant density. Territorial male density was limited by habitat quality. By quantifying the effect of land use on breeding density it could be possible to assess implications of future changes in land use. Their studies suggested that new woodland planting and management could increase the breeding pheasant density.

1.2.2 Overview of pheasant studies in Asia: In this section I have not touched upon work done in India as I have dealt with this in a separate section of the chapter. Generally very little is known about the distribution and ecology of pheasant species in Asia though the introduced Common Pheasant has been a subject of a large amount of research in Europe and North America. There have been a few intensive studies on pheasant species in China, Nepal, Malaysia, India and Pakistan but most of the available literature are on surveys and short term studies. British sportsmen or naturalists documented most of the work on pheasants in Asia in the nineteenth century. Some of them are Hodgson (1846), Wilson and Jerdon (in Jerdon 1877), Hume and Marshall (1879), Blandford (1898) and Osmaston (1935). Although they did not work on any pheasant species, their anecdotal accounts provided valuable information on the general distribution and habits of pheasants found in the subcontinent. Beebe's "Monograph of the pheasant" (1918-1922) was considered the classic book on pheasants as after that authors provided information on the pheasants based on that book (Baker 1935, Bates and Lowther, 1952, Ali and Ripley 1969, Delacour 1986).

1.2.2.1 Surveys and general habitat studies: Pheasant surveys in Pakistan (Mirza *et al.* 1978) recorded the presence of five species of pheasants. Attempts were made to locate the Cheer pheasants in west central Nepal (Lelliott 1980-81). Very few birds were seen or heard which according to their observations indicated its scarcity and shyness. The species was found at 2200-2440 m altitude in open scrubby forests and cliffs at close proximity to human habitation. Duke (1989) conducted call count surveys of Western Tragopan at four sites in Pakistan Himalaya and recorded relative density estimates ranging from 28 -195 birds. Of these the mid-Palas contained the largest surviving population of Western Tragopan.

Islam and Crawford (1987) studied the habitat of Western Tragopan in Pakistan and observed very little consistency in the selection of major plant species association. The species selected shorter life forms and avoided taller vegetation and it was concluded that structural components influenced habitat use by Western Tragopan more than forest type or plant association. Hen Fen Qi (1988) studied the ecology of Chinese Monal and observed the species to inhabit alpine scrub, subalpine and alpine pastures and exposed rocky and cliffy mountainsides. Studies on the Elliot's Pheasant (Syrmaticus ellioti) in China (Ding Ping and Zhugo Yang 1989) recorded that the species occurred at 300-1500 m altitude and occupied shrubby zone in winter and early spring, mixed and coniferous forest in the breeding season and high mountain zone in autumn. McGowan *et al.* (1989) studied the habitat of Palawan Peacock Pheasant (Polyplectron emphanum) and its habitat pressures. The distribution of the species was determined by the level of human disturbance in its habitat because of which the species faced a bleak future due to habitat loss. Severinghaus and Severinghaus (1989) studied the ecology and behaviour of the Mikado (Syrmaticus mikado) and Swinhoe's (Lophura swinhoii) Pheasant in the Yushan National Park (Taiwan). Swinhoe's Pheasant occurred at 1000-2000 m in warm temperate zone in broad-leaved forests with gentle slopes while the Mikado Pheasant occurred at 1900-3800 m and inhabited cold temperate zones in coniferous and mixed forest on steep slopes. Though sympatric the two species were separated by distinct habitat characteristics. Young *et al.* (1991) observed that during winter in southwestern China the Cabot's Tragopan used areas with thick undergrowth, a greater percentage of bare ground, proximity to water sources and a gentle slope. *Daphniphyllum macropodum* was an important food plant and roosting site for the species. Bland and Han Lixian (1992) studied the ecology of Lady Amherst Pheasant (Chrysolophus amherstiae) in China. Li Xiang Tao (1992) studied Brown-eared Pheasants (Crossoptilon mantchuricum) in the Dongling Mountain area in China and found the species associated with broad-leaved and coniferous mixed forests at 1300-2200 m with a density of $1/km^2$. The habitat was seriously under threat from changes due to agriculture. Malaysian Peacock Pheasant were found to be clustered and not evenly distributed in their available habitat in Peninsular Malaysia (McGowan 1994). These clusters were located in areas that were away from the river and more stable. Presence and absence of ground vegetation directly influenced the dispersion of display scrapes in the species. In another study in China the Brown Eared-Pheasant was found to inhabit broad-leaved and coniferous forests at 800-1800 m (Li Xiantao 1995). Temmick's Tragopan showed differential habitat use during different seasons (Ding Chang Quing and Zheng Guang-mei 1993, Shi Hai-tao *et al.* 1996). In summer they were associated with areas having good cover and abundant bushes. In autumn they affected broad-leaved mixed forest while in winter the range increased and they occurred in a variety of broad-leaved bamboo mixed forests.

1.2.2.2 Population studies: Chinese Monal (Lophophorus lhuysii) were gregarious with changeable sex ratio. Population density estimate was found to be $1.5\text{-}2/km^2$ and some birds of prey were its natural enemies (Hen Fen Qi 1988). Zhang Junping and Zheng Guang-Mei (1989) surveyed population structure and number of Cabot's Tragopan in Wuyanling Nature Reserve (China). Fifty birds were recorded with a density estimate of

7.1birds'km^{-2} and the sex ratio was almost equal. Population fluctuated through the season with the highest number observed in May and the least in winter. Li Xiangtao and Lu Xiaoyi (1989) in their studies on Temmick's Tragopan in winter found the male birds to be solitary or in family units of 2-5 birds. Studies on the Western Tragopan by Islam and Crawford (1992) found that sex ratios were biased towards the males at all study sites and they suggested 60:40 sex ratios as more appropriate than the equal one.

1.2.2.3 Breeding and Nesting: Nesting ecology of the Cabot's Tragopan in China (Zheng-Wang and Zheng Guang-mei 1989) revealed that the birds nested in forest edges on trees of *Pinus taiwanensis* with a clutch size of 2-6 eggs. Nest losses occurred due to predation, inclement weather conditions or collection of eggs by the locals. Of these 74% was attributed to predation (Eurasian Jay, Grey Tree Pie and small mammalian carnivores). Breeding in Hume's Pheasant (Symmathicus humiae) occurred in February- June and nests were made on the ground with fairly dense cover (Liu Xiao Hua *et al.* 1989). Birds were reared exclusively by the female till July, accompanied by the cock up to early August when the males in the brood began to assume their adult plumage. Zhao Zhengjie (1989) studied the breeding ecology of the Ring-necked Pheasant in China. The species was found to inhabit low mountain plains in shrubs and grasses in natural secondary Oak Forest. Flocking occurred in autumn and winter while in spring and summer the pheasants were single or in pairs. Cock pheasants were territorial during the breeding season, which lasted from May-July. Nests were built on grassy or bushy ground with a clutch size of 10-19 eggs. Habitat destruction was one of the main threats to this species. Swinhoe's and Mikado Pheasants were generally solitary seen in pairs during the breeding season or in family parties (Severinghaus and Severinghaus 1989). Li Xiantao (1995) studied the status of the Brown Eared Pheasant in the Dongling Mountain (China). The status of the species was found to be stable with low population density and poor breeding success. High rate of egg loss to predators and local people were the main cause responsible for decline in breeding success.

1.2.2.4 Diet: Davison (1981c) in his studies on the Crested Fireback Pheasant in Kuala Lompat (Malaysia) observed the majority of the birds in moist areas with abundant invertebrates. The diet of Cabot's Tragopan was primarily vegetarian and crop content consisted of 95% dry weight of fruits (Li Xiang Tao and Lu Xiang 1989). Studies on Hume's Pheasant (Liu Xiaohua *et al.* 1989) found the species to be ground foragers and primarily vegetarian in diet. The Ring-necked Pheasant in China was found to be mainly vegetarian in food habit, and vegetarian food comprised up to 83% of the crop and stomach contents of 42 birds (Zhao Zhengjie 1989).

1.2.3 Overview of Pheasant studies in India

Except for the works of Kaul (1989), Sharma (1990), Iqbal (1992) and Ahmed (1994) there has been no detailed work on any of the pheasant species in India. However numerous and short term studies on various aspects of the behaviour, ecology and distribution of pheasants have been conducted from time to time.

One of the first studies conducted on pheasants in India was the work of Collias and Collias (1967) near Dehradun on the vocalisations of Red Jungle Fowl. Their studies revealed that crowing was used by the dominant male to advertise territorial rights and assert dominance. These studies suggested that the breeding behaviour and vocal repertoire of the Red Jungle Fowl in nature were similar to those of the domestic fowl and considered the Red Jungle Fowl to be its ancestor. In the 1980s there were a series of surveys in various locations, which contributed to the information about the distribution of pheasants in India. Bland (1980) made observations on gallinaceous birds in western and central Himalayas. Within Indian limits Western Tragopan were observed in Uttar Pradesh for the first time in nearly twenty years while Koklass were observed in plenty in Kulu (Himachal Pradesh). Gaston and Singh (1982) surveyed the Chail Sanctuary in Himachal Pradesh for Cheer Pheasants. 12 Cheer was sighted and nine pairs were located through calls. Birds were mainly seen on steep grassy slopes in areas scattered with trees and bushes. Lamba *et al.* (1982) censused pheasants in Kashmir and found the Monal and the Koklass Pheasants to be commonly distributed but were not able to locate the Western Tragopan and Cheer Pheasants in the valley. Gaston *et al* (1983a) carried out surveys in 1979 and 1980 in the Upper Beas Valley in Kulu district (Himachal Pradesh) and in some adjacent parts of Ravi and Sutlej Valleys and western most part of Yamuna catchment. Seven species of pheasants were reported and habitat destruction was identified as the most immediate threat to pheasants in the Western Himalayas. Gaston *et al.* (1983b) carried out wildlife and habitat surveys in the upper Ravi, Beas and Sutlej catchments of Himachal Pradesh. Five species of pheasants (Cheer, Monal, Koklas, Kaleej and Western Tragopan) were recorded. Altitudinal distribution for all species except Kaleej was broadly similar extending from lower part of the temperate zone to the subalpine forests. Hunting and habitat destruction were identified as the two main threats to wildlife in that area. Kaul (1986) surveyed the Limbar valley in Jammu and Kashmir, India and recorded an area with a Western Tragopan population. Young and Kaul (1987) carried out surveys in Kumaun Himalayas and documented the presence, calls, habitat and distribution of five species of pheasants (Cheer, Koklass, White Crested Kaleej, Himalayan Monal and Satyr Tragopan). Young *et al.* (1987) studied the calling behaviour of Cheer Pheasant in the Almora district of Uttar Pradesh. Five types of calls were identified with long dawn choruses in April-May and though the chorus was shorter, they were most consistent in June. The results suggested that 'passive' transect surveys were best in late May-early June. Response to broadcast of calls was immediate before sunrise while response to broadcast later in the day or before dusk elicited short response. Bisht *et al.* (1989) studied the status and habitat utilisation of Monal Pheasant at four sites of Kedarnath Wildlife Sanctuary. Population of the species was found to be low in areas with substantial human interference. The pheasant used temperate forests, sub-alpine coniferous forests/scrub and alpine forests in the different seasons. Chandola-Saklani *et al.* (1989) investigated some behaviourial traits and seasonal movements of the White crested Kaleej Pheasant at three sites in Garhwal. There was a significant negative correlation emergence and day length and a positive correlation between return of the birds and day length. Female birds showed greater foraging activity and a decline in the feeding rate during the breeding season. Nine different populations of White Crested kaleej Pheasant were monitored in Garhwal Himalaya (Sharma and Chandola-Saklani 1993). Breeding in the species occurred from March - July with some variation in successive years. Surveys in the Shimla hills confirmed the occurrence of pheasants in 23 sites of Himachal Pradesh (Sharma and Panday 1989). Ahmed and Musavi (1992) estimated the density of White Crested Kaleej Pheasants to be 5 birds/km^2 and most of the birds (65%) were observed in scrub vegetation in Ranikhet (Uttar Pradesh, India). Iqbal 1992 studied the patterns of habitat use by White Crested Kaleej Pheasant at two sites in the Himalaya. In Kumaun the birds were observed to prefer grassy openings and scrub while in Himachal Pradesh the species showed preferences for oak and chirpine mixed forest and avoided terraced and open pastures. Garson *et al.* (1992) studied the ecology and conservation of the Cheer Pheasant in Kumaun Himalaya. These studies described how the stock and land management systems had a number of features that maintained the Cheer habitat throughout the year. Habitat preference studies on the Red Jungle Fowl in Kaleswar Reserve in Haryana (Kalsi 1992) revealed that the species preferred mixed forests with cultivation to Sal and mixed forest. Pheasant surveys conducted in the upper Beas Valley recorded six species of pheasant (Panday 1992). Cheer Pheasants were confirmed at ten new sites, White Crested Kaleej Pheasant at nine sites, Monal and Koklass Pheasant were seen at six sites each while Western Tragopan, Red Jungle Fowl and Peafowl were recorded from two sites each. Human interference occurred in all the protected areas of this valley. Preliminary surveys of the Western Tragopan in Daranghati Sanctuary (Himachal Pradesh, India) by Panday (1992) recorded a density of 1.5 birds'km^2 in their winter habitat. Sathyakumar *et al.* (1992) studied the abundance and habitat of Kaleej and Monal Pheasants in Kedarnath Wildlife Sanctuary. 16/17 pairs/km^2 and 10-16 pairs /km^2 of Kaleej and Monal Pheasants were estimated in the study area. Kaleej pheasants inhabited temperate forests at 1600 - 2000 m altitude in north, northeastern and eastern aspects while the Monal Pheasant were found in subalpine forests at 2600-3300 m in south, southeastern and southwestern slopes. The main threats to the pheasants were poaching, habitat destruction by grazing, collection of bamboo and litter and forest fire. Western Tragopan were searched for and observed at six localities in Himachal Pradesh (Narang 1992). The species was distributed in 2700-3300 m altitudinal range in the upper half of the temperate belt. Distance to habitat in the form of grazing, collection of forest produce, timber distribution, clearing for cultivation up to tree line and poaching were some of the threats to the Western Tragopan. Though extremely common there are very few studies have been conducted on the peafowl. Sathyanarayana and Veeramani (1992) observed the Peafowl to use eight species of trees as roosting sites. 78.4% of the birds used *Acacia sundra* for roosting and most of the birds roosted at a height of 16 - 33 m above the ground. Yasmin (1995) studied the roosting behaviour of Blue Peafowl in India. Peafowls used trees with greater heights, girths and heights of first branch. Analysis of roost sites in relation to availability revealed that *Dalbergia sisso* was the most preferred tree species for roosting. Ghose (1997) studied the ecology of Blyth's Tragopan in the Blue Mountain National Park (Mizoram, India). The species was found to inhabit the cliff side vegetation with less tree, shrub and ground cover. Four pairs of birds were heard during the calling season. Poaching, clearing of land for shifting cultivation, forest produce collection and unmonitored human movement in the protected area were the main threats identified by the study. Kumar *et al.* (1997) studied the winter habitat use of the Monal Pheasant in the Kedarnath Wildlife Sanctury. Monal Pheasants showed a strong preference for dense wooded areas with a high litter cover during autumn and winter and were found near cliffs and open areas during spring. During autumn the male and female birds were observed in loose groups which changed to distinct groups in winter. The males remained in groups for a short period and with the advent of spring moved to higher altitudes and became solitary.

1.2.4 Overview of Satyr Tragopan studies

Literature on observations made on the Satyr Tragopan were available from the pioneering works of. Jerden (1863), Beebe (1918-1922), Meinertzhagen (1926), Baker (1928), Whistler 1926, Inglis 1933a and Bailey (in Inglis 1933a). There were reports of the bird from the Darjeeling hills from the last century (Hickell 1842 in Inglis 1933a, Jerden1863 and Inglis 1933a & b). Ludlow & Kinnear 1937 observed the Satyr Tragopan to be distributed in eastern and western Bhutan between 2743 m -3353 m. Ludlow (1944) also reported the species from the Chumbi valley in Tibet adjacent to Sikkim.

1.2.4.1 Distribution: Review of reports form various sites of Satyr Tragopan distribution revealed that there was severe paucity of information about the distribution of the Satyr Tragopan from the Garhwal Himalaya as observed by (Gaston (1982). In Kumaun, Young and Kaul (1987) in their surveys recorded the birds in the Pindari and Milam valleys in the inner ranges of the Kumaun Himalaya at altitudes of 2400-4250 m. In very recent surveys in Kumaun, (Shah *et al.* (1997) Kumaun the species was reported from two sites. The Satyr Tragopan has been in reported in surveys all over the Nepal Himalayas (Lelliott and Yonzon 1980, Forster & Lelliott 1982, Roberts 1983, Picozzi 1985, 1987, Roberts 1987, Inskipp 1989, Inskipp 1989, Amatya 1997, Maskay 1997). The Satyr Tragopan was reported to be distributed throughout the hills of Sikkim in thick canopy of tree or climbers in the Kanchanjunga National Park (Pazo 1982, Lepcha 1997) and is considered to be fairly common in its sites of distribution throughout the country. The species has been was recorded from various sites in Bhutan (Ali *et al.* ~~1972~~ Ali et al 1973 in press, Inskipp & Inskipp 1993b, ~~Inskipp 1993b,~~ King 1996, Bishop1997, ~~Murphy 1994, Inskipp 1996,~~ Pradhan

1983, Clements 1992, Dreyer 1995, King 1995, Holt 1996, Bishop 1997, King 1996, Tymstra *et al.* 1996). Surveys were conducted in Arunachal Pradesh to record the presence of galliformes. The Satyr Tragopan was recorded in the Thingbu and Mago area of Tawang district (Kaul and Ahmed 1992, Singh 1994, Kaul *et al.* 1995). In China Cheng (1989) reported the species from Mount Jumulong Ma (Quomolangma) National Park in the southwest border of the Tibetan Autonomous Region. Recent surveys in the Gaologongshan Region in the Yunan Province of China have recorded Satyr Tragopan in Dulongjiang (Nushian Nature Reserve) (Zheng Guang-mei 1992, Xian1995, Ma Shilai *et al.* 1996).

1.2.4.2 Call counts: From 1979 to 1998 fairly regular counts of pheasants have been conducted in the Pipar area of Central Nepal. Lelliott and Yonzon (1981) in late May counted 10 Satyr Tragopan and estimated a density of 4.2 pairs/km^2 for the Satyr Tragopan. Tamrakar and Lelliott (1981) recorded 13 birds in late April in 1981. In the next year there were records of 8 birds (Yonzon 1982) while 16 birds (Roberts in litt.) were recorded a couple of years after that. Picozzi (1987) recorded 19-21 calling Satyr Tragopan in April 1987 after which there were no call counts for the next three seasons. In 1991 Howman and Garson (1992) recorded 30 calling Satyr Tragopan which indicated a 50% increase in the number of Satyr Tragopan recorded in 1987. However Kaul and Shakya (1998) who conducted the most recent counts in Pipar and recorded eighteen Satyr Tragopan believe that the 1991 figure was exaggerated due to double counts. Kaul and Shakya (1998) obtained a density index of 9 groups/km^2 in Pipar and an encounter rate of 10.3 groups/100 party hours. In Kumaon Shah *et al.* (1997) obtained encounter rates of 16.6 groups/100 man-hours and 18.6 groups/100 man-hours from two sites in which they encountered the Satyr Tragopan.

1.2.4.3 Habitat: Beebe (1918-22) in his pioneering work on pheasant reported the Satyr Tragopan to inhabit broad-leaved forests with bamboo understorey in narrow side gorges with tiny streamlets. Ali and Ripley (1978) found the Satyr Tragopan associated with oak, fir and rhododendron forests in steep hillsides with scrubby undergrowth of ringal bamboo at 2400- 4250 m elevation. Lelliott and Yonzon (1980) studied the highland pheasants on the forested southern slopes of the Annapurna Himal in Nepal. Satyr Tragopan was associated with *Rhododendron-Arundinaria-Betula-Sorbus* forests with other broad-leaved species and *Berberis* sp. scrub in altitudes between 3000-3300 m.

1.2.4.4 Diet: Satyr Tragopan was considered a primarily herbivorous species though insects were also observed in its diet (Hume and Marshall 1879-1881, Hodgson in Hume and Marshall 1879-1888, Baker 1930, Beebe 1918-1922, Meinertzhagen 1926). More recently Lelliott and Yonzon (1981) found the species to be omnivorous. Yonzon (1981) and Bhandary (1983) observed the Satyr to be primarily a vegetarian. In captivity the species is largely vegetarian (Howman 1979). The species was found to be open area foragers or deep undergrowth foragers (Baker 1920, Beebe 1918-22) while Lelliott and Yonzon (1981) observed the species to be early morning and late afternoon feeders, which included arboreal feeding.

1.2.4.5 Calling and Social organisation: Johnsgard (1986) in his comprehensive book on pheasants reported the Satyr Tragopan to be highly territorial birds. Beebe (1918-1922) made several observations on the birds and found that the birds did not call during the winter unless the hen communicated with the nearly grown up young by low clucking calls. In case of sudden flight or distress both the male and the female give a series of loud raucous notes. Wayre (1969) observed the Satyr Tragopan call to gradually rise in volume until it became almost a shriek and the whole sequence lasted for 20-25 seconds. Jerdon (1864) described the wailing call of the Satyr as a deep bellowing sound while Hume (1879) thought it was a loud bleating cry chiefly heard in spring. Lelliott (1981) distinguished four types of calls, which he considered to be an incomplete description of the species vocalisations. Islam and Crawford (1996) in their work on Tragopan vocalisations described and acoustically analysed four types of calls of Satyr Tragopan.

1.3 Aims and objectives

- To obtain information about the presence and distribution of the Satyr Tragopan in the Singhalila National Park (SNP), Darjeeling. This would identify areas of high Satyr Tragopan distribution/presence in the Singhalila National Park and identify possible sites in the adjoining parts, which have not been included in the protected area.

- To formulate techniques for abundance indices. This would help to monitor the abundance of the Satyr Tragopan in the various areas of the National Park and also provide a crude population trend of the Satyr Tragopan.

- To study the habitat utilisation patterns of the Satyr Tragopan in the SNP. This would generate information on the broad characteristics of available and utilised habitats of the species (macrohabitat and microhabitat), yearly shift in habitat use, seasonal shift in habitat and habitat selection.
- To study and identify the food plants of the Satyr Tragopan and study their phenophases in the different seasons of the year. These studies would provide us with a range of food items that ~~from~~ form a part of the Satyr Tragopan's diet and also generate information on food availability and utilisation through different seasons of the year. On the whole the dietary requirements of the species will be available.
- To study the social organisation and calling behaviour of the species. Studies on social organisation would provide information on the group composition and group size at different times of the year and a rough estimate of sex ratio in the species. Calling behaviour studies would provide information on the calling period, duration of calling, possible factors affecting calling and will suggest possible functions of calling in the Satyr Tragopan.
- To study the effect of human pressures on the pheasant habitat like lopping fodder collection, forest produce collection and grazing and browsing by cattle from human habitats. These studies identify the various types and levels of activities that may be possible threats to the Satyr Tragopan in the Singhalila National Park. This would help in formulating conservation measures and management techniques for the Satyr Tragopan in particular and the Singhalila National Park as a whole.

CHAPTER 2

MATERIAL AND METHODS

2.1 STUDY AREA

2.1.1 Location: The Singhalila National Park (27° 13' 15" N - 27° 1' 46" N; 88° 1' 52" E - 88° 7' 5" E) is located at the extreme north-western part of the Darjeeling district in the state of West Bengal in eastern India. The National Park derives its name from the Singhalila spur, which descends from Mount Kanchanjunga (8335 m) and runs southwards for about 100 km to the northern fringe of the Gangetic plains. The eastern side (Sikkim) of the Singhalila spur is the valley of the Teesta River and the western side (Nepal) is the valley of the Tamur River, one of the tributaries of the Kosi River. Physiographically the hill ranges on either side of the Singhalila range are similar. The National Park occupies an area of 108.77 km^2 (core zone = 78.60 km^2, buffer zone 30.17 km^2) with an altitudinal zone of 2600 m -3650m (Fig. 2.1).

The Forest (Conservation) Act of 1988 recommends that ideally 60% of land area in the hills should be under forest cover. However the forest cover of the entire Himalayan belt falls far short of this target and averages only 21.78% (Anon 1991). The forest cover of the Darjeeling Hills comprises only 35.2% (Anon 1991) and therefore the Singhalila forests form a very important part of the already depleting forest cover of the region.

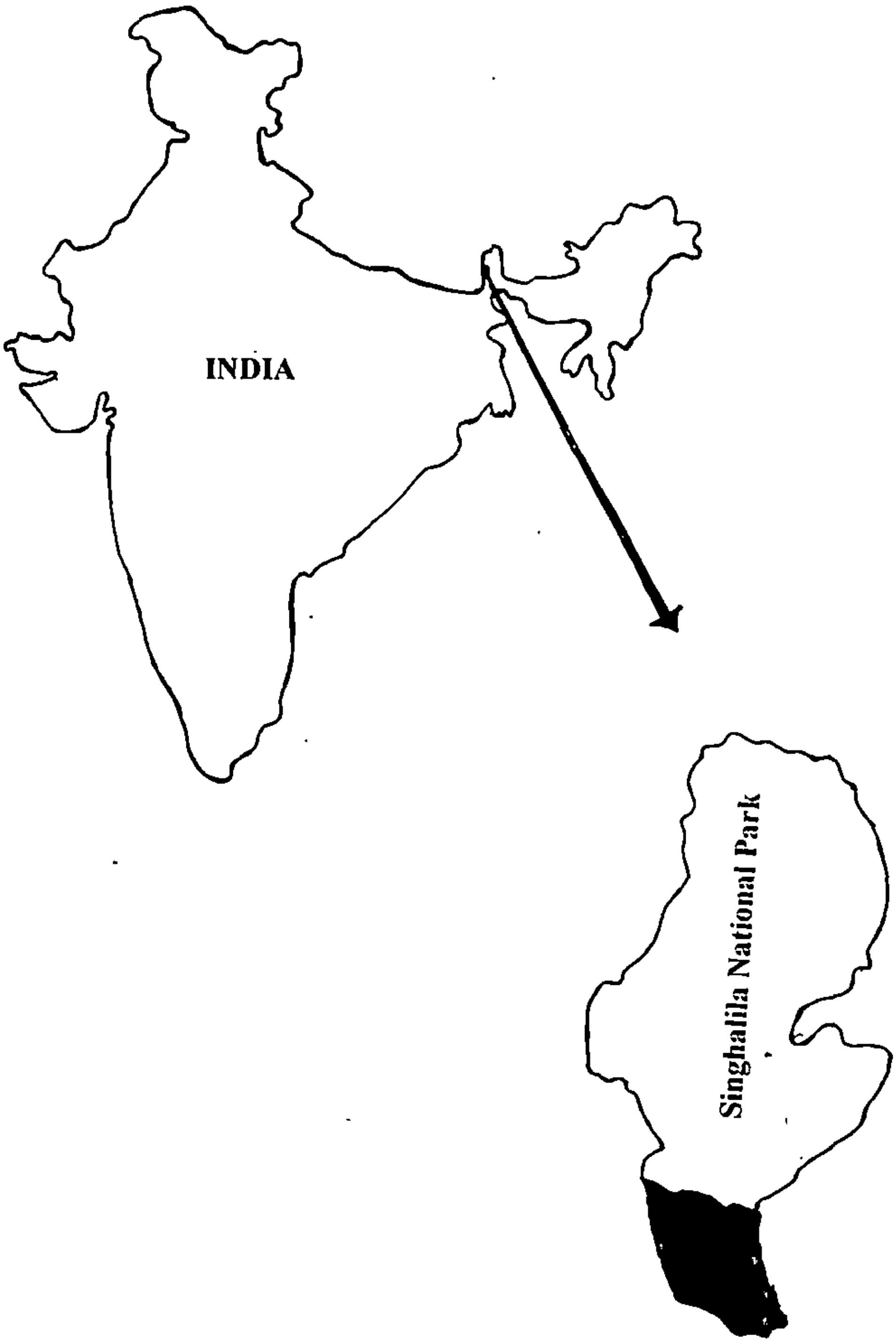


Fig 2.1 Location of Singhalila National Park, Darjeeling, India and intensive study area (shaded portion)

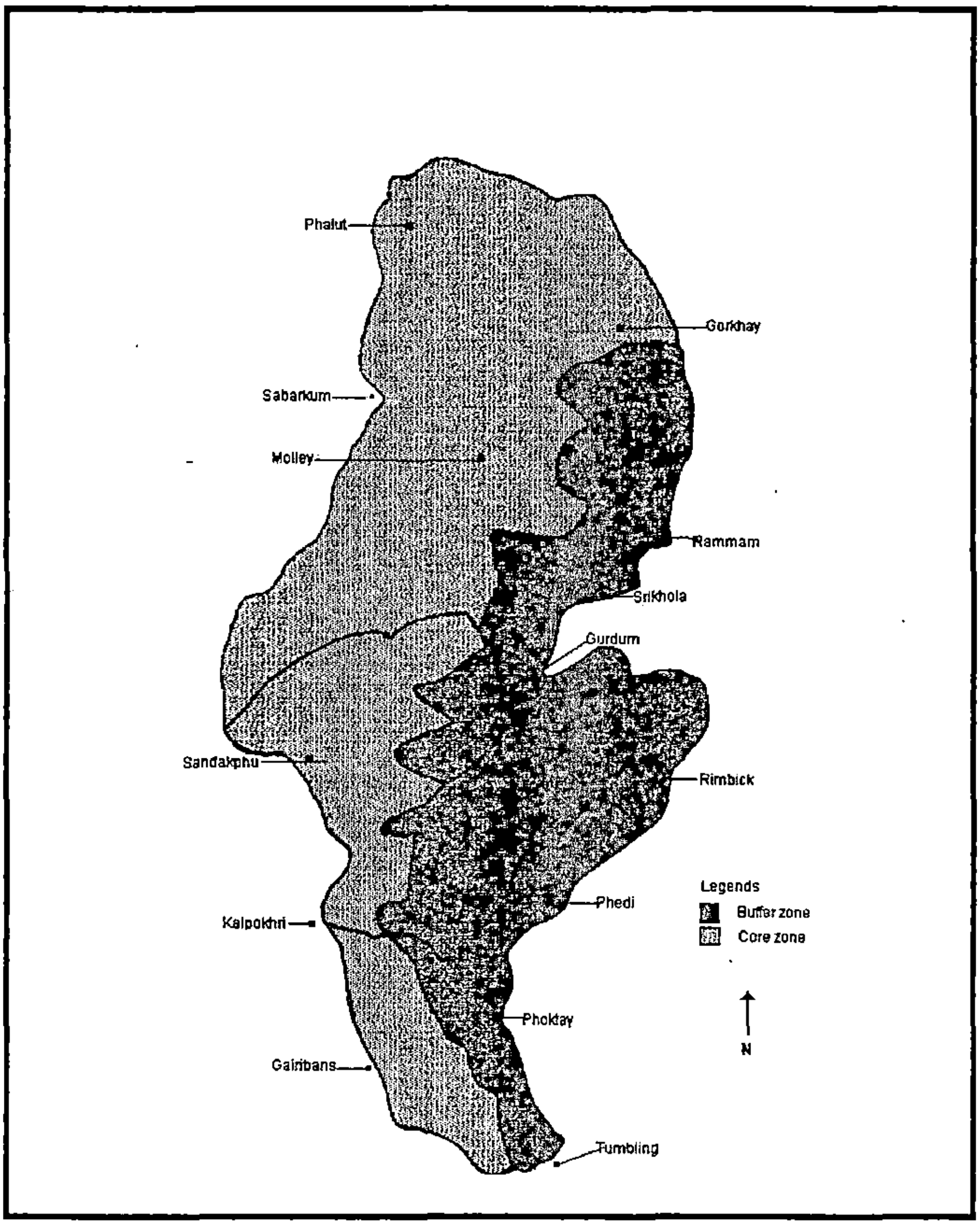


Fig. 2.2 Map of Singhalila National Park, Darjeeling, India showing core and buffer zones and various settlements

According to Chaudhari (1992) the subalpine man made grasslands of Singhalila range merge beyond Singhalila peak in Sikkim, while the temperate forests are contiguous with the subtropical forests of the lower altitudes and the Sal forests of the foothills.

2.1.2 Boundaries: In the north the Singhalila National Park is bounded by the Rongbong khola (khola = stream or rivulet) from Sikkim while at the south-western part the Indo-Nepal border is identified by an unmetalled road running all along the Park border from Tumling (southern most tip) right up to Phalut (northern most tip). The core zone is separated from the buffer zone by another unmetalled road, which runs along the eastern border of the National Park. (Fig. 2.2).

2.1.3 Geomorphology: Singhalila area belongs to that part of the Himalaya which was subject to large scale tectonic movements in recent geological periods. Thus the rocks of this area are very folded, faulted and consistently lie in inverted succession. The rock formation belongs to the Darjeeling gneiss and Daling stage schists of Archaean age (Chaudhari 1992). In the Darjeeling region the Daling schists are of the Pre-Cambrian age while the Darjeeling gneiss is regarded as the granitised representative of the same formations (Rau 1974). Typical successions of Sillimanite-Kyamite-Garnet metamorphic zones of the gneisses are also seen here. The Darjeeling gneiss has metamorphosed into mica schist or a variety intermediate between the two - a feldspar mica schist or gneiss schist. The gneiss is generally composed of translucent, colourless and grey quartz, dark brown feldspar and silvery mica. The overlying Darjeeling gneiss has definite character with much mica schist (Anon 1992).

Due to the heterogeneity of rocks and high rainfall the SNP soil formation is rapid except in those areas which have steep slopes. Most of the hills here lie on Darjeeling gneiss, which generally produce still red loam or sometimes pure sandy or still red clay. The soils throughout the SNP hills are deficient in lime.

2.1.4 Distribution of water sources: The slopes of SNP are criss crossed by a number of streams and rivulets, which drain, into larger rivers in the valleys. The main rivers of the Park are the little Rangit and Rammam which drain water from the National Park. Smaller streams like the Rithu khola, Singpratap, Devithan, Gurdum drain water from the main catchment area of the National Park.

2.1.5 Biogeography: The Singhalila National Park has been placed under the bio-unit Central Himalaya (2C) according to the Biogeographical classification of India by Rodgers and Panwar (1989). In the past this region had always been categorised as a part of the eastern Himalaya (Mani 1974, Ali and Ripley 1978, Negi 1985, Anon 1991). According to Chaudhari (1992) SNP lies at the confluence of the Ethiopian, Palearctic, Mediterranean and Indo-Malayan floral and faunal realms.

2.1.6 Singhalila forest types: Gamble (1875) and Cowan and Cowan (1929) were the pioneers in listing the plants of Darjeeling hills and classifying the forest types accordingly. I have however followed the classification according to Champion and Seth (1968)

2.1.6.1 Wet temperate forests: Commonly known as the upper hill forests by Cowan and Cowan (1929) the forest composition varies with altitude, aspect, rainfall, and biotic and edaphic factors. Evergreen oak forests are found in the 2500-2800 m, which consist predominantly of *Quercus pachyphylla* along with *Q. lamellosa* and *Quercus lineata* on the lower slopes. Besides oak, the forest consists of other species like *Machilus odoratissima, Acer campbellii, Meliosoma dilleniaefolia, Castanopsis tribuloides, Magnolia campbellii* and *Sorbus cuspidata.* The middle canopy layer is formed by *Acer hookeri, Nessa javanica, Pieris ovalifolia, Corylus ferox, Cinnamomeum obtusifolium, Daphniphyllum himalayensis, Rhododendron arboreum, R. cinnamomeum, R. griffithianum, R. falconeri* and *Schleffera impressa.* The understorey layer is predominantly formed of *Arundinaria maling* along with species like *Strobilanthes* sp., *Viburnum erubescens, Viburnum nervosum*, and *Daphne cannabina.*

2.1.6.2 Moist temperate forests: This corresponds to the oak hemlock forests of Cowan and Cowan (1929) found from 2850 m - 3600 m. Here the forests consists of *Quercus pachyphylla, Betula utilis, Sorbus cuspidata, Castanopsis tribuloides, Rhododendron* spp with groups of hemlock (*Tsuga brunniona*). *Litsaea elongata, L. sericea, Endospermum chinense, Osmanthus suavis, Eurya acuminata* and *Symplocos theifolia* form the middle storey. There is a very dense growth of *Arundinaria maling, Thamnocalamus aristata* and *A. racemosa* over a large extent known as temperate bamboo brakes. These are found in large fire swept areas of the Park as a seral type vegetation (Champion and Seth 1968) from where other tree species have been exterminated. *Daphne cannabina, Berberis aristata*, and *Pipthanthus nepalensis* are the other species known to occur with the ringal species understorey. Good hemlock stands are found in the slopes of south-eastern part of the National Park, which finally give way to the fir forests above 2900 m.

2.1.6.3 Subalpine forests: This forest type consists of Silver fir (*Abies densa*), *Betula utilis* and various species of *Rhododendron* like *Rhododendron campanulatum, R. barbatum, R. cinabarinum, R. grande, R. hodgsoni,* and *R. thomsonii.* In the lower altitudes the silver fir is mixed with birch and rhododendron but on the spurs and ridges pure silver fir stands are found. The silver fir forests appear from about 3000 m up to 3650 m after which trees are rarely seen and regeneration is not adequate. Along the main ridge of the Park at 3500 - 3650 m there are man made alpine pastures which have bushes of *Berberis* sp, *Rosa sericea, Glautheria griffithiana* and *Cotoneaster* sp. Trees of *Juniperus pseudosabina* have been reported from these forests but are not found any longer.

Gopal and Meher-Homji (1983) divided the temperate forests of India into three types based on differences in rainfall during the growing season (period with more than 13° C temperature). These are montane wet temperate forests, montane moist temperate forest and Himalayan dry temperate forest. The forests of Singhalila National Park according to their classification fall under the montane wet temperate forests under the subdivision Northern wet temperate forests. At 1800 m-3000 m these forests are dominated by evergreen species in stands up to 25 m height. Epiphytes, ferns, mosses and aroids are abundant in these forests due to heavy rainfall.

According to Kanai (1966) the Rhododendron forests mark the timberline at a height of 4000 m and the region up to 5000 m is occupied by alpine meadows of prostrate *Juniperus squata, Androsace* sp., *Arenaria* sp., *Cassiope* sp., *Saussurea* sp. and others. *Rhododendron* sp. was reported to be abundant at the top of Mount Singhalila (4000 m).

2.1.7 Climate: Climatically the Singhalila National Park is considered to fall in temperate to subalpine zone as moist temperate conditions prevail throughout the year (Anon. 1992). The annual mean temperature in summer in the temperate zone varies from 7 °C to 17 °C and 1 ° C to 10 °C in winter. In the subalpine zone the mean summer temperature is below 7 °C and the mean winter temperature is below 1 °C. Moist and foggy atmospheric conditions prevail throughout the year with an annual rainfall of 350 cm and the relative humidity readings vary from

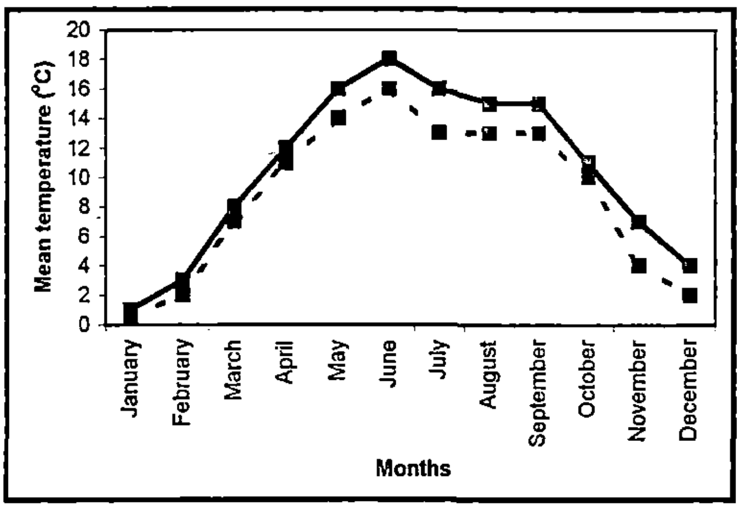


Fig. 2.3 Mean maximum (thick line) and minimum (broken line) temperature recorded in Singhalila National Park (1994-1996)

83% to 96%. Moderate storms which are accompanied by hail occur in April and May. There is regular snowfall in winter all over the Park and in areas above 3300 m the snow may not thaw up to March (Anon 1992). Snowfall may occur as early as in October and as late as in April in the higher reaches of the Park. Frost is also fairly common in all areas of the Park during this season. During the period of 1994 June to October 1996 the mean temperature varied from 0.5°C to 18°C (Fig. 2.3). Conditions were wet throughout the year, the Relative Humidity records varied from 70.80% to 96.70 % (Fig. 2.4). As the area belongs to a high precipitation region the rainfall varied from 155 mm - 7500 mm. (Fig. 2.5).

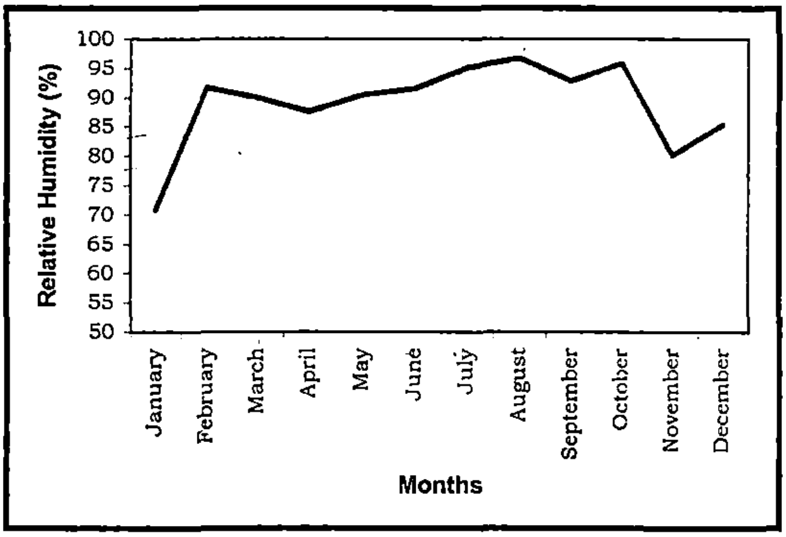


Fig. 2.4 Mean monthly Relative Humidity (%) recordings of Singhalila National Park, (1994-1996).

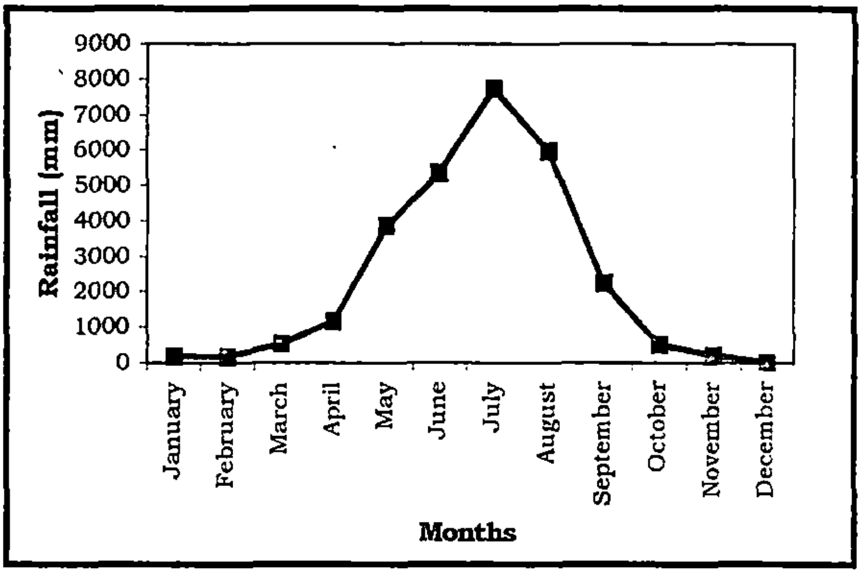


Fig. 2.5 Mean monthly rainfall (mm) recorded at Singhalila National Park (1994-1996)

2.1.8 Fauna: Some of the interesting mammal fauna of the Singhalila National Park which I saw or obtained evidences of are the Himalayan Black bear (*Selenarctos thibetanus*), Red Panda (*Ailurus fulgens*), Barking deer (*Muntiacus muntjak*), Wild boar (*Sus scrofa*), Serow (*Capricornis sumatraensis*), Himalayan yellow throated marten (*Martis flavigula*), wild dog (*Cuon alpinus*), common leopard (*Panthera pardus*), Himalayan mouse hare or pika (*Ochotona roylei*), Chinese pangolin (*Manis pentadactyla*) and Great eastern Horseshoe bat (*Rhinolophus luctus)* . Besides, some species of small cats are believed to occur in the Park. The Singhalila National Park and adjoining areas are considered to be amongst the richest avifaunal zones of the world from where 550 species of birds have been reported. Some of the prominent ones are Slenderbilled Scimitar Babbler (*Xiphirhynchus superciliaris*), Goldenbreasted fulvetta (*Alcippe chrysotis*), Brown Parrotbill (*Paradoxornis unicolor*), Fire tailed myzornis,

(*Myzornis pyrrhoura*), various sunbirds, flycatchers, finches, warblers, babblers, raptors, laughing thrushes, chats, forktails, pipits, nuthatches, tree creepers, tits, yuhinas, bulbuls, etc.

I recorded a total of 175 species of birds in the Singhalila National Park during my study. Among galliformes, besides the Satyr Tragopan, the other species known to occur in the Park are Black backed Kaleej Pheasant (*Lophura leucomelana melanota*), Blood Pheasant (*Ithaginis cruentus*), Hill Partridge (*Arborophila torqueola*) and Redbreasted Partridge (*Arborophila mandellii*). Besides these, I also saw the all black Kaleej Pheasant, which I suspect, might have been the *L. l. moffotti*. Reports from the local people indicated that the Himalayan Monal (*Lophophorus impejanus*) was also present in the National Park but this is probably from the Singhalila Peak (4000 m) area, which lies adjacent to the northern end of the SNP. Besides these the National Park is rich in amphibian, reptilian, lepidopteran and coleopteran diversity.

2.1.9 Flora: The main forest types of the SNP have already been mentioned above. The large number of species of Rhododendron makes the area a typical eastern Himalayan zone. I could list at least 14 species of *Rhododendron* from the Park area following the descriptions of Cowan and Cowan (1929). These include *Rhododendron arboreum, R. cinnamomeum, R. griffithianum, R. campanulatum, R. falconeri, R. cinnabarinum, R. thomsonii, R. barbatum, R. triflorum, R. lepidotum, R. lindleyi, R. edgeworthhii, R. aucklandi*, and *R. grande*. The family Magnoliaceae which is endemic to the eastern Himalaya occurs in the Singhalila National Park and is represented by *Magnolia campbellii* and *M.globosa*. Besides there is a large variety of shrubs, bushes, climbers and creepers in the SNP. There is a rich variety of flowering plants in the SNP, some of which are *Primula* spp., *Iris hookeri, Aconitum ferox, A. heterophyllum, Arisaemia* spp., *Rheum australe, Fragaria* spp., *Potentilla* spp., *Meconopsis* spp., *Geranium* spp., *Impatiens sulcata, Viola* spp., *Anemone* spp., *Rosa* spp., *Saxiphraga* spp., *Senecio* spp., *Calamintha* spp., *Viburnum erubescens, V. nervosum., Piptanthus nepalensis, Schizandra grandiflora, Holboellia latifolia, Actinidia, strigosa, Rubus nepalensis, Mahonia sikkimensis, Aster* spp., *Valeriana* sp., *Pleone praecox, P. humilis* etc. In Singhalila National Park most of the tree species are covered with moss and have many species of epiphytic ferns and orchids. The area is also known to have a large variety of mushrooms, lichens and bryophytes.

2.1.10 Threats: Like most other protected areas in India the presence of human settlements in the vicinity of SNP is the main cause of all forms of threat observed in the NP. The western boundary of Singhalila National Park falls on the International border with Nepal and is identified by a 42 km unmetalled road running along this border. This road is marked all along its course by human settlements and cattle stations in the Nepalese territory. Larger villages are not too far away from the Park boundary. Apart from this the buffer zone of the National Park is marked all along the eastern side by human settlements on the Indian territory. The main human related activities that may be potential causes of threats to the Park area were grazing and browsing by yak, firewood collection and hoarding, forest produce collection and hoarding, poaching for recreation and sale of animal parts, minor construction work and indirect pressures of tourism. The galliform fauna was most vulnerable to habitat destruction and poaching. It seemed to be relatively easy to snare galliformes and the size of the game being relatively small it escaped the notice of the Park authorities fairly easily.

2.2 GENERAL METHODOLOGY

In this section I have touched mainly upon the design of the study and certain methods that were adopted. More specific details of methods used are given at the beginning of each chapter.

I divided the study period into four seasons viz. the pre-monsoon season from March to May, monsoon season from June to August, post-monsoon season from September to November and winter season from December to February. Review of the available information about the Satyr Tragopan in the Singhalila National Park through various sources indicated that its local distribution, abundance and general habitat requirements were poorly known. Two reconnaissance surveys were conducted to initiate intensive studies on the Satyr Tragopan. Based on the findings of these two investigations I conducted extensive surveys and covered all the beats (administrative unit of a range) of the 108.77 km^2 National Park on foot. During these extensive surveys I used the existing network of forest paths/trails of varying lengths which passed through different habitat/forest types to search for evidences of the Satyr Tragopan. Based on these extensive surveys I delineated an intensive study area which comprised of Gairibans, Kalpokhari and parts of Sandakphu as these areas provided maximum concentration of Satyr evidences (Fig: 2.6). For systematic monitoring the intensive study area of approximately 25 km^2 was stratified into three altitude zones of 2600-2900 m (zone 1), 2900-3200 m (zone 2) and 3200- >3600m (zone 3). Four permanent transects/ trails were marked out in each altitude zone which were monitored on a monthly basis ensuring that equal weight~~age~~ing was given to each in terms of observer effort. Of these twelve trails eight were 3 km long, three were 1.8 km and one ~~of~~ was 2 km long. Sites with evidences of target species were temporarily marked for carrying out vegetation sampling studies.

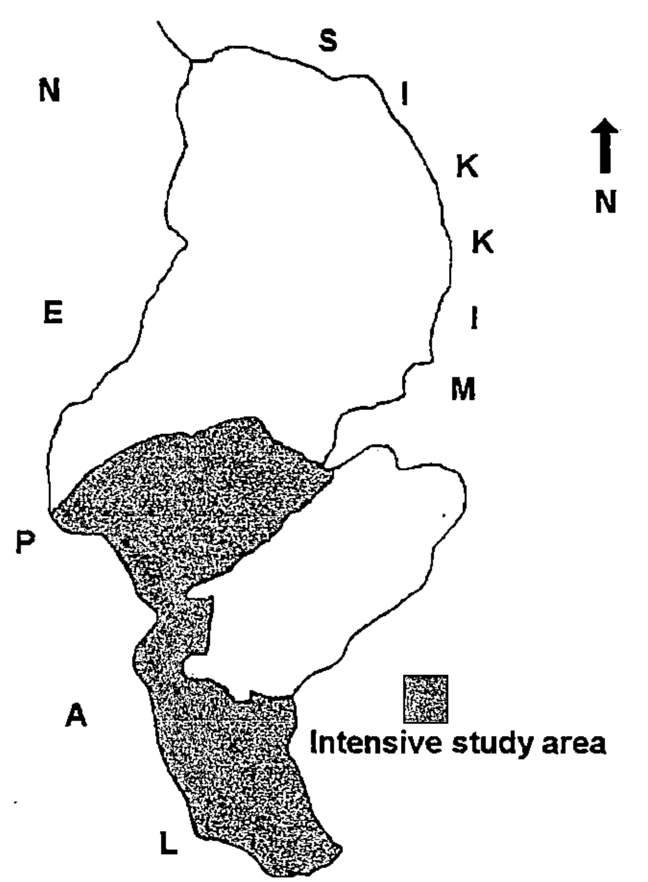


Fig 2.6 Singhalila National Park showing the intensive study area (shaded portion)

Indirect evidences like droppings and feathers they were also collected. To ensure that the records were not repeated these indirect evidences were completely cleared. All animal details were recorded as mentioned in the extensive monitoring section while the monitoring the permanent trails.

2.2.1. Dawn call counts: I also used 3 of the 12 trails for dawn call counts. While selecting trails care was taken to ensure ~~the~~ that all types of areas could be represented. Due to limited calling period of the bird I monitored only three trails covering an altitude range from 2600-3100 m. Each trail was replicated for three successive mornings each month for three years. The permanently marked points in each trail were used in all the three years of observation. Data thus obtained were used to study the distribution, relative density and also the calling behaviour of the Satyr Tragopan.

2.2.2. Habitat studies: The 12 permanently marked trails were monitored systematically to produce data on habitat use. Each of the 12 trails was walked once every three weeks (1 week/trail). Monitorings were timed so that effort was equally distributed . This scheme of work was continued for all 12 months of the year including seasons of inclement weather (monsoon and winter)

2.2.3. Food and feeding ecology studies: The diet of the Satyr Tragopan was studied by the faecal analysis. All the droppings of Satyr Tragopan that were found during regular trail monitoring as well as outside these were collected in plastic packets. From there they were transferred to paper trays for air or oven drying depending on the season of collection. The droppings were then labelled and sealed in new polythene packets and stored in an air tight container with camphor and a desiccating agent like silica gel. Later in the laboratory the preserved droppings were pooled across seasons and analysed to study the diet of the species. All the places from where droppings were collected were temporarily marked for carrying out vegetation sampling studies.

2.2.6 Threat studies: Threats to the Satyr Tragopan in the Singhalila National Park were studied by assigning intensity categories to various kinds of threats recorded during habitat studies.

2.2.7 Analyses: Univariate and multivariate statistical tests were used to analyse data following Sokal and Rohlf (1995), Zar (1984), Snecdor and Cocharan (1967) and Siegel (1957). For multivariate analysis, data variables were appropriately transformed (arcsine, lognormal, logratio) to normalise the data. All analysis was carried out manually and by the software package SPSS 7.5 for Windows (Norusis 1990). Details of analysis have been described in more details in the methods section of each chapter.

CHAPTER 3

DISTRIBUTION AND ABUNDANCE

3.1 Introduction

Among the genus *Tragopan* the Satyr Tragopan is considered the most widely distributed species after the Temmick's Tragopan, *Tragopan temmickii.* It was believed to occur between 79° - 92° E (Gaston 1982) from Garhwal in the west through Kumaun, Nepal, Sikkim, Bhutan and Arunachal Pradesh (Ali and Ripley 1978, Johnsgard 1986) at altitudes between 2400 m- 4300 m descending to 1800 m during winters (Vaurie 1965). Recent surveys have shown that this species is present in Garhwal, Kumaun, Nepal, Sikkim, Darjeeling hills of north Bengal, eastern and western Bhutan, western Arunachal Pradesh and more recently from south eastern China (Han Xian1995, Ma Shilai 1996). The current distribution encompasses the geographical area from 79°E to between 98°E - 99°E.

In this chapter I have reviewed the global distribution of the Satyr Tragopan and attempted to find out overlaps with other congeners along the range of distribution. I have also reviewed the recent information about the presence of this species from farther eastern longitudes and commented on the possible relationship the Satyr Tragopan may have with its other congeneric species along this new range. Though discussed separately I have not intended to treat abundance as a separate topic from distribution. Apart from distribution and abundance I have made an attempt to obtain a relative density index from dawn call counts in the SNP. Such studies are expected to provide some information on the relative abundance and distribution pattern of the species in the study area. Through my studies on the distribution and abundance of Satyr Tragopan I have tried to:

1.Update and comment on the global distribution of the Satyr Tragopan.

2 Map the distribution of Satyr Tragopan in the different areas of the SNP.

3.Obtain some measure of relative abundance including relative density indices.

4.Monitor any changes in these indices.

5.Identify the factors that determine the distribution and abundance of Satyr Tragopan in the Singhalila National Park.

6. Identify the main field problems/difficulties in the methods adopted during the studies and to comment on their suitability and utility in the prevailing field conditions.

3.2. Methodology

A review of the available information about the Satyr Tragopan in the SNP through various sources indicated that its local distribution, abundance and general habitat requirements were very poorly known. To initiate any studies on the species I first had to verify the presence of the species in the National Park and to identify areas where the species was distributed locally. Prior to my surveys in the Park the Satyr Tragopan had been documented from Singhalila National Park over sixty years ago (Inglis 1933a & b).

I conducted extensive surveys over various periods of time with an aim to establish the presence/absence and distribution of the Satyr Tragopan in the different parts of the Singhalila National Park. Apart from collecting such information I also delineated areas that would serve as sites for intensive ecological studies in future on a limited population of birds.

3.2.1 Extensive monitoring: Due to paucity of reliable information on the distribution of Satyr Tragopan in Darjeeling hills in general and Singhalila National Park in particular I initially relied on second hand information obtained from various sources. These included villagers living across the Park borders, Wildlife Department staff, forest village dwellers living within the forest, shepherds/cattle herders in the numerous cattle/yak stations along the National Park border and regular trekking guides (Sharma and Panday 1989, Kaul 1995). Subsequently, based on the information provided by the sources, I conducted extensive surveys and covered all the beats (administrative unit of a range) of the 109km^2 National Park on foot. During these extensive surveys I used the existing network of forest paths/trails passing through different habitat/forest types to search for evidences of the Satyr Tragopan.

True line transects (Burnham *et al.* 1980) could not be laid in SNP. The main assumptions of the line transect method are: (a) that all birds on the transect line are detected, (b) birds are detected before they move, (c) measurements of distances are accurate, (d) there are no double counts of individuals, (e) bird detection is independent and (f) biases from observers, seasons and weather are well understood (Bibby *et al.* 1992). These assumptions indicate that the process is based on the ability of observers to follow a straight line or segments of straight lines (Anderson *et al.* 1979). In SNP laying of such straight line transects was not possible because of the very folded topography and steep and rugged terrain. I therefore used the existing network of roads and paths, which followed contour lines as monitoring trails (Fig 3.1 and 3.2).

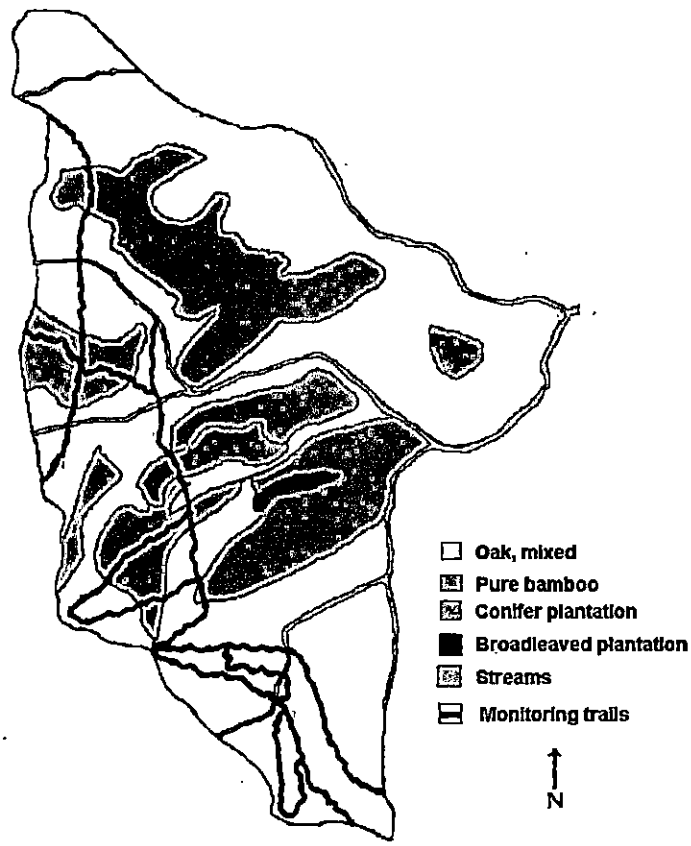


Fig 3.1 Map of Gairibans Beat of Singhalila National Park (including Gairibans, Kainyakatta and Kalpokhri) showing the broad habitat types and trails used for monitoring.

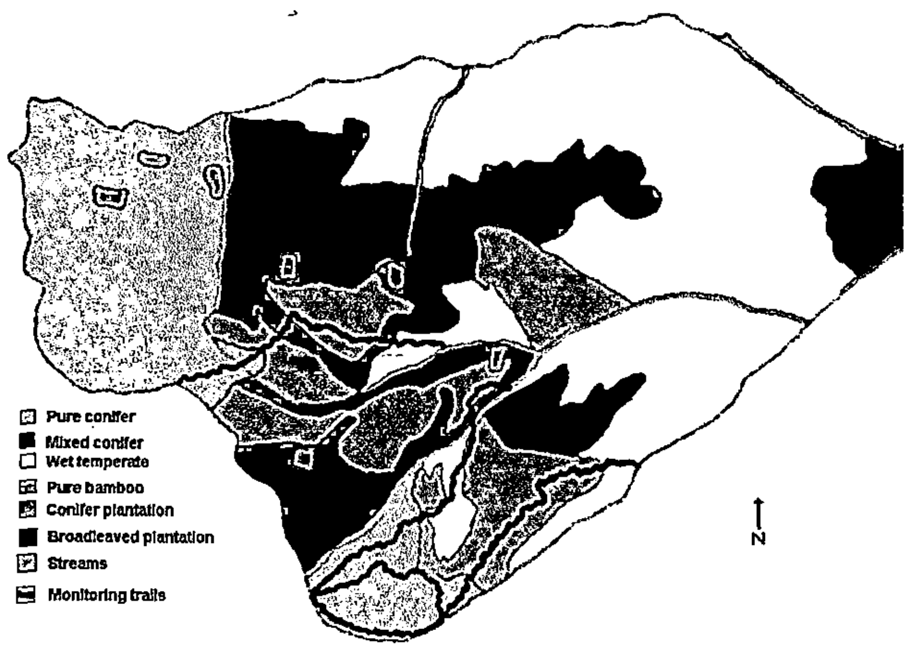


Fig 3.2. Map of Singhalila National Park (Sandakphu area) with broad habitat types and monitoring trails

Detection of birds along a trail was rendered very difficult by the shy and elusive nature of the Satyr Tragopan. Similar to the experience of Katti *et al.* (1992) concerning poor detectability of birds in Arunachal Pradesh forests, detection of Satyr Tragopan was difficult in the Singhalila National Park due to the density of vegetation at the understorey level. Accurate distance measurements were not possible, as the birds when encountered were highly motile and easily flushed. Flushing sometimes occurred without the bird being visible and perhaps many birds were missed during these monitorings even when they were close by. Thus almost all the assumptions of line transect method would have been violated in this study had this method been applied. I therefore used the trail monitoring data to obtain relative abundance estimates by calculating the relative encounter rates (Kaul and Ahmed 1992) rather than attempting to obtain real density estimates.

I relied on direct sightings as well as indirect evidences in the form of droppings and feathers to verify presence of the birds in a particular area (Gaston *et al.* 1981b, Gaston *et al.* 1983, Kaul 1995). Surveys parties consisted of one to four observers who recorded the date, time, locality, general vegetation, number, sex and age category (adults, juveniles, chicks) for all encounters with pheasants or their evidences.

3.2.2 Intensive monitoring: Based on these extensive surveys an intensive study area was delineated which comprised of Gairibans, Kalpokhari and parts of Sandakphu. These areas provided maximum concentration of Satyr evidences during that period.

I stratified the entire intensive study area of approximately 25 km^2 into three altitude zones of 2600-2900m (zone 1), 2900-3200m (zone 2) and 3200- >3600m (zone 3). Four permanent transects/ trails (see table 3.1) were marked out in each altitude zone which were monitored systemically on a monthly basis ensuring that equal weight~~age~~ing was given to each in terms of observer effort. I tried to identify trails of 3 km length for monitoring the intensive study area but in some areas trails of this length were not found and thus I had to select shorter trails for monitoring. Of the twelve trails eight were 3 km long, three were 1.8 km and one of 2 km long. Sites with evidences of Satyr Tragopan were temporarily marked for carrying out vegetation sampling studies. Indirect evidences like droppings and feathers were also recorded. To ensure that the records were not repeated these indirect evidences were completely cleared. All animal details were recorded as for extensive surveys.

Table 3.1: Showing the salient features of the monitoring trails in the intensive study area.

Trails	Length (km)	Altitude (m)
1	3	2600-2625
2	3	2625-2900
3	1.8	2600-2700
4	1.8	2600-2600
5	3	2900-3010
6	2	2900-3000
7	1.8	2900-3000
8	3	3000-3200
9	3	3200-3400
10	3	3200-3636
11	3	3200-3300
12	3	3200-3400

3.2.3 Dawn call counts: I conducted call counts (Kimball 1949) on 3 of the 12 transects that were used for routine monitoring. All these trails had good vantage points affording large area coverage in the Gairibans and Kalpokhri areas of the SNP. No universal method for estimating bird densities is available and appropriate methods may vary according to species, time and the place of study (Clobert and Lebreton1991). I used call counts (Gaston 1980, Duke 1989) to obtain relative density estimates of Satyr Tragopan in the Singhalila National Park. Observers were placed at five points along each trail and separated by a distance of 600 m. This distance was considered to be adequate between two adjacent observers (Gaston 1980) so that the possibility of missing out any calling birds between points was reduced. All these observation points were permanently marked so that the same place could be used for call counts in subsequent seasons. Counting of calling males was recorded on appropriately designed data collection sheets on which a set of concentric circles was drawn for marking distances between the observer and the calling bird. The inner most circle of the chart represented the series of 3 concentric circles represented widths of 100m, 200m and 300m respectively from the observer. At the census points the northerly orientation of each point was marked the evening before the census exercise and the observer oriented himself/herself accordingly at the time of count. For convenience, digital watches were used as far as possible and special care was taken to ensure that the watches of all observers were synchronised prior to counts. Each observer noted down the time and direction of the call, the approximate distance of the source of the call, the number of calls (note), duration of each call, the number of birds heard calling and marked the location of the bird (s) in the appropriate width bands. Other important variables recorded were weather conditions including cloud cover, wind conditions, temperature, relative humidity, rainfall and time of sunrise. The dawn call counts were repeated for three consecutive mornings along each trail.

3.2.4 Analyses: Encounter rates were calculated to measure relative abundance from the direct sightings through observer effort by the relation ER=n/100 hrs where n= number of groups of Satyr Tragopan sighted. In cases of indirect evidences I used only faecal droppings to calculate the encounter rates through indirect evidences by the relation ER = n/km where n = number of groups of faecal droppings collected. Other forms of indirect evidences were ignored in the calculation of encounter rates. The maximum number of birds heard calling on any particular day of the census was considered the closest approximation of the relative density indices (birds/km^2) across trails through call counts. Due to small sample size on encounters I mainly performed non-parametric tests (Siegel 1953).

3.3. Results

3.3.1 Distribution

3.3.1.1 Historical: The Satyr Tragopan was known to be distributed in Garhwal, east through Nepal, Sikkim to Assam north of the Brahmaputra as far east as Darrang (Beebe 1918, Whistler 1928). According to Johnsgard (1986) the species is distributed in the Himalaya between 8000 ft (2424 m) and 12000 ft (3636 m) and occasionally 14000 ft (4242 m) from Garhwal eastward to Bhutan and forests of neighbouring Tibet and Monyul to about 92°E. This species was known to descend to 6000 ft (1818 m) in winter in dry and moist coniferous forests (Vaurie 1965). Beebe (1918-1922) reported the bird from Sikkim and Nepal inhabiting narrow side gorges with small streams in Rhododendron-Oak-Magnolia forests with bamboo and flowering undergrowth. Similarly, Ali and Ripley (1978) described the distribution range of Satyr Tragopan from Garhwal in the east through Nepal, Sikkim, Bhutan and Arunachal Pradesh at altitudes between 2400 - 4300 m, and descending to 1800 m during severe winter. The species was associated with oak-deodar and rhododendron forests on 'khuds' (hollows) with steep hillsides of scrubby undergrowth and ringal bamboo. It is noteworthy to mention here that the hills of Darjeeling have not been mentioned in the historical distribution of the species though there were reports of the bird from as far back as 1842 from Kurseong (Hickell 1842 in Inglis 1933a), in the vicinity of Darjeeling (Jerdon 1853) and Singhalila hills (Inglis 1933a & b) (Fig3.3).

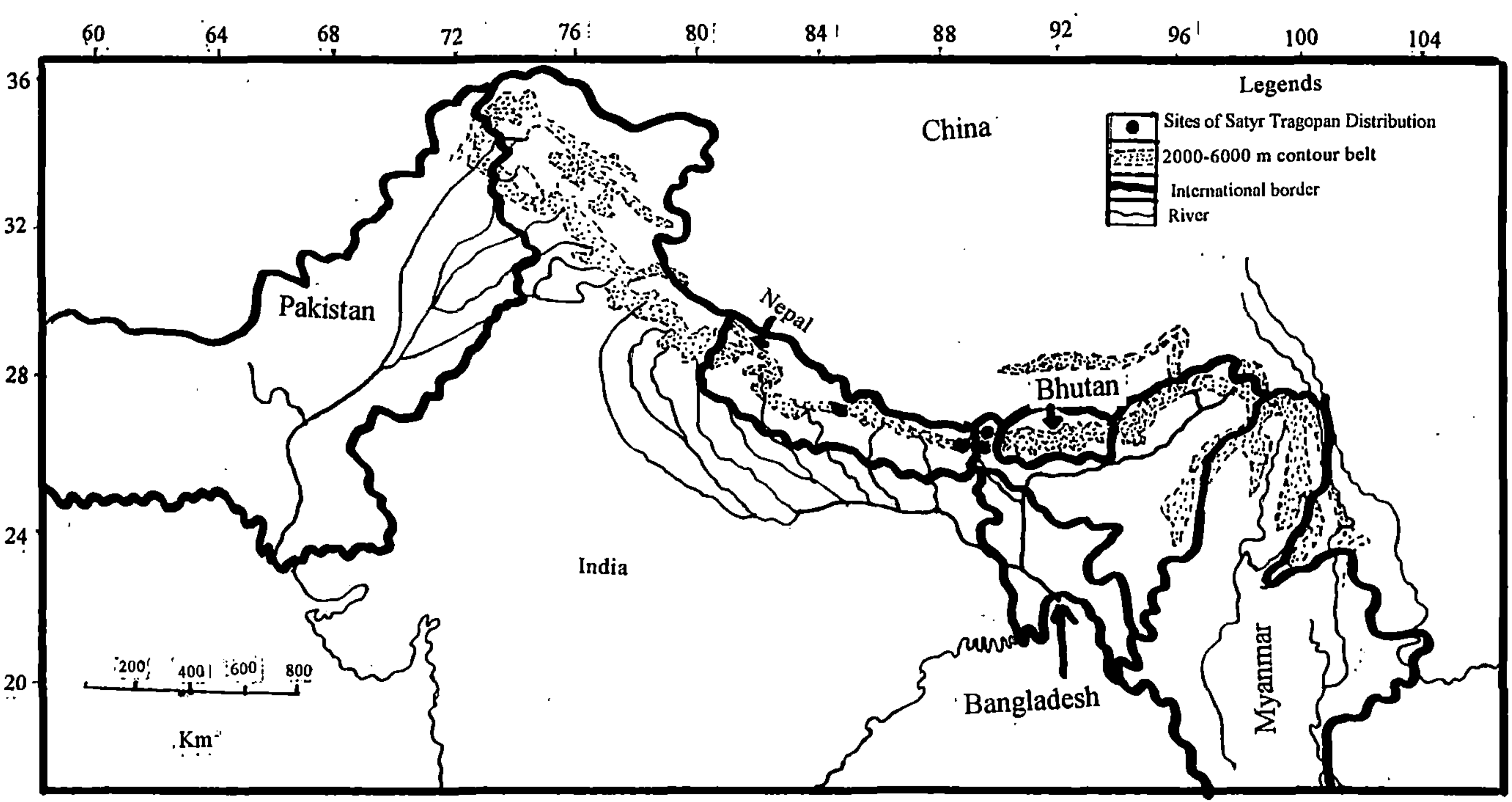


Fig . 3.3 Old distribution sites of Satyr Tragopan

3.3.1.2 Current distribution: The accepted geographical range of Satyr Tragopan extended from 79°E - 92°E (Gaston 1982). Recent reports confirm the presence of the species from Garhwal (Prasad 1993), Kumaun (Young and Kaul 1987, Shah *et al.* 1997), Nepal (Lelliot and Yonzon 1980, Forster 1982, Upreti 1982, Yonzon 1982, Roberts 1983, Picozzi 1985, Picozzi 1987, Inskipp 1989, Roberts 1990, Inskipp (1991), Amatya 1997, Maskay 1997) Sikkim (Pazo 1982, Lachungpa 1997, Lepcha 1997), Darjeeling hills in north Bengal (Anon 1992), Bhutan (Pradhan 1983, Clements 1992, Inskipp 1993, Bishop 1996, Holt 1996, King 1996, Ali *et al.* 1996, Tymstara *et al* 1997) and Arunachal Pradesh (Kaul and Ahmed 1992, Kaul *et al.* 1995, Singh 1998). There were some recent reports of the presence of Satyr Tragopan from southern Tibet (Cheng 1989) and from one site farther east near the northeastern border of Myanmar and China known as Dulongjiang (Nujian Nature Reserve) of Gaologongshan region in the Yunan province of China (Zhjeng Guang-mei 1992, Han Xian 1995 and Ma Shilai 1996). With the inclusion of this region of China the distribution range of the species has increased substantially and now encompasses the geographical area from 79°E up to between 98°E and 99°E. A region wise description of the distribution of Satyr Tragopan, based mainly on review of available literature is presented below (Fig 3.4).

Garhwal: There was severe paucity of information about the distribution of the Satyr Tragopan from the Garhwal Himalaya (Gaston 1982). Except for Garhwal as the western limits of Satyr Tragopan distribution no sites have been mentioned from the region in the historical distribution of the species. Currently the bird is suggested to be present in the Tons River catchment (Prasad1993) but this is based on reports provided by the local people of the area.

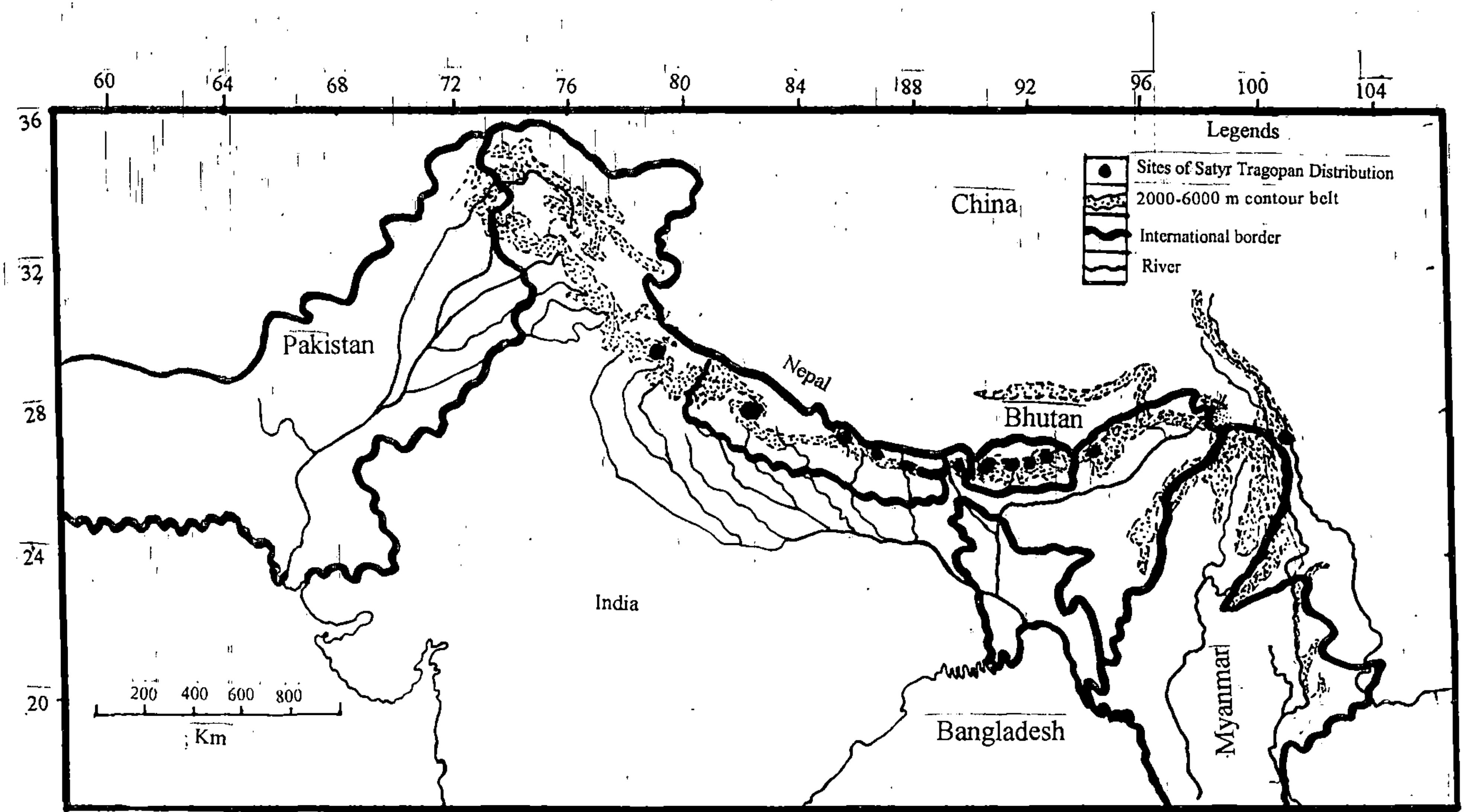


Fig. 3.4 Current distribution sites of Satyr Tragopan

Kumaun: In the Kumaun Himalaya the Satyr Tragopan was reported from Dakuri (Abudali 1969). Young and Kaul (1987) recorded the birds in the Pindari and Milam valleys in the inner ranges of the Kumaun himalaya at altitudes of 2400-4250 m. In very recent surveys (Shah *et al.* 1997) the species was recorded from Sunderdhunga and Dwali areas in Almora district and Munsiari area in the Pithoragarh district of Uttar Pradesh.

Nepal: The Satyr Tragopan was reported from the Kali-Gandaki valley in western Nepal at 2740 m in winter (Rand and Fleming 1957). There are several reports of the species from the Annapurna Conservation Area (ACA) in Central Nepal. The Pipar Pheasant Reserve which lies within ACA is a pheasant sanctuary harbouring a good population of Satyr Tragopan. Here pheasant populations including the Satyr Tragopan have been monitored for nearly two decades now (Lelliot and Yonzon 1980, Roberts 1983, Picozzi,1985,1987, Howman and Garson 1992, Kaul 1995 and Kaul and Shakya 1998). Apart from the Pipar area the Satyr has been reported from Ghasa (Roberts 1990) and Dhorpatan Hunting Reserve (Lelliot 1982, Roberts 1982, Inskipp 1989). Protected areas from central Nepal like Khaptad, Langtang, Sagarmatha and Makalu Barun all fall within the distribution range of the Satyr Tragopan (Forster 1982, Inskipp 1989) and each have the potential of holding Satyr Tragopan populations.

Ripley (1950b) and Biswas (1960a) have reported the Satyr Tragopan from eastern Nepal in the Dudh Kosi and Hangu valleys. In the extreme north eastern part of Nepal, the species was known to be present in the Kanchanjunga Conservation Area at elevations above the zone of intensive arable activities (above 2000 m) in temperate forests (Amatya 1997, Maskay 1997). Towards the southeastern borders of Nepal I have observed and recorded the birds at sites lying along the western border of the SNP at 2600-3300 m altitudinal range.

Darjeeling hills: Historically the Satyr Tragopan was reported to be found in the vicinity of Darjeeling at 7000 - 8000 ft. (2121 m - 2424 m) by Jerdon (1863). Inglis (1933a) reported the presence of this bird in the Singhalila range or the present Singhalila National Park. Hickell (in Inglis 1933a) recorded the bird between the present Kurseong and Sonada regions in Darjeeling district as far back as 1842. Currently the species is reported to occur in Neora Valley National Park (Anon 1992) in the western part of the hilly district in addition to Singhalila National Park (Anon 1992).

Sikkim: Satyr Tragopan, the first species of pheasant known to naturalists was reported from Sikkim Himalaya as quite common at higher elevations (Jerdon 1863, Beebe 1918-22). It was reported to occur between Changu and Nathula in north Sikkim (Inglis 1933a) and Bailey (in Inglis 1933a) recorded the birds near Gangtok at about 8000 ft (2424 m). Steven (in Inglis 1933a) further specified that the species was distributed in the outer ranges in the interiors of Sikkim at 7000 ft-8000 ft (2121 m - 2424 m) in spring going down to 6000 ft (1818 m) in winter and ascending to 14000 ft (4242 m) in summer. Meinertzhagen (1926) recorded the species as commonly distributed in Lachung (north Sikkim) at 8,750 ft - 9,200 ft (2651 m - 2787 m). The Satyr Tragopan was reported to be distributed throughout the hills of Sikkim in thick canopy of tree or climbers in the Kanchanjunga National Park (Pazo 1982, Lepcha 1997). Very recent surveys have confirmed the presence of the species from the Kyongnosla Alpine Sanctuary, Menmoitse Forest, Singhba Rhododendron Sanctuary, Kanchendzonga National Park and Maenam Wild Life Sanctuary (U.Lachungpa pers. com., Ghose 1998).

Bhutan: Satyr Tragopan was found to be distributed in eastern and western Bhutan between 2743 m -3353 m (Ludlow 1937). It is considered to be fairly common throughout the country. The species was recorded from Hadzong in western Bhutan near Phuntsoling (Ali *et al.* 1972). Other sites of current distribution include Gogona gompa (Inskipp 1993b), Phobjika and Dochula in Blue Mountain Natural Forest (Inskipp 1993b, King 1996, Bishop 1997), Jigme Dorji National Park (Murphy 1994, Inskipp 1996), Pelela, Sangela, Zedeke, Mela, Pegula, Lingshi and Barshang (Pradhan 1983), Phephela (Clements 1992), Lingmithang (Dreyer 1995, King 1995, Holt 1996, Bishop 1997), between Tsongsa and Bhumthang (King 1996), Yutongla and Chendebji (Tymstra *et al.* 1996)

Arunachal Pradesh: There were very few site records of the Satyr from this state. The bird was considered to be restricted to the western portion in the Thingbu and Mago area of Tawang district (Kaul and Ahmed 1992, Singh 1994, Kaul *et al.* 1995). Very recently the Satyr Tragopan was sighted in the Eagle's nest Wildlife Sanctuary in western Arunachal Pradesh (R. Suresh Kumar pers. comm.).

China: Historically Ludlow (1944) reported the species from the Chumbi valley in Tibet adjacent to Sikkim. Cheng (1989) reported the species from Mount Jumulong Ma (Quomolangma) National Park in the southwest border of the Tibetan Autonomous Region. However the most interesting part of the distribution was the recently reported site on the southeastern side beyond Myanmar. Here the species was reported in Dulongjiang (Nushian Nature Reserve) in the Gaologongshan region of Yunan Province of China (Zheng Guang-mei 1992, Xian1995, Ma Shilai *et al.* 1996). With this the global distribution or range of the species extends further east by nearly 7°.

3.3.1.3 Distribution in Singhalila National Park: The first survey in SNP was carried out during the post-monsoon season of 1993 when the birds had stopped calling. Therefore I relied on other evidences like droppings, feathers and local reports in addition to sightings to obtain some patterns of Satyr Tragopan distribution within Singhalila National Park.(Table 3.2).

I spent a total of 1218 man hours in four extensive monitorings and encountered the Satyr Tragopan 17 times during the period (direct and indirect). Fifteen (88.2%) of the encounters occurred in the Gairibans-Kainyakatta-Kalpokhri (GKK) areas (southern SNP) while one each (5.8 %) in Sandakphu-Bikhay areas (central SNP) and Phalut-Molley (northern SNP). Over all encounter rates obtained from the extensive surveys were quite low. The highest value (2.03/100h) was obtained from the Gairibans-Kainyakatta-Kalpokhri area while Sandakphu-Bikhay and Phalut-Molley area had lower encounter rates of 1.63/100 hrs and 1.74/100 hrs respectively. From our extensive study results it was evident that Satyr Tragopan was primarily distributed in the southern part of the NP, through lower slopes of central part, the lower parts of the northern areas through to Sikkim. Towards Gairibans-Kainyakatta-Kalpokhri on the western side, the distribution was continuous with Nepal. The altitudinal range of the bird in the National Park was

2600-3300 m in moist temperate, oak-dominated forests, moist temperate rhododendron dominated forests and birch-rhododendron forests. In all these sites ringal bamboo (*Thamnocalamus aristata* and *Arundinaria maling*) formed the main understorey .

Table 3.2: Showing extensive survey sites and evidences received
from 1993 - 1996

Season	Sites	Altitude (m)	Evidences	Forest type
Premonsoon	Sabarkum	3200-3500	NE	Subalpine
	Phalut	3400-3650	NE	Subalpine
	Gorkhay	2450-2900	NE	Moist temperate
	Rammam	1800-2400	NE	Subtropical
	N.Rimbick	1800-2425	NE	Moist temperate
	Molley	2900-3400	LR	Fir and oak mixed
	Meghma	3000	LR	Wet temperate
Monsoon	Gairibans	2625-3000	F, D, S, C	Wet temperate
	Kainyakatta	2900	F, C, D	Wet temperate
	Kalpokhri	3100	C	Rhododendron
	Sandakphu	3000-3636	NE	Subalpine
	Tumbling	3200	D	Bamboo pure
Postmonsoon	Gairibans	2626-3000	D, F, LR	Wet temperate
	Kainyakatta	2900	S	Wet temperate
	Tumbling	3200	F	Bamboo pure
	Sabarkum	3200-3500	NE	Subalpine
	Gorkhay	2450-2900	NE	Moist temperate
	Sandakphu	3636	NE	Subalpine
Winter	Gairibans	2625-3000	NE	Wet temperate
	Kainyakatta	2900	NE	Wet temperate
	Sandakphu	3636	NE	Subalpine
	Bikhay	3300	NE	Birch
	Phalut	3400-3650	NE	Subalpine
	Sabarkum	3200-3500	EN	Subalpine
	Gorkhay	2450-2900	NE	Moist temperate
	Rimbick	2250-2700	NE	Moist temperate

Legends: NE= No evidences, LR= Local reports, S= Sightings, F= Feathers, D= Droppings
C = Calls

In the 2400-2700 m altitudinal zone there were mainly north-east and south facing slopes in Gairibans area with oak (*Quercus pachyphylla, Q. lamellosa, Q. lineata*) dominated forests along with other tree species like *Acer* spp, *Magnolia campbelli,* *Rhododendron* spp. and *Sorbus cuspidata*. In the Kainyakatta areas above 2800 m upto Kalipokhri the slopes were mainly north-east facing, and were covered with more mixed species of trees like *Symplocos theifolia, Daphnipyllum himalayensis, Betula utilis,* and *Lindera* sp. From 3000-3300 m in the Bikhay areas where the slopes are north facing the Satyr Tragopan were found in forests that were dominated by *Rhododendron* spp., *Betula utilis* with *Abies densa.* In the Molley and Phalut areas of the National Park the slopes are east and southeast facing and the Satyr Tragopan was distributed in areas below 3200 m in pure stands of Hemlock (*Tsuga brunniona*) along with evergreen broad leaved trees like *Quercus* spp., *Litsaea* sp., *Rhododendron* spp., and *Castanopsis* sp. In all these areas, as mentioned earlier in the text the shrub cover was dominated by ringal bamboo especially in the region up to 3000m. Above this there were some stands which had *Rhododendron campanulatum, R. cinnabarinum, R. thomsonii* as the understorey. In the areas below 3000 m, the shrub species besides ringal bamboo comprised mainly of *Viburnum erubescens, V.nervosum, Daphne cannabina, Piptanthus nepalensis,* and *Rosa* spp. In the areas above 3300 m i.e. the Sandakphu area the slopes were north facing with forests that were fir dominated (Fig. 3.5)

3.3.2 Abundance: I spent approximately 1236 man hrs in 249 intensive monitorings and covered a distance of 747 km in the approximately 25 km^2 intensive study area. This exercise yielded 55 direct encounters with the Satyr Tragopan. Of these 52.2% (28) occurred in the pre-monsoon, 40% (22) in monsoon, and 4% (2) each in post-monsoon and winter. The birds were found to be distributed mostly in the 2600m-2900 m and 3000m-3300 m altitude zones where

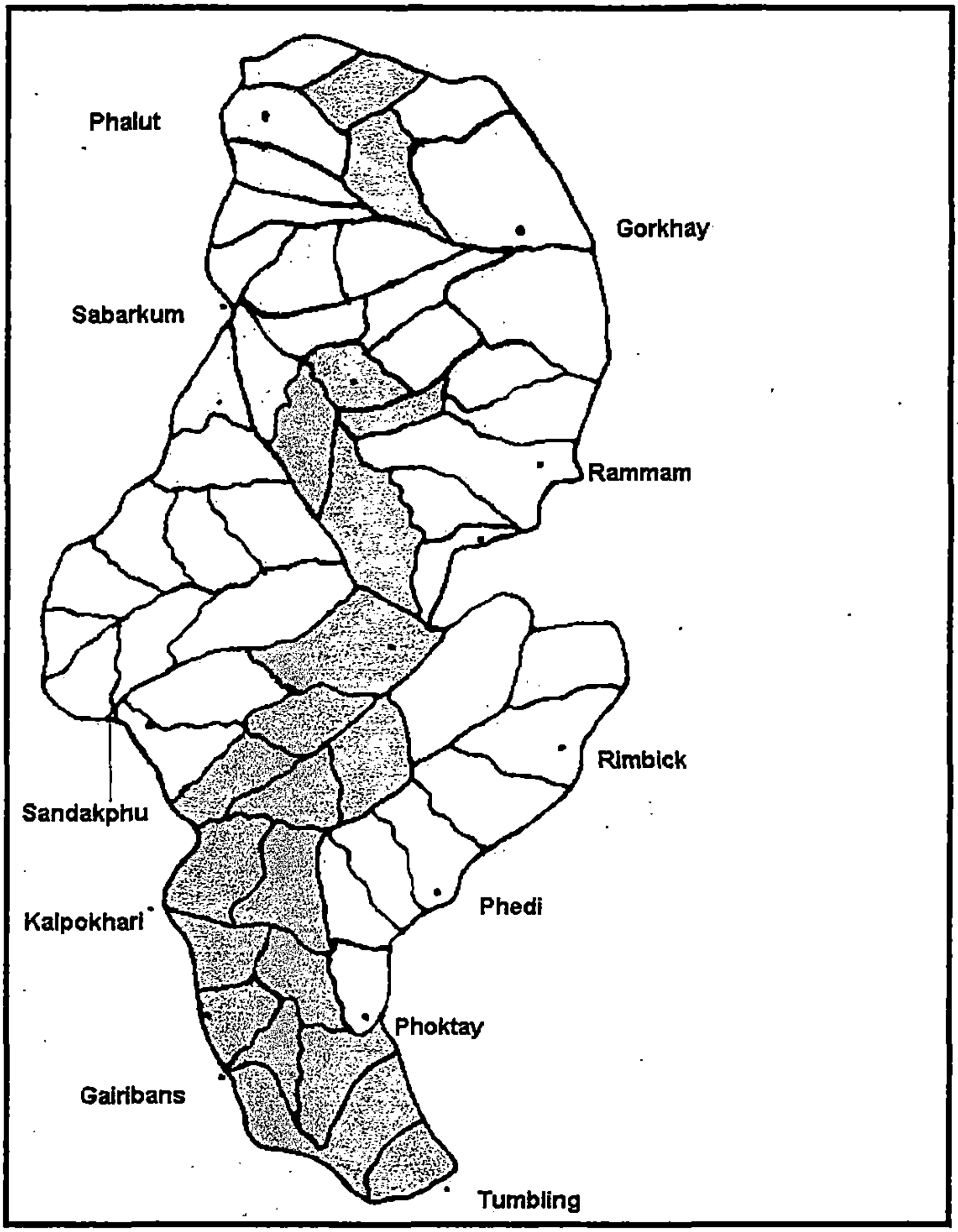


Fig 3.5: Distribution of Satyr Tragopan in various compartments of Singhalila National Park, Darjeeling (Shaded Grey)

59.2% (32) and 34% (18) of the encounters occurred respectively while in the regions above 3300 m only 4% (2) encounters occurred (Fig 3.6).

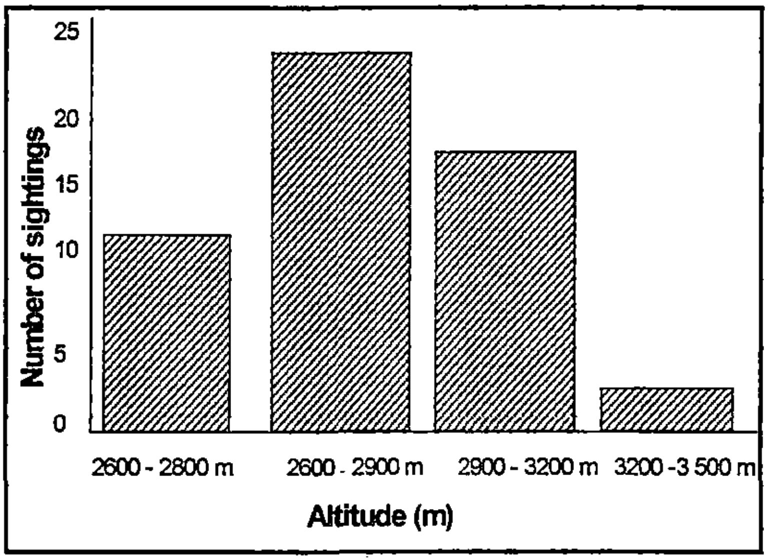


Fig. 3.6:Showing altitudinal distribution of Satyr Tragopan in the intensive study area

The results indicate that the Satyr Tragopan was mainly distributed in the altitudinal range of 2600 m-3300 m in the Gairibans-Kainyakatta-Kalpokhri area and Sandakphu-Bikhay areas of the intensive study site. The birds were most abundant in Trail 2 of Zone1 and Trail 5 of Zone 2 while in Trail 7 of Zone 2 and Trail 10 and Trail 12 of Zone 3 no birds were encountered throughout the study period (Table 3.3). Encounter rates fluctuated across the four seasons of the year, $\chi^2 = 8.90$, $p = 0.05$ (Friedman Two way ANOVA).

Table 3.3: Showing overall sightings and encounter rates in the intensive study area.

Altitude zone	Trails	No of groups	Number of individuals	Number of individuals/grp	Encounter rate (groups/100 hrs)
Zone1 (2600-2900m)	1	3	3	1	2.45
	2	8	21	2.63	11.15
	3	2	2	1	1.90
	4	12	21	1.75	11.24
Zone 2 (2900-3200m)	5	9	10	1.11	7.30
	6	6	10	1.67	7.45
	7	0	0	0	0
	8	2	2	1	2.32
Zone 3 (3200->3600m)	9	1	1	1	.935
	10	0	0	0	0
	11	0	0	0	0
	12	1	1	1	1.11

Main differences in the encounter rates lay between pre-monsoon and post-monsoon ($Z = 2.3664$, $p = .0180$, Wilcoxon Signed Rank Test) and monsoon and post-monsoon seasons ($Z = 2.2014$, $p = .0277$, Wilcoxon Signed Rank Test). The differences in the encounter rates/relative abundance indices across the seasons were perhaps due to the difference in detectability of the birds in the prevailing weather conditions, the type and density of vegetation associated with each season as well as the behaviour of the birds in the different seasons.

Kruskal -Wallis One Way ANOVA showed a significant difference in the encounter rates/abundance indices across the different transects situated in the three altitude zones ($\chi^2 = 5.7931$, d.f. = 2, $p = .0552$). The main difference lay in the trails of zone

1 and zone 3 (U = 2.3802, p = .0173 Mann -Whitney U test) and zone 2 and zone 3 (U = -1.9283, p = .053 Mann -Whitney U test) indicating that the birds were distributed mainly in Zone 1 and Zone 2. There was no significant difference in the relative abundance indices across the trails of zone 1 and 2 (U = .4328, p = .6651 Mann -Whitney U test). In addition to these sightings, 45 groups of faecal droppings were encountered from the trail monitorings in the intensive study area of which 53.3% (24) were from zone1, 42.2% (19) were from zone 2 while 4.4% (2) were encountered from zone 3. Seasonally 44% (20) of the dropping groups were collected during the pre-monsoon, 37.8% (17) in winter, 13.3% (6) in monsoon, 4.4% (2) in post-monsoon (table 3.4)

Table 3.4: Showing the mean encounter rates derived from faecal droppings (groups/km^2) of the Satyr Tragopan in SNP.

Zones	Pre-monsoon	Monsoon	Post-monsoon	Winter
1	0.38	0.12	---	0.19
2	0.16	0.03	---	0.22
3	----	---	0.03	---

Thus encounter rates calculated by using the direct sightings and faecal droppings showed the same trend which indicated that the Satyr Tragopan was largely distributed ~~in the~~ between 2600 -3300 m (Table 3.5).

Table 3.5: Seasonal mean encounter rates through sightings and faecal droppings.

Season	Groups/100hours (sightings)	Groups/km (droppings)
Pre-monsoon	2.10	0.18
Monsoon	2.70	0.05
Post-monsoon	0.51	0.01
Winter	0.65	0.13

altitudinal range though occasionally may occur in the region above 3300m in the intensive study area. The relatively higher collection of the droppings during pre-monsoon and winter may be linked to the dry conditions and sparse vegetation associated with these two seasons. Encountering of faecal droppings was easier in winter especially if the ground was snow covered.

3.3.3 Call counts: During spring call counts in 1995, 1996 and 1997 observers at each point on three trails (Trail 2, 4 and 8) were assumed to have recorded calls from an area of 0.28km^2 (radius being fixed at 300m for each observer point). There was a general increase in the number of birds heard calling with increase in the radius of the call count point. Maximum number of groups were heard in the 300m radius belt after which the increases in groups heard were marginal (Fig 3.7), thus implying that 300m radius was optimum for counting Satyr Tragopan in the existing field conditions.

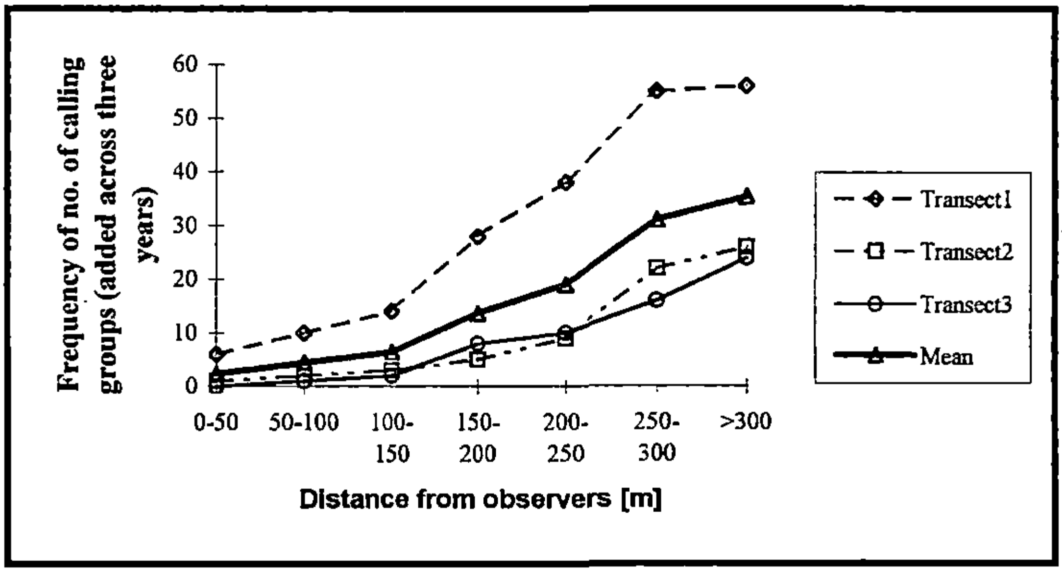


Fig.3.7 : Number of calling groups heard from various distances during call counts in SNP

All double counts between adjacent observers or points were deleted immediately after the call count exercise by comparing the time and direction of the calls. Thus an area of 1.4km^2 (0.28km^2 x 5) was covered along each trail. A total of 28 calling groups were recorded from the three trails in 1995, 19 groups in 1996 and 24 groups in 1997 with a mean density index of 6.19/km^2, (±0.87) 4.52/km^2 (±0.58) and 5.71/km^2 (±0.38)for three years (Table 3.6)

Table 3.6 : Showing the mean relative density indices (calling groups/km^2) of Satyr Tragopan in 1995, 1996 and 1997.

Transect	1995	1996	1997
GBII	10.71	7.14	6.43
GBIV	4.29	2.86	7.00
KKIV	5.71	5.00	6.42

The number of calling groups of Satyr Tragopan was consistent on Trails 2 and 8 in all 3 calling seasons while the number of calling groups on trail 4 fluctuated between the three seasons ($F_{2,18}$ = 6.375, p = .0081, 1 Way ANOVA). Birds appeared to be more abundant on Trail 2 (15,10,9) in all three years than on the other two trails Trail 4 (5,4,7) and Trail 8 (8,5,9). The number of calling groups of Satyr Tragopan differed when considered across the trails in all the three years ($F_{2,60}$ = 3.148, p = .050 One Way ANOVA). The over all difference in density indices across trails in three years was possibly due to differences in relative density indices across pairs of trails in the three years (Table 3.7).

Table 3.7: Values of paired t test showing the differences in density indices across 2 trails (1995-1997)

Year	Trails	t	d.f.	p
1995	GBII & GBIV	3.01	8	.017
1995	GBII & KKIV	3.71	8	.006
1996	GBII & GBIV	3.84	5	.012
1997	GBIV & KKIV	8.18	5	.000

There was a significant positive correlation between the encounter rates derived from trail monitoring and the density indices obtained from dawn call counts (r_s= 0.758, p = 0.05) indicating agreement between the indices obtained from call counts and encounter rates. Both the methods may therefore be used to obtain relative measures of abundance surveys for Satyr Tragopan populations.

3.4. Discussion

3.4.1 Global distribution: According to Johnsgard (1983) one of the centres of pheasant diversity occurs near northern Myanmar and Yunan and the upper reaches of Yangtze, Mekong, Salween and Irrawady rivers. The Tragopan prototype population is believed to have originated in this region (Islam 1992). All the species of Tragopan pheasants are montane forest birds endemic to Asia (Johnsgard 1986). Except for the Cabot's Tragopan other species of Tragopan are distributed in the Himalaya at varied altitudes and forest types. The distribution of Tragopan pheasants is believed to be allopatric with minor zones of overlap between Temmick's Tragopan and Cabot's Tragopan in China and the Satyr Tragopan and Blyth's Tragopan in eastern Bhutan (Delacour 1979, Cheng 1980, Johnsgard 1986).

According to their plumage patterns and geographic range the Western Tragopan, Satyr Tragopan and the Temminck's Tragopan are closely related and represent one superspecies while the Cabot's Tragopan and the Blyth's Tragopan form a second group (Johnsgard 1986). On the other hand, based on their call types, Islam and Crawford (1996) placed the centrally distributed species Blyth's Tragopan, Temminck's Tragopan and the Satyr Tragopan in one acoustic group while the peripheral species i.e. Cabot's Tragopan and Western Tragopan were considered two separate groups.

The Western Tragopan is the most westerly distributed species of the genus. It is currently found from the Palas Valley in Indus Kohistan in Pakistan through Kashmir, Kishtwar in the Chenab valley to Kinnaur, Sutlej valley in north western India (Gaston *et al.* 1983, Islam 1983, Islam 1986). According to Johnsgard (1986) though there are no physiographic or ecological barriers, the upper waters of the Ganges forms the eastern limits of its range and perhaps overlaps with the range of the Satyr Tragopan. According to Gaston (1981a) the Jamuna valley represents the approximate point of contact between the Satyr and the Western Tragopans. Perhaps it is in these regions that the Satyr Tragopan is replaced by the Western Tragopan. Such ecological replacement where species inhabit separate but adjoining ranges according to Lack (1971) may occur for two reasons (1) they have such similar ecology that only one can persist in any one area and (2) each is better adapted than the other to a part of their combined ranges. As one moves westwards in Himalaya the climate becomes drier and subarctic conditions prevail at 2000 m - 2500 m and arctic conditions from above 2600m (Negi 1985). In the central and eastern Himalaya the sub-arctic conditions start at 2500 m-2600 m and arctic at

3500 m-3600m. Eastern himalaya is a zone of very high precipitation while it is moderate in Nepal and western Himalaya (Negi 1985). These conditions produce a completely different set of vegetation communities and habitat types all across the region which are strikingly different types especially at the two ends of the Himalaya.

According to Young and Kaul (1987) though Kumaun marks the boundary between the ranges of Western Tragopan and the Satyr Tragopan there are no physical barriers holding their populations apart and thus there are possibilities of finding the two species close together. The last reported record of the Western Tragopan in Kumaun was in 1877 of a skin obtained from Almora bazar (Jerdon 1877). It is conjectural however to base the distribution of Western Tragopan in Almora based on the discovery of a skin in a local bazar.

From Kumaun eastwards upto Bhutan the Satyr Tragopan is the only species of the genus occurring all along the Himalaya. In Nepal the Satyr Tragopan is distributed throughout the Himalayan from the west to the east. The Pipar Pheasant Reserve in westcentral Nepal is a pheasant sanctuary harbouring a good population of Satyr Tragopan (Lelliot and Yonzon 1980, Roberts 1983, Picozzi,1985,1987, Howman and Garson 1992, Kaul 1995 and Kaul and Shakya 1998). Apart from the Pipar area the Satyr has been reported from Ghasa (Roberts 1990) and Dhorpatan Hunting Reserve (Lelliot 1982, Roberts 1982, Inskipp 1989). Protected areas from western and central Nepal like Khaptad, Langtang, Sagarmatha and Makalu Barun all fall within the distribution range of the Satyr Tragopan (Forster 1982, Inskipp 1989) and each have the potential of holding Satyr Tragopan populations.

In east central Bhutan, the range of Satyr Tragopan may overlap with the eastern Blyth's Tragopan. According to Ripley (1961) this subspecies is distributed in southeastern Tibet, Bhutan and the upper ranges of the upper hills east of Mishmi in altitudes between 6000 ft-12000 ft (1818 m- 3636 m) in moist temperate and coniferous forests. In Bhutan the Satyr Tragopan is reported to have a very wide altitudinal range from 2200 m-4200 m (Pradhan 1994, Dreyer 1995, Holt 1996, Bishop 1997, King 1997). The records of the Blyth's from Bhutan on the other hand indicate they may be confined to the 2400 m-2600m altitudinal range (McGowan and Garson 1995). Altitude probably plays a vital role in segregating the two species in this part of their distribution.

Western Arunachal Pradesh appears to be the western limits of Satyr Tragopan distribution in India. This species has however been reported form farther east in very recent surveys in Dulondjiang (Nujian Nature Reserve) of the Gaologongshan Region in the Yunan Province of China (Zheng Guang-Mei 1992, Xian 1995, Ma Shilai 1996). It may be pertinent to add here that although the Satyr Tragopan has been listed as present in that area of China, it is not clear if any evidence of the Satyr Tragopan have been procured from these areas. Temminck's Tragopan and Blyth's Tragopan (subspecies not specified) have also been recorded from this area. Though present within the same range the three species seemed to be segregated by their latitudinal range, altitudinal range, forest type and the aspect of the terrain. The Satyr Tragopan was reported to occur at 2400 m-3000 m in mid mountain moist evergreen and mossy elfin forest. The Blyth's Tragopan from mid mountain mossy evergreen forests at 2000- 2400m and the Temminck's Tragopan in mid mountain mossy evergreen forests, mossy elfin forests and cool coniferous forests in 1600 m- 2900 m (Xian 1995). The Satyr Tragopan and the Blyth's Tragopan appear to be present in a very narrow latitudinal range of 27° 6' - 27° 10' N whereas the Temmick's Tragopan was relatively well distributed between 25°-27°N. The Temmick's Tragopan range also touches the Satyr Tragopan range in western Arunachal Pradesh. Recently Singh (1998) has reported on the range extension of the Temmick's Tragopan in the West Kameng district of Arunachal Pradesh in localities having approximate co-ordinates of 27° 28' N, 92° 23' E which were west of the western limit of 93° 30' E of the species. In the same region Satyr Tragopan has also been recently sighted (R.Suresh Kumar pers.com.) in an area further south but at almost the same longitude. These observations suggest an overlap in the ranges of Satyr Tragopan and Temmick's Tragopan in West and East Kameng districts of Arunachal Pradesh (Singh 1998).

Ludlow and Kinnear (1944) considered the Subansiri- Manas water shed (Dafla hills in Arunachal Pradesh) as the dividing line between the ranges of the Satyr Tragopan and the Temmick's Tragopan. It is not known whether there is any hybridisation in the wild between Satyr Tragopan and Temmick's Tragopan as they are considered to be the most closely related species among the Tragopan pheasants. Hybridisation cannot be ruled out because in captive conditions the birds hybridise quite freely and the offsprings are fully fertile (Seville 1979) and indistinguishable from chicks of either species (Delacour 1979). Recently a skin was located in a museum in China which had been collected from the wild. This skin presents a mixture of the morphological characters of the Satyr Tragopan and the Temmick's Tragopan indicative of hybridisation of the two species in the wild (David Rimmlinger, pers. comm.).

The estimated range size of the Satyr Tragopan according to McGowan and Garson (1995) is between 50,000 and 100,000 km^2 but with the additions of new areas from China the range might increase by another 50,000km^2 based on the authenticity of these reports. There appears to be a large gap in the distribution of Satyr Tragopan in the eastern most known site in India (Mago, Arunachal Pradesh, 92°, 30' E) and Gaologongshan (97°E). Between these two sites Temmick's Tragopan has been found distributed from Bomdilla, Arunachal Pradesh (92° 30'E) (Singh, 1998) through to Machuka (94° E) (Kaul *et al.* 1992) and beyond probably contiguous with China to the east. Therefore in all probability Satyr Tragopan and the Temmick's Tragopan co-exist across the length of Arunachal Pradesh. If not then the occurrence of Satyr Tragopan in an isolated pocket in China raises many doubts.

Out of the five species of Tragopans the Satyr and the Temmick's have relatively larger ranges than the rest. A number of studies have shown that species occurring over large geographic ranges tend to have more local abundances than restricted Fuller 1982 range species (Bock 1984,1987, Brown and Maurer 1987, Ford 1990, ~~Fuller 1982~~ etc.) This happens because a species, which is widespread is capable of exploiting a wider range of resources than the ones confined to small ranges (~~Brown 1984~~; Brown 1984 McNaughton and Wolf 1970). Thus among the Tragopan pheasants the Temmick's Tragopan and the Satyr Tragopan appear to be capable of exploiting a wider range of resources than their congeneric species. Nevertheless even the Temmick's does not encounter the amount of diversity that the Satyr Tragopan does in its distribution from the eastern Himalaya to the western. Thus it would not be inappropriate to say that the Satyr Tragopan is most adapted to a diverse set of habitats along its geographical range and perhaps the most stable of the Tragopans.

3.4.2 Local distribution:

According to Krebs (1978) the distribution of animals is governed by certain factors which include dispersal, habitat selection, interrationships with other animals (predation, competition), temperature and moisture and physicochemical factors (light, soil, water, fire etc.). The Singhalila ranges fall within the suggested course of westward movement of the Satyr Tragopan from its probable area of origin (Johnsgard 1983). In the Himalaya altitude is one of the most important factors governing vegetation communities (Mani 1974). Altitude is directly and indirectly responsible for governing the faunal distribution in these regions. Singhalila Hills are a part of the eastern Himalaya (Ali 1978, Negi 1985, Rau 1974, Anon 1991) where the forests vary in composition with altitude (Anon 1992). Such variation in vegetation composition is bound to affect the distribution of Satyr Tragopan along an altitudinal gradient. The altitudinal zone of Satyr Tragopan recorded in Singhalila National Park generally agreed with the range of the species elsewhere (Gaston 1980, Lelliot and Yonzon 1980, Picozzi 1987). I never recorded any birds below 2600 m probably because the study area did not extend much below this altitude.

In addition to the Singhalila National Park the Satyr Tragopan is reported to be distributed locally in two protected areas in the Darjeeling hills, one from Senchal Wildlife Sanctuary from fairly recent reports (Sargam Rasaily pers. comm.) and Neora Valley National Park (Anon 1992). Perhaps the other sites in the Darjeeling hills reported to have Satyr Tragopan in the past (Jerdon 1864 and Tickell in Inglis 1933) do not possess the species any longer.

In the SNP the southern portions (Gairibans-Kainyakatta-Kalpokhri) had a wide spread distribution of Satyr Tragopan. In this portion of the Park the birds were found to be more abundant than in other areas. Here the fairly undisturbed primary forest cover (principally oak dominated) extended beyond the boundaries of the National Park. In the central part (Sandakphu-Bikhay) the Satyr Tragopan distribution was limited to the narrow upper strip of the Park in areas between 2600m - 3300m. The east central border of the Park is dotted by numerous settlements and the forest in the vicinity of these habitations has undergone drastic changes. In the past there were major construction works in the form of roads, clearing for agriculture, logging operations, clearing for plantation of exotic species like *Cryptomeria japonica* and *Pinus petula* and the presence of numerous cattle and yak stations. So perhaps only the narrow central strip of remnant forest retained the distribution of the Satyr Tragopan in this area. Nepal borders the western part of the National Park and there are only a few small patches of forests, which are contiguous with the forest in SNP. The distribution of the Satyr Tragopan in this area is also contiguous. There is possibility of the occurrence of Satyr Tragopan in the north western part of Sikkim adjoining the Phalut-Molley areas of Singhalila National Park due to contiguity of suitable habitat across the states. This is confirmed by local reports, which indicate the presence of Satyr Tragopan from the border areas of Sikkim. I have confirmed the presence of Satyr Tragopan in the Phalut-Molley areas of the Park. Over all, except for the narrow area of distribution in the central portion of the Park the Satyr Tragopan was found to be well distributed all over the National Park particularly in those areas which had undisturbed primary forests at 2600 m-3300 m altitudes.

The other species of galliformes present in the Singhalila National Park were Black Backed Kaleej Pheasant (*Lophura leucomelana melanota*), Blood Pheasant (*Ithaginis cruentus*), Common Hill Partridge (*Arborophila torqueola*) and Redbreasted Partidge (*Arborophila mandellii)*. Though studies on niche separation and resource partitioning were beyond the scope of this dissertation it may be worthwhile to mention the local distribution of the different galliform species in relation to the distribution of the Satyr Tragopan in the Singhalila National Park. The Blood Pheasant was distributed in the upper elevations of the Park above 3300 m in subalpine forests and was thus completely isolated in ecological terms from the Satyr Tragopan. The Redbreasted Partridge was at the other extreme found at lower elevations i.e. below 2600 m and perhaps the ones recorded by me at 2600m were occasional birds. The Kalij Pheasant and the Hill Partridge were perhaps the only real competitors of the Satyr Tragopan.

3.4.3 Abundance: As it was not possible to fulfill most of the assumptions of the line transect method (Burnham 1980, Bibby *et al.* 1992) due to prevailing field conditions in the SNP I found monitoring trails a suitable alternative method for estimating relative abundance indices of the Satyr Tragopan (Kaul and Howman

1992, Kaul and Ahmed 1992 and Sathyakumar 1992). Distribution studies in Singhalila National Park revealed that the species was most commonly encountered and possibly most abundant in the 2600 m-3300 m altitude zone of the intensive study area. The fluctuations in the encounters or density indices of the Satyr Tragopan across the trails were due to the differences in the altitude of trails with the maximum abundances in zone 1 and zone 2. These two zones were associated with [redacted] broadleaved evergreen forests dominated by *Quercus pachyphylla* along with other *Quercus* species like *Q. lineata* and *Q. lamellosa*, *Rhododendron* spp., *Magnolia campbelli* and *Acer* spp. The high altitude areas or zone 3 had more silver fir (*Abies densa*) dominated forests. The Satyr Tragopan seemed to be more associated with broadleaved forests and were therefore abundant in zone 1 and 2. The habitats and altitudes of zone 1 and 2 were also quite similar and therefore the abundance indices did not show any significant differences. The main differences occurred between these two zones and zone 3 where both variables were quite different.

The fluctuation of encounters across the seasons was probably because of the variation in detectability of the birds on the trails during various weather conditions associated with each season. In the pre-monsoon season, the Satyr Tragopan were more easily detected through their calls and their advertisement behaviour. However in the middle and latter part of monsoon and the post-monsoon there were fewer encounters with the birds during the trail monitoring probably because the birds were either incubating or rearing their young ones. The monsoon and post-monsoon season are also associated with dense vegetation cover which, probably further enhanced the difficulty of detection of Satyr Tragopan on the trails.

Moreover in spring and early crowing periods, pheasants are probably more homogeneously spread throughout their range than at any other time of the year (Kimball 1949). According to Ali (1980) the Satyr Tragopan migrate to areas as low as 1800 m during severe winter but in Singhalila there were no changes in the encounter rates during winter on any of the trails suggesting that Satyr Tragopan probably did not migrate in SNP. In winter, areas below 3000 m did not have extreme conditions and the snow cover remained thick and unthawed only in the north facing slopes. Therefore, soil and vegetation did not remain covered with snow for long and as a result there was not much apparent change in the availability of resources.

Although the birds were less vocal in 1996 the relative density indices on two of the trails across the three years of study were quite consistent. Weather and wind conditions did not vary very much over the three years. It is difficult to predict the trends in the population from only three years monitoring and more counts at regular intervals could give a definite indication about the population trends. Such trends are now possible to deduce from monitoring done in Pipar, Nepal where call counts of Satyr Tragopan and other pheasant have spanned nearly two decades (Kaul and Shakya 1998).

The positive correlation between the two sets of abundance data derived from encounter rates and call counts indicated established the validity of both techniques for surveys (Kaul 1992). As Satyr Tragopan call only during the breeding season the trail monitoring method could be used to achieve encounter rates in order to produce some relative abundance estimates at other times of the year when the

Satyr Tragopan are not calling. In vocal pheasants the call count surveys are preferred because it involves very little time and effort for the comparatively larger area coverage achieved.

As experienced by other workers like Duke (1989) and Picozzi (1985,1987) I also experienced some field difficulties while using the call count method to estimate the relative density index of the Satyr Tragopan in the SNP.

1. Accurate estimation of the distance between the observer and the source of call was not possible. An accurate estimation of the area surveyed was therefore not possible. Although I used fixed radii in distance classes, in cases where birds called from areas which were close to boundaries it was difficult to assign a caller to a proper distance class.

2. Folded topography made audibility, distance assessment and judgement of the direction of calls difficult which may have led to over counts and undercounts. This was especially true in cases where bird calls bounced and birds called from the valley bottoms.

3. Hearing capacity of observers differed and some calls coming from fairly long distances might have been left out leading to undercounts.

4. Adverse weather conditions like thick fog and rains affected the calling behaviour, while wind with high velocity completely distorted the direction, distance and loudness of the calls.

5. All calling males that were heard from around a certain point did not call every morning of the survey. They might also shift their calling position each morning.

6. Birds were assumed to start calling from near their roosts but may not be stationery as the morning progresses which probably lead to over counts. Therefore call counts are best when kept short.

Despite all these shortcomings I found the call count method the most appropriate way of obtaining the abundance/relative density indices and establishing the presence/absence status of Satyr Tragopan in my study area. This method can be suitably used in Satyr habitats which are usually steep, with thick bamboo understorey (like in SNP) that rule out flushing and visual counting. The dawn chorus in Satyr Tragopan is very pronounced and requires little expertise, expenses and time. Call counts is a non-invasive technique which causes little or no disturbance to the birds during the crucial breeding season which methods like flushing would involve. It can be suitably used in short surveys too because with little effort the presence/absence status of the species in any area can be determined. For long term studies if the method is used in previously surveyed areas without changing the observation stations then changes in the abundance/density indices can be monitored over long periods. To ensure that all birds around a listening station are counted, it is advisable to count from the same stations for at least three consecutive mornings as all birds do not call every morning. In folded terrain the accuracy of counts would increase if the distance between two listening stations is not more than 600m so that no birds are missed out between two successive observation points. I used a fixed radius for recording the distance of calls to obtain an approximate estimate of the survey area. This was not rigid and I recorded and estimated distances of calls coming from more than 300m distance which were kept out of the analyses. Therefore the figures of density and abundance that I have obtained from these studies are not absolute but are indices. Use of such indices relies on the assumption that the indices measure a constant but unknown proportion of the population (Clobert and Lebreton 1991). However data should be treated with caution as extrapolation to produce absolute counts and measures of absolute density may produce erroneous results for reasons already discussed. Above all calibration should ensure that the relative measures are comparable (Clobert and Lebreton1991).

3.5. Conclusion:

With the confirmed reports of the Satyr Tragopan from the Gaologongshan region of China the geographical range of the species has changed markedly. The species seemed to have radiated both eastward and westward from its prototype population. Its extent across 78°E - 98°E (fomerly upto only 92°E) showed that the species was adapted to a wide variety of forest and vegetation types not encountered by any of its congeneric species within their respective geographic ranges. Many of the areas between 92°E and 98°E which include parts of Arunachal Pradesh and Myanmar have not been surveyed thoroughly to confirm the presence or absence of the species. Information from these areas would throw more light as to whether the Satyr Tragopan has a continuous distribution till the end of its range or is replaced by the Blyth's or Temmick's towards the eastern part and then reappears to share the range with the other two species at the eastern limits of its distribution. Within the study area the Satyr Tragopan seemed to be distributed in those areas that have good primary wet temperate, moist temperate or subalpine forest cover at altitudes ranging from 2600 m- 3300m. The distribution was continuous in the National Park with the distribution area at the central portion being narrow probably due to habitat changes by human activities over periods of time. Intensive monitoring showed that the wet temperate and moist temperate forests were the most preferred forest covers. Although call count studies for three years were not enough to predict any population trends, yet these studies indicated that the Satyr Tragopan were fairly abundant and their relative density indices quite consistent in the intensive study area ranging from $4.52/km^2$-$6.19/km^2$.

CHAPTER 4

HABITAT STUDIES

4.1 Introduction

Habitat use by a species is affected by its density, densities of and interactions with other species, availability and abundance of resources and various other biotic and abiotic factors (Block and Brennan 1993). Role of habitat selection in speciation and adaptive radiation was developed by Lack (1940, 1944). He emphasised the importance of habitat segregation in closely related species and of habitat diversity in the multiplication of congeneric species. In closely related species like the Tragopan pheasants with continuous distribution perhaps habitat plays an important role in segregating sympatric populations.

There have been some habitat studies of the Ring-necked Pheasant in England and America (Hill and Robertson 1988a). Among the Tragopan pheasants, habitat studies on the Western Tragopan, Cabot's Tragopan and the Temmick's Tragopan have recieved fair amount of attention (Islam and Crawford 1987, Young *et al.* 1991, Bland and Han Xian1992, Ding Chang Qing and Zheng Guang-mei 1992, Shi Hai Tao *et al.* 1996). In India a detailed single species work has been performed on the Cheer Pheasant (Kaul 1989), Himalayan Monal Pheasant (Sharma 1990, Kumar 1997), and the White-crested Kaleej Pheasant (Iqbal 1992, Ahmed 1994).

Perusal of literature on the habitat of Satyr Tragopan served no more than to establish the fact that it was a forest bird. No quantitative information on habitat use so critical for the conservation of this rare and threatened species was available.

Satyr Tragopan is essentially a forest inhabiting species rarely wandering up towards the snow or into the open. Though the species is known to remain in the outskirts rather than the deeper recesses of the woods it seldom voluntarily leaves the cover of its habitat (Hume and Marshall 1879). Beebe (1918-22) considered the species to be a thorough forest bird, which kept to thick cover and was found in ringal hillsides. The ruggedness of its habitat can be judged by the description of Beebe (1918-22) - "the narrow side gorges etched out of the slopes by tiny unchartered streams" while Lelliot and Yonzon (1980) observed them on ridge tops rather than the steep bamboo covered slopes. Inglis (1930) observed the bird in impenetrable cover of ringal bamboo and Gaston (1980) described the habitat as dense cover with well developed understorey.

4.2 Methodology

Sites where Satyr Tragopan were encountered were marked and considered a bird site. Various parameters of the habitat were measured at this site.

I sampled the tree density according to 10 trees sampling method. I used only 5 trees because the distribution of trees was homogenous and counting 10 trees took a much longer time. In this method of sampling habitat variables, the size of the sampling plot is governed by the density of trees. Thus in areas where the trees are widely spread, 10 trees may occupy an area or plot which may not represent the true microhabitat of the Satyr Tragopan. At each sampling point, the species and ther distance of the 5th and 6th trees from the sampling point were measured to obtain the size of the sampling plot. Tree cover variables were measured inside this plot of 5 trees. Within this a 3m x 3m quadrat was laid for measuring the understorey characteristics while two 1m x 1m quadrats were laid inside each 3 m x 3 m sampling quadrat to measure the ground cover characteristics. The habitat variables measured by this method in each sampling point are given in Table 4.1

The vegetation characteristics were defined before being measured . These were:
Trees: Were defined as those plants with woody stems greater than 5 m in height and greater than 30 cm in g.b.h.

Shrubs: Were defined as those woody stemmed plants with 1- 5 m height and less than 30 cm g.b.h.

Ground cover: Were defined as those annual or perennial plants less than 1m height.

Around each bird site four random plots or non-bird plots were laid for comparison with the bird plot. The locations of these plots was determined by four compass bearings (north,south,east and west) and their distance (paces) from the animal site by generating random numbers from 1 to 100.

Table 4.1: Showing the various habitat parameters measured in habitat studies

Variable	Definition	Measurements
Altitude (alt)	Height of sample site above m.s.l.	Altimeter (m)
Slope (sl)	Steepness of slope	In degrees by Abney's compass
Aspect (asp)	Direction faced by the slope	Directional compass
Topography (topo)	General features of sampling site	Descriptive
Snow cover (snc)	% of snow cover within the sampling plot	Occular estimation
Snow cover depth (snd)	Depth of snow covering the plot area	Measuring scale in cm
Canopy cover (cc)	% tree cover within the sampling site	Occular measurement using a pipe of 1.5cm diameter and 18cm length. 5 occular measurements in four directions
Canopy height (ch)	Height from the ground to inner canopy cover	Occular estimation in metres
Shrub cover (sc)	% shrub cover within the sampling site	Occular estimation
Shrub cover height (sh)	Height from ground cover of understorey	Measuring tape in metres
Ground cover (gc)	% ground cover	Occular estimation
Ground cover height (gh)	Height of ground cover	Measuring scale in cm.

Analysis: To determine the area of the sampling plot for obtaining density measurements of trees, the mean of the distance between the 5th and the 6th tree was considered as the radius of the sampling plot ($r= d_1 + d_2/2$, where r = radius and d_1 = distance to 5th and d_2 = 6th trees in metres). Density of trees (td) was calculated in the following way:

Area occupied by 5 trees = πr^2

Area occupied by 1 tree = $\pi r^2/5 = x$

Therefore the density (trees/hectare) = 10,000/x

As shrub and ground cover were measured in quadrats of fixed dimensions shrub density (sd) and ground density (gd) were calculated by number of plants/m^2. The identity of the trees, shrubs and ground cover vegetation and their number were used to calculate the species diversity and species richness. Tree species diversity (tsd), shrub species diversity (ssd) and ground cover species diversity (gsd) were measured by the Shannon-Wiener's diversity index ($H' = -\sum pi \log pi$, where pi is the proportion of the ith species in the sample). Tree species richness (tsr), shrub species richness (ssr) and ground cover species richness (gsr) were measured by the Margalef's Species Richness Index ($RI = s-l/(\ln N)$ where s is the number of species in a sample and N is the total number of individuals in a sample. Both the indices were calculated by using the software package "Ecopack".

Habitat and community studies are multidimensional in nature and it is desirable to use multivariate statistical procedures to identify variables that may be useful in assessing habitat (Rextad *et al.* 1988). For analysis of Satyr Tragopan habitat variables, I used Principal Component Analysis (PCA). This method of analysis identifies variables that account for maximum variation in a data set and produces a smaller number of uncorrelated variables that are the linear functions of original variables (Bhattacharyya 1981, Seber 1984:176-203). To identify discriminating variables between the animal plots and random plots I used Discriminant Function Analysis (DFA). This procedure is used to develop linear models of variance that maximise the separation of groups and classify additional observations (Williams 1981). DFA generates a discriminant function(s) based on linear combinations of predictor variables, which provide the best discrimination between the groups. To calculate the avoidance and preference of broad habitat types of the study area I generated Bonferroni confidence intervals (Neu *et al.* 1974 and Byers *et al.* 1984). The computer programme PREFER (Prasad and Gupta 1992) was used to calculate these confidence intervals. Parametric one way ANOVA and Mann Whitney U tests were used for other comparisons while Pearson Correlation Coefficient was used for calculating the relationship between different variables. All proportional data were arcsine transformed while the others were log transformed to obtain normal ly distributed data sets amenable to multivariate analysis.

4.3 Results

4.3.1: Macrohabitat: Broadly, five habitat types were available to the Satyr Tragopan in the Singhalila National Park. The type and their proportions (in parenthesis) were wet temperate or mixed oak forests (0.481), pure conifer or subalpine forests (0.126), mixed conifer forests (0.119), pure bamboo patches (0.231) and plantation forests (0.04). Generally in this method utilisation of a certain habitat type is quantified by the number of separate sightings in that habitat. In my studies on the Satyr Tragopan direct sightings of the bird ~~was low,~~ were rare therefore I also took into consideration the number of faecal droppings collected from different habitats along with direct sightings to quantify availability-utilisation.

4.3.1.1 Pre-monsoon season: During this season 50 evidences (direct and indirect) were obtained for vegetation sampling of the Satyr Tragopan habitat. The species seemed to significantly prefer mixed oak forests while it significantly avoided pure conifer or subalpine forests indicating their dispersal in lower altitudes of the study area (Table 4.2).

Table 4.2: Availability-utilisation of different vegetation types by Satyr Tragopan during pre-monsoon season

Habitat type	Relative Area (ha)	Expected usage	Observed usage	Confidence intervals
Oak forests	0.481	24.05	39	0.629-0.931**
Pure conifer forest	0.126	6.3	0	0.000-0.000
Mixed conifer forests	0.119	5.95	4	0.000-0.179*
Pure bamboo patches	0.231	11.55	6	0.001-0.239
Plantation forests	0.040	2.00	1	0.000-0.071

** = used more than available, * = used less than available, rest not significant at p = 0 .05

4.31.2 Monsoon season: During this season 26 animal plots were located based on direct and indirect evidences of Satyr Tragopan. The species used pure bamboo patches more significantly in proportion to their availability while mixed conifer and plantation forests were used significantly less in proportion to their availability (Table 4.3).

Table 4.3: Availability and utilisation of different habitat types by Satyr Tragopan during the monsoon season.

Habitat type	Relative area (ha)	Expected usage	Observed usage	Confidence intervals
Oak forests	0.481	12.51	17	0.467-0.840
Pure conifer forest	0.126	3.28	1	0.000-0.114
Mixed conifer forest	0.119	3.09	0	0.000-0.000*
Pure bamboo patches	0.231	6.01	8	0.127-0.489**
Plantation forest	0.040	1.04	0	0.000-0.000*

** = used more than available, * = used less than available, rest not significant at p = 0.05.

4.3.1.3 Post-monsoon season: 30 plots were located for habitat sampling studies during this season. From the dispersion of these animal plots in the different habitat types of the study area it seemed that the Satyr Tragopan used oak forests significantly more in proportion to their availability while plantation and mixed conifer forests were used significantly less in proportion to their availability (Table 4.4).

Table 4.4: Availability and utilisation of different habitat types by Satyr Tragopan during the post-monsoon season.

Habitat type	Relative Area (ha)	Expected usage	Observed usage	Confidence intervals
Oak forests	0.481	14.43	20	0.495-0.889**
Pure conifer forest	0.126	3.78	4	0.009-0.257
Mixed conifer forest	0.119	3.57	1	0.000-0.099
Pure bamboo patches	0.231	6.93	5	0.031-0.303*
Plantation forest	0.040	1.20	0	0.000-0.000*

** = used more than available, * = used less than available, rest not significant at $p = 0.05$.

4.3.2. Microhabitat

4.3.2.1 Premonsoon season

4.3.2.1.1 General microhabitat: From the pre-monsoon season general habitat data PCA extracted 4 factors which cumulatively accounted for 64.528% of variance in the habitat variables. Factor 1 and Factor 2 explained 37.9% variance (19.28% and 18.62%) while Factor 3 explained 15.89% and Factor 4 explained 11.23%.

In Factor 1 there were high positive loadings for ground cover variables (henceforth ground cover factor) and this Factor apparently represented open areas with abundant herb cover as ground cover was negatively correlated with canopy cover ($r = -.208$, $n = 197$, $p = .001$) and shrub cover ($r = -.200$, $n=197$, $p = .001$). Factor 2 showed high loadings for shrub cover (henceforth shrub factor) and this probably reflected areas with tall and dense shrub cover which is most likely to be ringal (*Arundinaria maling*), with sparse ground cover. Factor 3 represented steeply sloping areas (slope factor) with good tree cover (henceforth tree factor) ($r = .160$, $n= 197$, $p= .05$) (Table 4.5).

Table 4.5: Showing four extracted factors and factor loadings (>.50) of random plots in pre-monsoon season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover			.761	
Canopy height				.529
Tree density			.744	
Shrub cover		.923		
Shrub height		.921		
Shrub density				
Shrub diversity				.701
Ground cover	.819			
Ground cover height	.603			
Ground cover density	.841			
Ground cover diversity	.673			
Steepness of slope			.572	
Variance explained	**19.28%**	**18.62%**	15.39%	**11.23%**

Thus it seems that during the pre-monsoon season the general habitat available to the Satyr Tragopan were equally represented by areas with good ground or scrub cover as well as with dense and tall vegetation at the understorey level while wooded areas with tree cover were poorly represented (Figure 4.1).

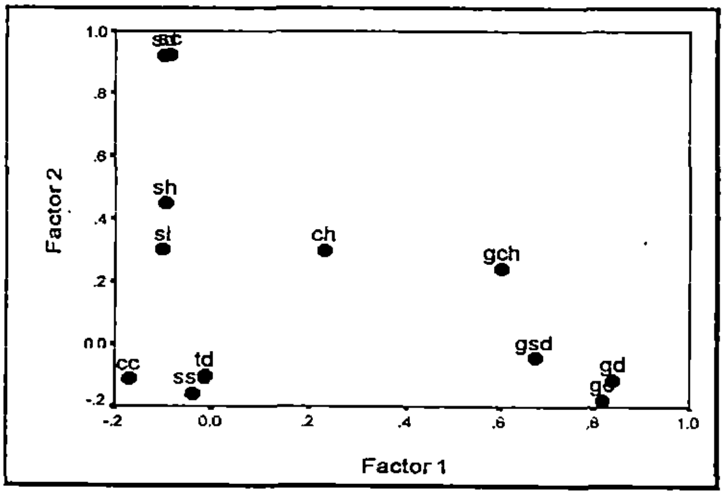


Fig 4.1. Factor Plot in rotated space of habitat variables of random plots. (pre-monsoon season)

4.3.2.1.2 Utilised habitat : PCA extracted four factors from the original animal centered habitat data set for the pre-monsoon season. These together accounted for 73.7 % of variance. Heavy positive loadings (>.5) were obtained for shrub factor and ground cover height in Factor 1. Ground cover factor was heavily loaded in Factor 2 and tree factor was had high loadings in Factor 3. (Table 4.6).

Table 4.6: Showing the four extracted factors and the factor loadings (>.5) of habitat variables for animal plots of Pre-monsoon season

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover			.794	
Canopy height			.815	
Tree density			.712	
Shrub cover	.916			
Shrub height	.852			
Shrub density	.888			
Shrub diversity				.923
Ground cover		.770		
Ground cover height	.525	.559		
Ground cover density		.749		
Ground cover diversity				
Steepness of slope				
Variance explained	**26.46%**	**19.13%**	**18.58%**	**9.53%**

Here Factor 1 seemed to reflect areas with abundant shrub or bamboo cover with sparse ($r= -.399$, $n= 50$, $p = .001$) but tall herb cover ($r = .346$, $n = 50$, $p = .05$) at the ground level. Factor 2 apparently represented areas having dense ground vegetation, a characteristic of open areas ($r = .299$, $n =50$, $p = .05$), while Factor 3 apparently represented wooded areas ($r = .514$, $n = 50$, $p = .001$). The Satyr Tragopan during this season seemed to be associated with vegetation prevalent at the understorey and ground level rather than wooded areas (Fig 4.2).

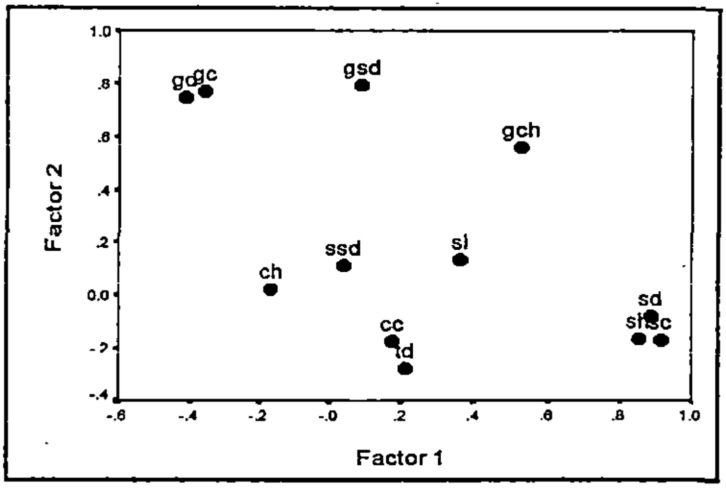


Fig.4.2 Factor Plot in rotated space showing habitat variables of animal plots. (pre-monsoon season)

4.3.2.1.3 Available and Utilised habitat: To assess the difference between animal and random plots 12 of the 17 habitat variables which were measured were included in the stepwise DFA. In discriminant function 1 shrub cover and slope were the variables which differed significantly between the animal and random plots (λ = .944, d.f. = 2, p = .001) and this function correctly classified 80.6% of the cases in the pre-monsoon data set (Table 4.7).

Table 4.7 Habitat variables discriminated by DFA showing standardised discriminant function coefficients (DFC) between animal plots (n= 50) and random plots (n= 197) of pre-monsoon season

Variables	DFC	Correlation coefficient	Animal Plots $\bar{x}$ (s.e.)	Random Plots $\bar{x}$ (s.e.)	F	p
Shrub cover	.695	.828	20.86 (±2.73)	31.62 (±1.69)	10.037	.002
Steepness of slope	.577	.737	31.54 (±1.78)	34.67 (±.667)	7.988	.005

According to this analysis the animal plots were characterised by low shrub cover and less steep ground as compared to the random plots.

PCA of all the habitat plots (animal and random plots combined) of the pre-monsoon season extracted 4 factors which together explained 64.78% of the variance (Factor 1 = 19.83%, Factor 2 = 19.32, Factor 3 = 16.44% and Factor 4 = 9.18%). In Factor 1 high positive loadings were obtained for shrub cover variables, in Factor 2 ground cover variables had high loadings while tree cover variables and slope were highly loaded on Factor 3. Factor Plot of animal and random plots were plotted against the scores of Factor 1 and 2 and this showed that both the types of plots were clumped together and there were no distinct separation between the animal and random plots (Fig 4.3).

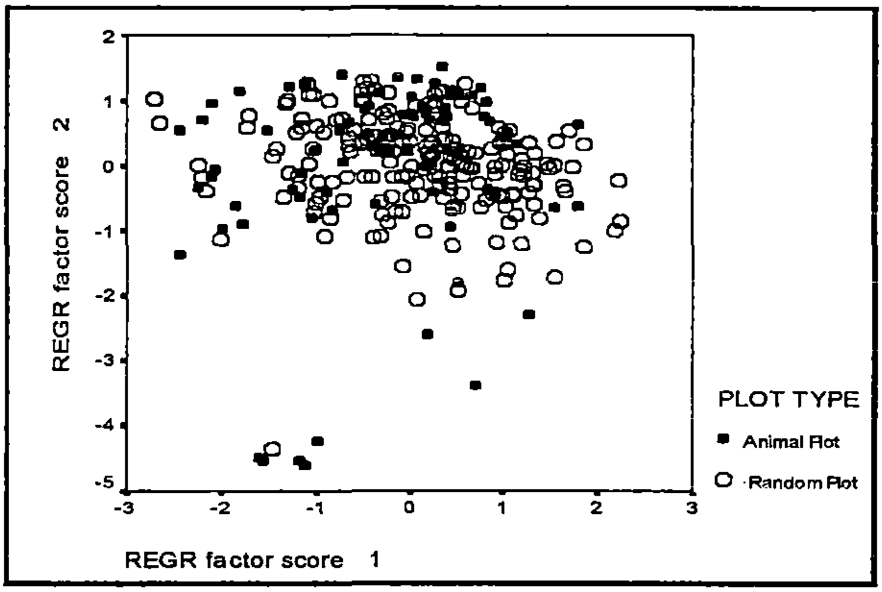


Fig. 4.3 Regression Factor Score Plot of animal and random plots of pre-monsoon season

4.3.2.2 Monsoon season

4.3.2.2.1 Available habitat: PCA extracted four factors from the general habitat of the monsoon season which explained 73% of the total variation with 25.6%, 20%,17.76% and 10.2% explained by Factors 1,2,3 and 4 respectively. Tree factor had high positive loadings in Factor 1 while ground cover factor had negative loadings. Factor 2 had high loadings for shrub factor while ground cover factor and slope were heavily loaded in Factor 3 (Table 4.8).

Table 4.8: Showing the extracted factors and the factor loadings (>.5) of habitat variables for random plots of monsoon season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover	.882			
Canopy height	.835			
Tree density	.875			
Shrub cover		.914		
Shrub density		.885		
Shrub height		.676		
Shrub diversity			.824	
Ground cover	-.588		.566	
Ground cover height			.558	
Ground cover density	-.579			
Ground cover diversity			.727	
Steepness of slope				.918
Variance explained	**25.6%**	**20%**	**17.76%**	**10.2%**

Factor 1 apparently represented densely wooded areas with bare ground ($r = -.313$, $n = 99$, $p = .001$) while Factor 2 represented areas with dense shrub vegetation and sparse ground cover (-.171, $n = 97$, $p = .05$) (Fig 4.4).

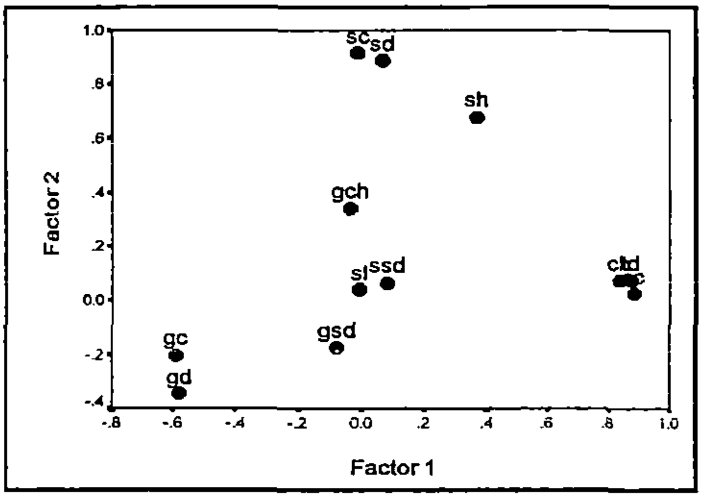


Fig. 4.4 Factor plot in rotated space of habitat variables of random plots (monsoon season)

4.3.2.2.2 Utilised Habitat: PCA extracted 4 factors which together explained 73.4 % of variance in the monsoon habitat of the Satyr Tragopan. High factor loadings were obtained for the tree factor in Factor 1 while in Factor 2 the shrub factor obtained high loadings. (r = -.142, n= 26, n.s.) (Table 4.9).

Table 4.9: Showing the extracted factors and the factor loadings (>.5) of habitat variables for animal plots of monsoon season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover	.858			
Canopy height	.785			
Tree density	.767			
Shrub cover		.942		
Shrub density		.857		
Shrub height		.798		
Shrub diversity	.507			
Ground cover	-.664			
Ground cover height				.773
Ground cover density			.825	
Ground cover diversity			.933	
Steepness of slope				.764
Variance explained	**25.2%**	**20%**	**14.18%**	**12.14%**

The ground cover factor had negative component loading in Factor 1 which probably indicated that during the monsoon season the Satyr Tragopan habitat consisted of areas with dense woodland (Factor 1) with bare ground ($r = -.577$, $n = 26$, $p = .001$) or dense shrubland (Factor 2) (Fig. 4.5)

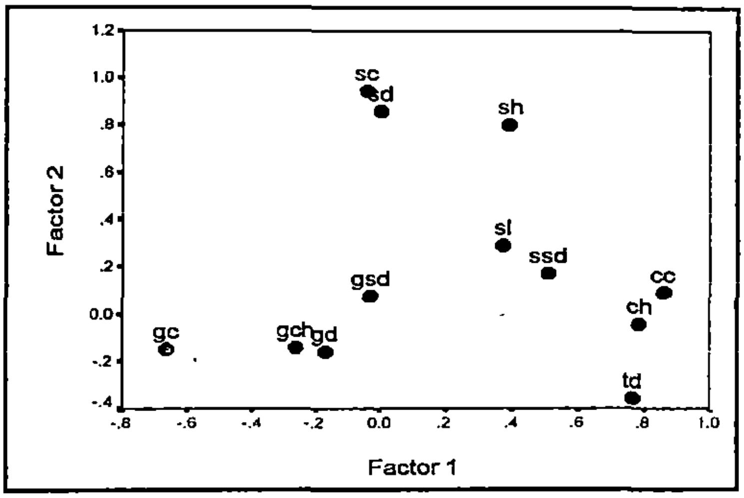


Fig. 4.5. Factor Plot in rotated space of habitat variables of animal plots (Monsoon season)

4.3.2.2.3 Available and utilised habitat: From the monsoon habitat data DFA extracted canopy cover, ground cover density, shrub cover density and shrub species diversity as the variables that discriminated significantly between animal and random plots ($\lambda = .562$, d.f = 4, $p = .000$). DFA had an efficiency of 88 % in correctly classifying the animal and random plots during the monsoon season (Fig. 4.6). Cover at the tree level and density of vegetation at the understorey and ground level were the main variables that separated the animal and random plots (Table 4.10). The Satyr Tragopan seemed to be associated more with lower canopy cover, lower ground cover density and lower shrub cover density in its monsoon habitat than compared to its surrounding habitat.

Table 4.10: Habitat variables discriminated by stepwise DFA showing the Discriminant Function Coefficient (DFC) on discriminant function 1 between animal plots (n= 26) and random plots (n= 99) with F values of extracted variables (Monsoon season).

Variables	DFC	Correlation coefficient	Animal Plots $\bar{x}$ (s.e.)	Random Plots $\bar{x}$(s.e)	$F_{1,124}$	p
Canopy cover	.785	.289	20.85(±4.2)	33.27(±2.10)	7.99	.005
Ground cover density	1.063	.366	46.63(±11.70)	125.87(±25.20)	12.82	.000
Shrub cover density	.769	.478	.6333(±.2370)	1.91(±.1722)	21.91	.000
Shrub cover diversity	-.285	-.057	.292(±.176)	.161(±.017)	.32	.569

PCA extracted 4 factors from the animal and random plots of the monsoon season which cumulatively explained 69.6% of variance (Factor 1 22.6%, Factor 2 20%, Factor 3 16.87% and Factor 4 10%). In Factor 1 high positive loadings were obtained for tree factor and negative loading for ground cover. In Factor 2 shrub factor obtained high loadings while in Factor 3 high loadings were obtained for ground cover factor. Regression Factor score plot were constructed by plotting the animal and random against Factor 1 and 2 scores. This showed separation between animal and random plots during monsoon season. The animal plots were negatively associated with Factor 2 i.e. with shrub factor whereas the random plots were scattered all over the rotated factor space (Fig 4.6).

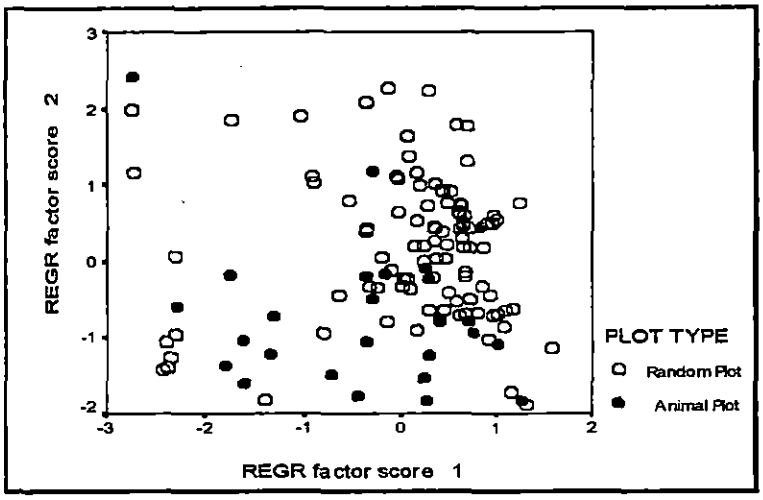


Fig 4.6. Regression Factor Score Plot of animal and random plots of the monsoon season

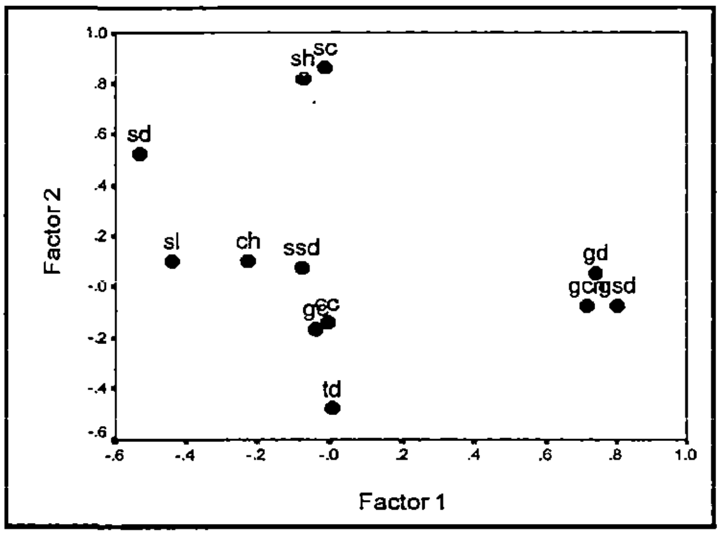
4.3.2.3 Post-monsoon season

4.3.2.3.1 Available habitat: PCA extracted 5 factors which together explained approximately 70% of the variance in the available habitat during the post-monsoon season. High loadings were obtained for ground cover factor in Factor 1 and shrub factor in Factor 2 (Table 4.11).

Table 4.11: Showing the extracted factors and the factor loadings (>.5) of habitat variables for random plots of post-monsoon season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Canopy cover			.861		
Canopy height			.797		
Tree density					
Shrub cover		.862			
Shrub density		.525			
Shrub height		.818			
Shrub diversity					.916
Ground cover					
Ground cover height	.716			-.838	
Ground cover density	.742				
Ground cover diversity	.806				
Steepness of slope				.606	
Variance explained	**18.7%**	**16.72%**	**13.78**	**11.5**	**9.2**

Factor 1 apparently represented open areas with abundant ground cover which was expected in this very moist and wet season prevalent in the study area. The ground cover variables though negatively correlated to the canopy variables were statistically insignificant due to their low values and therefore inconclusive. However Factor 1 seemed to represent sparse vegetation at the understorey level (-.239, n = 96, p = .001). Factor 2 represented areas with dense vegetation at the understorey level and sparse vegetation at the canopy and ground cover level (r= -.235, n= 96, p = .001) (Fig 4.7)



4.7

Fig. 4.7 Factor plot in rotated space of habitat variables of random plots (Post-monsoon season)

4.3.2.3.2 Utilised Habitat: Four factors were extracted out of the animal plots which cumulatively explained 72.42% variance. Factor loadings were high for canopy cover, shrub factor and negatively high for ground cover height and diversity in Factor 1. Factor 2 had high loadings for canopy cover, ground cover, shrub height and slope (Table 4.12).

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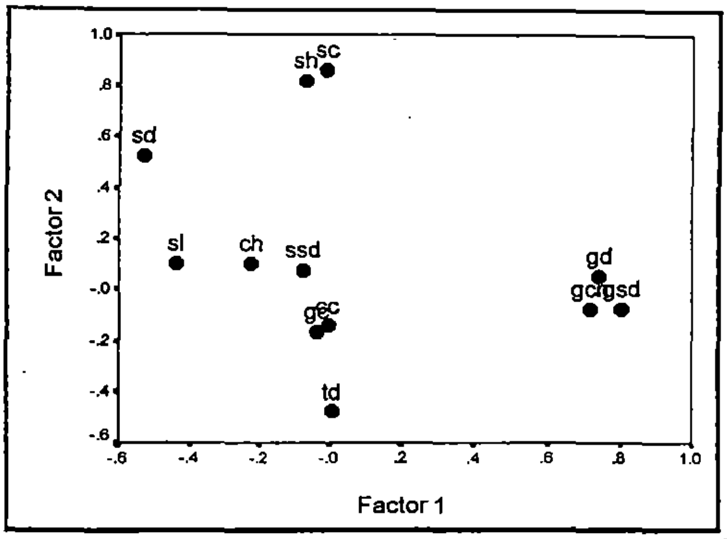

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Fig. 4.7 Factor plot in rotated space of habitat variables of random plots (Post-monsoon season)

4.3.2.3.2 Utilised Habitat: Four factors were extracted out of the animal plots which cumulatively explained 72.42% variance. Factor loadings were high for canopy cover, shrub factor and negatively high for ground cover height and diversity in Factor 1. Factor 2 had high loadings for canopy cover, ground cover, shrub height and slope (Table 4.12).

Table 4.12: Showing the extracted factors and the factor loadings (>.5) of habitat variables for animal plots of post-monsoon season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover	.590	.568		
Canopy height				.786
Tree density			-.918	
Shrub cover	.716			
Shrub density	.792	.809		
Shrub height				
Shrub diversity				-.785
Ground cover				
Ground cover height	-.778	.624		
Ground cover density				
Ground cover diversity	-.839			
Steepness of slope		.832		
Variance explained	**27.5%**	**21.48%**	**11.97%**	**11.43%**

Factor 1 seemed to reflect wooded areas with dense understorey vegetation and therefore sparse ground level vegetation (r = -.373, n = 30, p = .05). Factor 2 represented well wooded steep areas with tall understorey and dense ground cover (Fig 4.8).

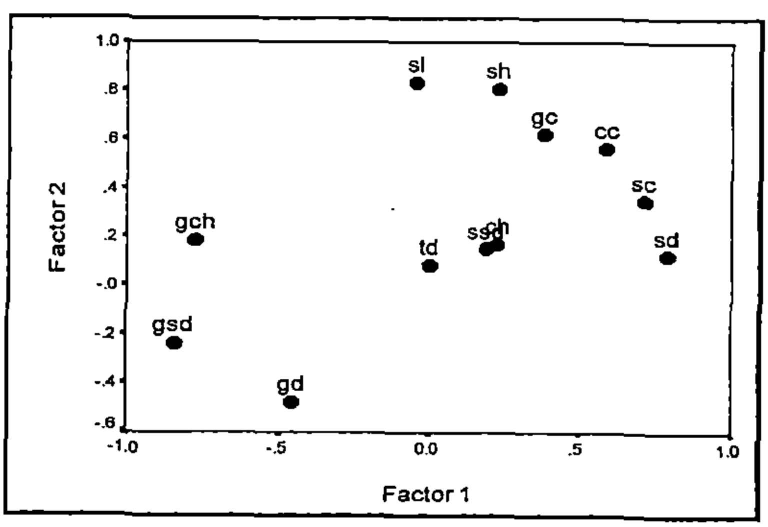

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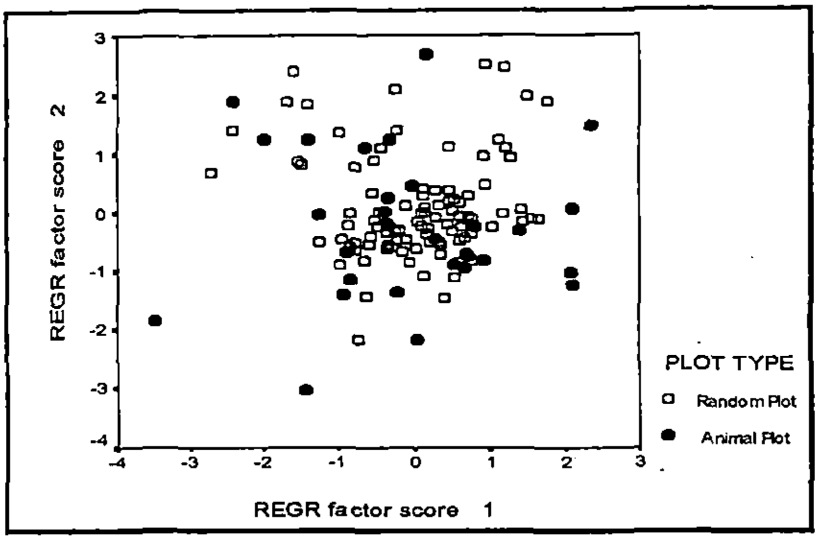
Fig 4.8 Factor Plot in rotated space of habitat variables of animal plots Post-monsoon season

4.3.2.3.3 Available and Utilised habitat: In Stepwise DFA the discriminant function 1 separated out canopy cover, ground cover height, shrub cover, shrub density and slope as discriminating variables from the post-monsoon habitat of Satyr Tragopan ($\lambda = .735$, d.f. = 5, p = .000). DFA had an efficiency of 83.3% in correctly classifying the animal and random plots of the post-monsoon season. Canopy cover, shrub cover and steepness of slope were the most important discriminating variables between the two plots. Moreover Satyr Tragopan was associated with low canopy cover, gentler slopes and more shrub cover during this season (Table 4.13).

Table 4.13 Habitat variables discriminated by DFA showing standardised discriminant function coefficients(DFC) between animal plots(n=30) and random plots(n=96) of post-monsoon season.

Variables	DFC	Correlation coefficient	Animal Plots $\bar{x}$ (s.e.)	Random Plots $\bar{x}$ (s.e)	$F_{1,125}$	p
Canopy cover	.509	.467	18.23(± 2.15)	21.11(± .97)	9.74	.002
Ground cover height	.563	.318	10.15(± 1.15)	11.41(± .49)	1.34	.248
Shrub cover	-.708	-.263	32.6(±5.08)	19.67(±1.37)	11.97	.001
Shrub density	.696	.271	2.99(±.582)	3.64(±.317)	1.01	.316
Steepness of slope	.473	.441	31.97(±1.90)	36.53(±.823)	6.32	.013

PCA extracted 5 factors from the animal-random plot matrix which cumulatively explained 67.87% of variance in habitat variables. Factor 1 and 2 accounted for an almost equal percentage of variance (16.77% and 16.72% respectively). The other factors explained less than 15% of variance individually (Factor 3 = 14.39%, Factor 4 = 10% and Factor 5 = 9.2%). In Factor 1 high loadings were obtained for shrub factor and slope while in Factor 2 high loadings were obtained for ground cover factor.



4.9

Fig ~~4.8~~: Factor Plot in rotated space of animal and random plots Post-monsoon season.

Regression factor score obtained by plotting the animal and random against scores of Factor 1 and 2 showed that the random plots were more or less clumped at the centre of the factor space with most positively associated with Factor 2 or ground cover factor. The animal plots were scattered all over the factor space. The plot thus showed that there was no clear separation of the animal and random plots during this season (Fig. 4.9).

4.3.2.4.1. Winter season:

Available habitat: PCA of the random plots extracted 4 factors which together explained 71.7% of the variance. In Factor 1 positive high loadings were obtained for ground cover factor and negative loadings for tree density and shrub cover height. In Factor 2 high loadings were obtained for shrub factor and in Factor 3 high loadings were obtained for canopy height, ground cover height and slope (Table 4.14).

Table 4.14: Showing the extracted factors and the factor loadings (>.5) of habitat variables for random plots of winter season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover				
Canopy height			.814	
Tree density	-.727			
Shrub cover		.866		
Shrub density		.914		
Shrub height	-.734			
Shrub diversity		-.501		
Ground cover	.863			
Ground cover height			.529	.579
Ground cover density	.866			
Ground cover diversity				.886
Steepness of slope			.878	
Variance explained	**23.5**	**19%**	**15.2%**	**13.9%**

Factor 1 apparently represented open areas with abundant ground cover while Factor 2 represented areas with dense shrub cover (Fig 4.~~9~~10).

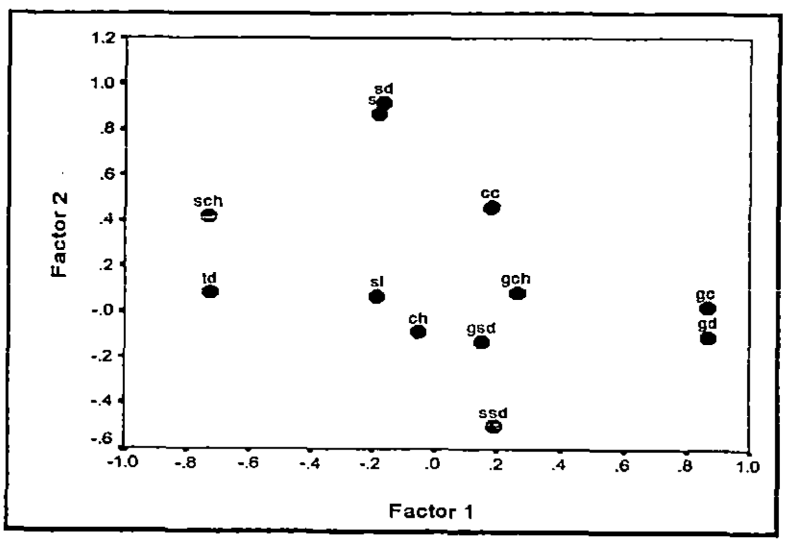


Fig. 4.~~9~~10 Factor Plot in rotated space of habitat variables of random plots winter season

4.3.2.4.2 Utilised habitat: In the utilised habitat or animal plots PCA extracted 3 factors which cumulatively explained 78 % of variance (Factor 1= 31.6%, Factor 2=25.8% and Factor 3= 20.6%). In Factor 1 high factor loadings were obtained for

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Table 4.14: Showing the extracted factors and the factor loadings (>.5) of habitat variables for random plots of winter season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover				
Canopy height			.814	
Tree density	-.727			
Shrub cover		.866		
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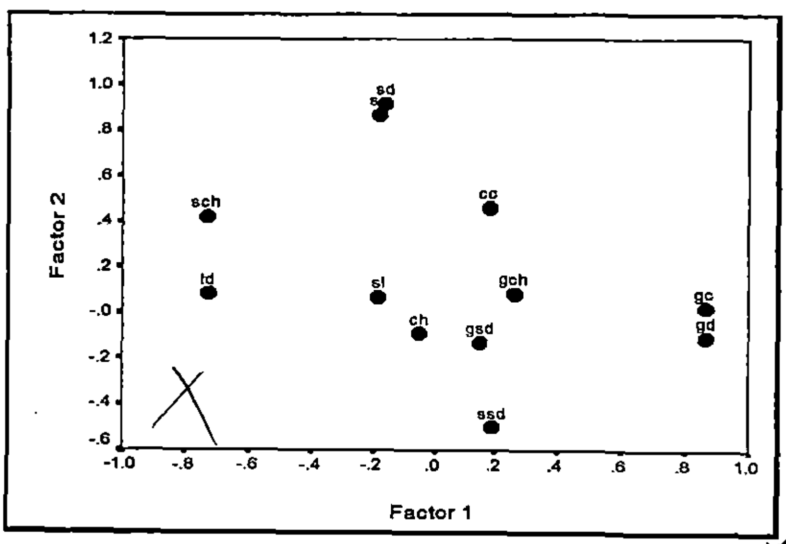

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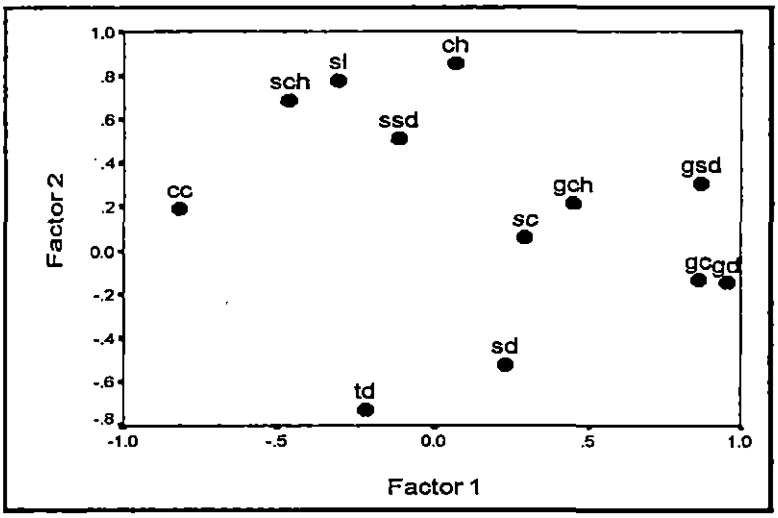
Fig. 4.10 Factor Plot in rotated space of habitat variables of random plots winter season

4.3.2.4.2 Utilised habitat: In the utilised habitat or animal plots PCA extracted 3 factors which cumulatively explained 78 % of variance (Factor 1= 31.6%, Factor 2=25.8% and Factor 3= 20.6%). In Factor 1 high factor loadings were obtained for ground cover factor. Factor 2 had high positive loadings for canopy height, shrub height, shrub diversity and slope with negative loadings for shrub density and tree density. In Factor 3 high positive loadings were obtained for shrub factor and negative loading was obtained for ground cover height (Table 4.15).

Factor 1 apparently represented open areas with abundant ground cover ($r = .742$, $n = 38$, $p = .001$) while Factor 2 represented steep areas with tall but sparse shrub and tree cover and Factor 3 represented areas with dense vegetation at the understorey level (Fig 4.11)

Table 4.15: Showing the extracted factors and the factor loadings (>.5) of habitat variables for animal plots of winter season.

Variables	Factor 1	Factor 2	Factor 3
Canopy cover	-.817		
Canopy height		.854	
Tree density		-.726	
Shrub cover			.863
Shrub density		-.524	.692
Shrub height		.689	
Shrub diversity		.511	.732
Ground cover	.865		
Ground cover height			-.680
Ground cover density	.958		
Ground cover diversity	.872		
Steepness of slope		.779	
Variance explained	**31.6%**	**25.8%**	**20.6%**



4.11

Fig. 4.~~10~~ Factor Plot in rotated space of habitat variables of animal plots winter season

The habitat variables of the winter when subjected to DFA showed no discriminating variables between the animal and the random plots indicating a random use of habitat during this season. PCA of the animal and random plots extracted 5 factors which explained 78% of variance (Factor1= 22.3%, Factor 2 17.1%, Factor 3 15.1%, Factor 4 14.1% and Factor 5 9.3%). High factor loadings were obtained for ground cover factor and negative loading was obtained for shrub height and tree density in Factor 1. High loading were obtained for shrub factor in Factor 2 while in factor 3 there were high loading for canopy height and slope.

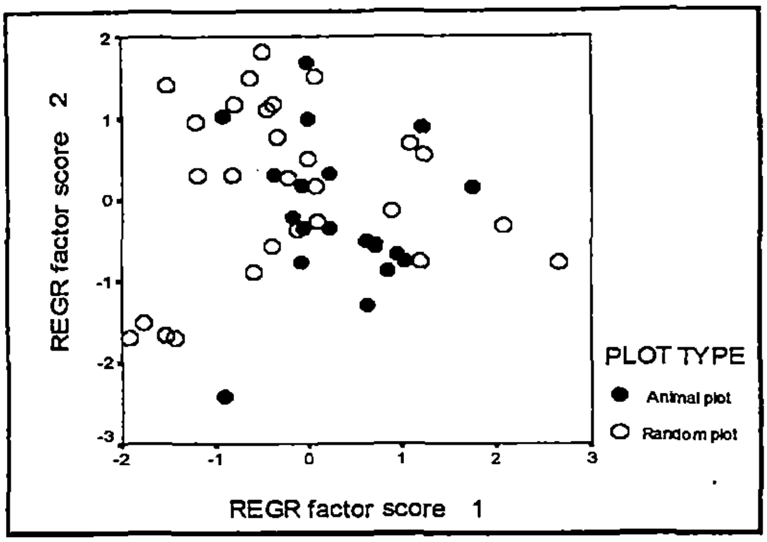


Fig. 4.12 Regression factor score plot of animal and random plots of winter season

Scatter constructed by plotting the Factor scores of Factor 1 and 2 showed that there was no separation between the available and utilised plots of the Satyr Tragopan. This indicated a random use of the habitat variables during the winter season (Fig. 4.12).

4.4. Discussion

Several authors (Lack 1933,1949, Svardson 1949, Hilden 1965) have theorised that birds select habitats on the basis of 'sign stimuli' that convey information about ultimate factors like food production and nest site availability. Root (1967) documented cases in which given bird species appear to be directly associated with ultimate factors. Other studies have described the structural and functional components of vegetation usually involving some form of symbolism denoting items considered important to the avifauna present (Weins 1969). MacArthur and MacArthur (1961) developed a technique to describe the layering of vegetation and found that by computing a foliage height diversity, based upon the distribution of vegetation layers one could predict the bird species diversity of a given community. Sturman (1968) found that the canopy volume and upper storey vegetation were significantly correlated with Chikadee abundance.

During the pre-monsoon season both the available and utilised micro habitats of the Satyr Tragopan were mainly associated with areas outside the primary forest in edges or secondary vegetation characterised by sparse canopy cover but dense vegetation at the understorey and groundstorey level. The habitat in the available and the utilised plots of Satyr Tragopan, generally, did not show much difference. However the two types of microhabitat differed in shrub cover and steepness of slope. It seemed that the Satyr Tragopan used areas that had lower shrub cover and ~~less steep~~ gentler slopes ~~than were available~~. Their habitat during this season was associated with open areas having good understorey and ground cover vegetation. Thus in spring, the Satyr Tragopan apparently occurred in oak forests preferring the forest edges with the shrub and ground cover forming important components of its habitat. Temminck's Tragopan was also observed to occur in forest edges which were rich in grasses and bushes in spring. During their studies on Temminck's Tragopan Shi Hai Tao and Zheng Guang-mei (*1997*) found that the species showed preference for areas of good cover and abundant bushes during the summer season.

Pre-monsoon season coincides with the breeding season of the Satyr Tragopan when the birds generally advertise their presence through calls and display (Islam and Crawford 1996). Such activities appear to be more advantageous in open areas. Being a ground dwelling species the herb layer probably forms a potential source of food for this species. Pre-monsoon may also be the season for the commencement of nesting activities (Baker 1921, Johnsgard 1986). Many studies on pheasants and grouse have shown that nest predation was an important reason for losses in productivity (Reynolds 1988). Deficiency in nesting habitat have been described as limiting factors to pheasant population (Trautman 1960, Leite 1971, Guthery *et al.* 1980). Predators were found to be the proximate factors in influencing nest loss in sage grouse (Gregg *et al.* 1994) and Cabot's Tragopan (Zhang Zheng Wang and Zheng Guang-mei 1989), but the ultimate cause in sage grouse and Cabot nest predation was related to the available vegetation. Tall dense vegetation may provide visual scent and physical barriers between predators and nests of ground nesting birds (Bowman and Harris 1980, Redmond *et al.* 1982, Sugden and Beyersbergen 1986,87, Crabtree *et al.* 1989) . The study of Delong *et al.*(1995) suggested that greater amounts of tall grass cover and medium shrub height were collectively associated with lower probability of nest predation. Wallstead and Pyrah (1974) and Gregg *et al.* (1994) demonstrated that the greater amount of shrub cover at nest sites was associated with non predated sage grouse nests. These studies suggest that cover and height of the shrubs in a relatively small area (i.e. nest site) influences nest fate. Snyder (1984) observed that that the number of early spring nests of Ring-necked Pheasant placed at different nesting cover was directly related to height-density quality of the vegetation. Pheasant breeding density was also related to the availability of woodland edges with high levels of shrub cover 200-300 cm in height and arable land (Robertson *et al.* 1993b). Thus cover at the shrub and ground levels seemed to be an essential feature of the nesting site and fate of ground nesting birds like the Satyr Tragopan. The shrub cover composed predominantly of ringal probably provided the species with vital cover for the nest and also a barrier against predation and nest loss. The relatively open areas with ground cover probably provided the food for this ground feeding species and also areas for communication and advertisement.

In the monsoon season also the general microhabitat characteristics of the bird and the non-bird sites were similar. Birds seemed to be associated with primary forests characterised by dense canopy cover and understorey vegetation and sparse ground cover. However while comparing the habitat of the animal and random plots four habitat variables were found to be different between the two types of plots in this season.

In the post-monsoon season the available habitat was represented by open canopy areas with dense shrub and ground cover while the birds were found to use close canopied steep areas with dense shrub and tall but sparse ground cover. Among the habitat variables significant differences were obtained for canopy cover, ground cover height and steepness of slope between the bird and the non-bird plots, therefore there seemed to be more or less an equal use of shrub variable in both the plots which formed a very important component of the Satyr Tragopan habitat in this season.

In both the monsoon and post-monsoon seasons the Satyr Tragopan was associated with breeding activities like incubation, hatching and rearing of broods which were expected to occur in areas of good cover. Studies (Meyers *et al.* 1988) have revealed that survival of Ring-necked Pheasants depended in part on the habitat they used because survival of broods was related to availability of thicker cover types and in some cover types survival was a function of the age of the brood. Warner (1984) has also suggested that mortality of young may contribute equally as a limiting factor to the survival of adult Ring-necked pheasants.

In SNP there is a very dense growth of *Arundinaria maling, A. racemosa and Thamnocalamus aristata* over a large extent known as temperate bamboo brakes. These are found in large fire swept areas of the Park as a seral type vegetation (Champion and Seth 1968) from where other tree species have been exterminated. *Daphne cannabina, Berberis aristata*, and *Pipthanthus nepalensis* are the other species known to occur with the ringal species. Perhaps ringal which formed the most common shrub cover in the Singhalila forests provided the secure hatching and early brooding cover. The dense overhead cover probably provided efficient lanes for travel and escape. It appears that in the monsoon and post-monsoon seasons the vital breeding activities necessitated the Satyr Tragopan to remain in well-wooded areas or primary forests with adequate cover for protection and shelter. Meanwhile abundant ground cover prevalent during these seasons apparently provided an abundant source of food to the adults as well as their broods.

In the winter the available sites were associated with steep edge areas possessing dense ground and shrub vegetation. Similar to the observations on the Ring-necked Pheasant (Collias and Taber 1951, Goransson 1980 and Ridley 1983) the Satyr Tragopan in this season were also associated with edge areas but with steep slopes having dense ground cover and sparse but tall canopy and shrub cover.

Similarly Cabot's Tragopan used areas with thick undergrowth , a greater percentage of bare ground, proximity to water sources and a gentle slope while areas with abundance of fallen nuts were preferred for roosting (Young *et al.* 1992). There was no difference in the habitat variables of the bird site and the non-bird site which indicated the rather random use of the area by the species. It is very important to understand the winter habitat use of Satyr Tragopan because work on the related Common pheasant has shown that winter habitat choice was a key factor in determining over winter survival (Gatti *et al.* 1989, Hill and Robertson 1988, Robertson *et al.* 1989). Winter habitat cover in Ring-necked pheasants is suspected to be the major limiting factor on pheasant population in southern Idaho. Declines have been attributed to loss of cover (Owen 1987). Winter habitat use by hen Ring-necked Pheasants (Leptich 1992) showed heavy use of wetlands because of the presence of adequate cover in this habitat type which was essential for moving around and escape during the day and roosting and thermal cover at night. In winter the Temmick's Tragopan expanded its range size occurring in a variety of broad-leaf bamboo mixed forest (Shi Hai Tao and Zheng Guang-mei 1997). Winter and spring habitat use by Gray Partridge (Perdix perdix) (Church and Porter 1990) showed that in winter coveys selected grain stubble as the waste or left over grain was an important source of food for the species. Thus all these studies have confirmed the importance of cover to survive the constraints of winter season. In Singhalila National Park snowfall began by November or December but did not remain for long. Snowfall in January was more severe and remained sometimes upto March April. The Satyr Tragopan therefore appear to range over larger areas because during winter due to scarcity of resources, the birds try and cover large areas to obtain scarce resources. The association of the bird with ground cover probably meant that the vegetation provided cover for roosting, warmth and food. At the canopy level all the deciduous species in the mixed oak forests were without cover, while most of the plants in the shrub and ground were either dead or in defoliated phase to survive the winter. Thus the cover at the ground cover level was a very important winter habitat variable of the Satyr Tragopan. The importance of ground cover in the winter habitat of the Satyr Tragopan agreed with the observations of Robertson (1985) who suggested that primary ground dwelling species like the Common Pheasant would be expected to be affected by the quality of habitat at the ground level.

4.5 Conclusions

Like all other species of Tragopan pheasants the Satyr Tragopan is a true forest bird and in Singhlila National Park it was found to be associated more with the shorter vegetation attributes of its habitat like shrub and ground cover than the tree cover variables. Corroborating the observations of others (Beebe 1918-1922, Ali and Ripley 1978, Lelliott and Yonzon 1980, Young and Kaul 1987) the habitat of the species included gentle to steep and rugged forested areas with shrubby undergrowth or dense ringal cover.

In SNP the Satyr Tragopan were found predominantly in mixed oak forests with marked seasonal shift in microhabitat use though there was marked difference between the available and utilised habitat only in the monsoon season. The habitat of the species showed association with habitat variables like shrub cover, height and density and ground cover, height and density. Canopy cover was important in reflecting the primary forest or edge areas within the forest while attributes like canopy height and tree density did not form any important component of the satyr Tragopan habitat. Similar to the studies of Islam and Crawford (1987) on the habitat use of the Western Tragopan, it seemed that in a Satyr habitat the structural components of the vegetation at the shrub and ground cover level were more important than the components at the canopy or tree level. Tall shrub cover, height and density probably were important for females that were nesting for cover and protection. On the other hand shorter shrubs and ground cover would be important for the brood while the brightly coloured males would also need dense cover as protection from potential predators. Being primarily ground dwelling and herbivorous the ground cover vegetation probably provided the species with abundant and easily procurable food. As suggested by Robertson (1985) it may be appropriate to conclude that because pheasants like Satyr Tragopan are primarily ground living birds, their habitat selection is expected to be on the quality of shrub and ground cover rather than on higher life forms like tree cover variables.

CHAPTER 5

FOOD AND FEEDING ECOLOGY

5.1 Introduction

Food is basic to an animal's survival and thus a large part of an animal's activities is devoted to procuring these resources. The quality and quantity of food are important factors that determine many aspects of the physical condition, breeding performance and chick survival in several species of birds. There is tremendous radiation in the diets of each animal species (Alcock 1989). Even in some closely related species each member has its own food choice and feeding, e.g. the Galapagos finches (Lack 1971). The traditionally favoured hypothesis for dietary differences is that competition among different species conferred a reproductive advantage on those individuals that reduced overlap in food preferences. However some ecologists now believe that different diets of animals could be an incidental effect and had little or nothing to do with reduction of ecological overlap in food demands (Alcock 1989).

Among the phasianids diet varies between different groups and seasons though food is available either below or above the ground. Food of pheasants includes seeds, leaves, flowers, stems, buds, tubers, roots, insects, annelids and even reptiles (McGowan 1995). Very little quantitative information is available on the diet of Himalayan pheasants. Most of the available information is from naturalists who shot these birds as game in the last century or early part of this century. It is however certain that diet of pheasants include all types of food matter and depends to a large extent on their habitats and thus the availability of food resources.

Pheasants of the genus *Tragopan* are almost similar in their food habits to each other. According to Johnsgard (1986) all the Tragopan pheasants are herbivores and invertebrate feeders with a partiality towards insects. Food varies from leaves, seeds, berries, fruits, roots, buds, acorns, annelids, insects and molluscs. In captivity all the species are preferably vegetarian (Howman 1979, Sivelle 1979). Grit is another important part of the diet of phasianids. The gizzard is highly muscular with ridged inner lining adapted for grinding up fibrous vegetable food. Like domestic chickens they swallow small stones and grit which are retained in the gizzard to help grind up the food.

According to Hume and Marshall (1879-1881) the Satyr Tragopan feed on insects, young green shoots of bamboos and on some onion like bulbs. Hodgson (in Hume and Marshall 1879-1888) found wild fruits, rhododendron seeds, and in some cases entirely aromatic leaves, bastard cinnamon and daphne in the crop of Satyr Tragopan. According to Baker (1920) the favourite food of the Satyr was bulbs and roots of plants, which they dug up. They also fed on seeds, shoots and tendrils. However there was no evidence of the birds eating insects and reptiles. The Satyr Tragopan was considered to be omnivorous by Beebe (1918-1922) specialising in buds and leaves. He found leaves and flowers of paper laurel, rhododendron petals and insects to be the diet of the birds in their habitat. Ferns like *Diplazium* sp. and *Polypodum* sp. were also known to be eaten by the birds (Meinertzhagen 1926).

Lelliott and Yonzon (1980) during their studies in Central Nepal found the species feeding on the leaf litter and stream debris or on mossy areas. They were also found to be feeding on the fruits of *Berberis* sp., *Symplocos* sp. and *Rhododendron* sp.

From faecal analysis they found leaf, moss, grass, roots, quartz fragments and an insect wing suggesting an omnivorous diet. Yonzon and Lelliott (1980) observed the Satyr to be primarily a vegetarian feeding on moss lichen, leaves, grass, roots, buds and few insects. Quartz fragments as grit were also a part of their diets. While studying the diets of pheasants in Pipar (Central Nepal) Bhandary *et al.* (1986) found that moss and grass leaves were the two main autumn foods of the birds. Thus, it seems that by and large the Satyr Tragopan is an omnivorous species in its habitat in the wild. In captivity the species is largely vegetarian feeding on fruits and berries (Howman 1979). Apart from these they are also observed to feed on alfalfa grass, squash, cucumber, apples, raspberries, mulberries, cut grapes and even small-shelled green peanuts (Seville 1979).

Most of the phasianids feed on the ground although some may climb into bushes or even low branches of trees like *Rhododendron* sp. and *Symplocos* sp. The Satyr Tragopan confine their foraging activities to early morning and late afternoons but during cloudy days they forage at more irregular intervals (Johnsgard 1986). The species mainly feed on open edges of the forest or deep among the undergrowth where they scratch spots (Baker 1920, Beebe 1918-22). Lelliott and Yonzon (1980) observed the species feeding principally in the early mornings and late afternoons. A large part of their observations included arboreal foraging in *Berberis* sp., *Symplocos* sp. and *Rhododendron* sp. plants

Direct observations on the feeding and foraging behaviour of Satyr Tragopan were extremely rare due to the shy and elusive nature of the birds. I did not observe the birds feeding on more than 2-3 occasions during the tenure of my studies.

Therefore an alternative method to determine the diet of the species was necessary. Satyr Tragopan is a Schedule I species under the Indian Wildlife (Protection) Act 1972 and killing of the birds for merely taking crop, gizzard and stomach contents is neither permissible nor practicable. Thus analyses of the crop, gizzard and stomach contents were ruled out and the most non-invasive (Poulsen and Aesbischer 1995) method of diet determination - faecal droppings analyses was adopted.

This chapter besides discussing the diet of the species also discusses the availability of different plant parts and invertebrates available in the habitat. I have addressed the following aspects:

1.Identification of the main food items of the Satyr Tragopan.

2. Seasonal fluctuation in the diet of the species.

3. Seasonal availability of plant parts and invertebrates.

4. Comment on the microtechnique used for galliform faecal analyses.

5.2 Methodology

5.2.1 Faecal analysis: This is one of the best and most widely used technique for diet determination though it is labour intensive and considered inaccurate by some workers (Slater and Jones 1971, Fitzgerald and Waddington 1979). Faecal analyses is based on the assumption that some part of the plant or animal material (plant epidermis, elytra, legs, mandibles, fangs, sometimes wings, seed and bracts) ingested by the species can resist the physiological process of digestion and pass through the gastrointestinal tract in an undigested form (Marti 1982, Mayers 1985).

The characteristic shapes of the epidermal cells of plant parts and the structure of the stomata are the keys in identifying the plant species in the microtechnical analyses of droppings (Fitzgerald and Waddington 1979)

5.2.1.1 Field: All the droppings of Satyr Tragopan that were found during regular trail monitoring as well as outside these were collected in plastic packets. They were then transferred to paper trays for air or oven drying depending on the season of collection. The droppings were then labelled and sealed in new polythene packets and stored in an air tight container with camphor and a desiccating agent like silica gel. All the places from where droppings were collected were temporarily marked for carrying out vegetation sampling studies. While monitoring the trails for evidences, care was taken to see that no faecal material was left behind at the site of collection.

5.2.1.2: Preparation of reference slides: Microtechnical procedures like faecal analyses require the presence of reference slides (Dusi 1949) of some plants representing the habitat of the species to aid in the identification of plant parts (Storr 1961). Baumgartner and Martin (1939) who developed the use of microtechnique in dietary analyses compared squirrel stomach contents with permanent reference slides. A reference collection comprising of plant parts was made by first preserving the freshly collected plants in 70% ethanol (Starling 1993) for 24 hours. Pieces of epidermis were then stripped off from the preserved plant parts. They were then passed through the ascending grades of ethanol for dehydration (30%, 50%, 70%, 90% and 100%) and then cleared in xylol. Permanent mounts were made by mounting in DPX or Canada Balsam. I did not use any staining technique to stain the materials as unstained mounts prepared from fresh plants required less time and was not cumbersome in the field. Besides Zyznar and Urness (1969) found that unstained mounts proved superior to staining techniques for identification.

5.2.1.3 Preparation of faecal droppings slides: All the faecal droppings were analysed according to seasons and therefore all droppings belonging to one season were considered as one major sample. From the preserved major sample 1-5 droppings were pulverised which comprised of a pooled sample and was used for the main analysis. This was cleared in 10% NaOH solution and boiled for 3-5 minutes times with 3-4 changes of the NaOH solution. The excess solution was then drained off and the settled volume poured on a petri-dish. A dropper extracted 10 sub-samples from this sample on 10 glass slides. The sub-samples/materials were allowed to air dry after which they were mounted in glycerol (Bhandary *et al.* 1986, Kaul 1989). The slides were examined in 50X and 100X magnification levels interchangeably (Holechek and Valdez 1985). Plant parts were counted by recording the frequency of occurrence of plant fragments in a microscopic field of view (presence/absence). Although frequency of occurrence tends to overestimate rare and underestimate common species (Hanson 1970) it is still the most widely used technique. Twenty frequency/fields of observations per slide and five slides per sample were considered adequate for a reasonable estimation of species comprising 20% or more of the diet (Holechek and Vavra 1981). For more adequate representation I made 20 fields/frequencies of observation per slide for ten slides per sample (major sample) to identify and enumerate the proportions of different plants present in the droppings. I did not use separate slide preparation for identifying invertebrate parts in the faecal droppings but I made an attempt to classify the different invertebrate parts observed in the slides by using the keys provided by Moreby (1987, 1993) and assigned them to their classes, orders and families where possible. I however made no attempts to classify the size of invertebrates nor rounded up numbers of their parts to the nearest whole number of individuals.

5.2.2 Phenology: As Satyr Tragopan are primarily ground feeders, phenological studies were carried out in the intensive study area to record the phenophases of some herb species which may be potential food items of the Satyr Tragopan. Phenological studies were carried out along one of the trails used for regular monitoring and which was situated nearest ~~form~~ to the base camp because of convenience and also because of a stringent field schedule. Monthly records of the phenophases for all plant types were made by assigning abundance ratings (Frankie *et al.* 1974, Guy *et al.* 1979, Opler *et al.* 1980, Balsubramanium and Bole 1991) where 0= none, 1 = few and 2 = many. For ground cover which included 19 species, phenological records were made in 1m x 1m permanent quadrats and the parameters recorded were leaf bud, immature leaf, mature leaf, flower bud, flower, immature fruits, mature fruits, fallen fruits and dead plants (annual species).

5.2.3 Pitfall trap sampling: Satyr Tragopan is known to feed on certain insects and invertebrates. Thus it was found necessary to sample these for estimation of invertebrate availability. For this 9 pitfall traps were laid in a grid of nine pitfall traps 1 m apart (Southwood 1978) in different habitat types. Each pitfall was a plastic cup of 2.5cm diameter and 12 cm height. Each was filled with a mixture of detergent and water to reduce surface tension to enable the trapped invertebrates to sink. Fortnightly collections were made and the collected specimens were preserved in 70% ethanol, labelled and sealed for identification.

5.2.4. Core sampling: While conducting vegetation sampling, the ground cover was quantified in two 1 m x 1 m quadrats within the animal and random plots. From every such plot soil samples were collected by means of an iron core which was 4 cm in diameter and 4 cm in height. Soil samples along with its contents were preserved in polythene packets by loosely tying up the mouths of the packets. Once in the laboratory the soil samples were subjected to the Tullgren funnel method of extraction. The extracted microarthropods were then preserved in 70% ethanol and sent for identification to the Zoological Survey of India.

5.2.3 Analyses: The prevalence of each food item was expressed as a Food Importance Index (Beck 1952 in Bhandary *et al.* 1986). Beck (1952) developed the food rank index to represent the importance of food items in the diet of any animal species using the principal measurable factors involved in food habits data like volume, weight and occurrence. It was derived by the formula $x.y.z = R$, where x = % volume of food times 100, y = % occurrence of food, z = specific gravity of the food item. This index was mainly useful for studies done by crop analysis, as the derivation of the formula requires the measurement of specific gravity of the food items. In studies involving the diet of Himalayan pheasants including the Satyr Tragopan where crop analysis is not practicable the index has been used by suitable modifications, as a food importance index i.e. Food Importance Index = Frequency% + Composition%/2 (Bhandary *et al.* 1986).

According to Holechek and Gross (1982), dividing the frequency of occurrence of each species by the total frequencies of occurrence of all species was found to be a slightly more accurate representation of dry weight composition than converting frequency to relative density or actual density (Sparks and Malchek 1968). Therefore I divided the frequency of occurrence of a particular food item in a sample slide by the total frequencies of occurrence of all food items occurring in that sample slide to obtain percent composition (multiplying by 100). Kruskal-Wallis One Way ANOVA and Parametric One Way ANOVA were used to test for differences in variables. Mann-Whitney U tests were used for testing differences between any two variables.

Compositional analysis was used to determine food selection among the important ground cover species identified from the faecal droppings of the Satyr Tragopan. The method of compositional analysis (Aitchison 1986) has been specifically developed for analyses of multivariate data in the form of a set of proportions that sum up to one (known as composition). One of the main principles underlying this method is that all the sample types (habitat types, plant species) have to be considered simultaneously so that the results obtained are independent. Aebischer *et al.* (1993) has discussed the application of this statistical technique on data generated from radio telemetry in detail. Although it was designed to analyse multivariate habitat data from radio telemetry it can also be used for activity budgets and dietary analysis (Aebischer *et al.* 1993).

For compositional analysis eight food items were identified based on their food importance index and their consistency of occurrence in all four seasons through dietary analysis. These were ferns, *Pilea scripta, Poa annuae, Primula* sp., *Theropogon pallidus, Valeriana jatamansi, Vaccinium nummularis* and others (*Impatiens sulcata, Senecio* sp. *Stachys sericea*). Food utilised was determined from proportions of each of the 8 dietary items per slide for a total of 10 slides giving a sample size of 10. This was expressed as percentage food composition and was calculated by the frequency of occurrence of the particular food plant in one sample slide divided by the total frequency of occurrence of all the other food plants in that given slide multiplied by 100. Thus in compositional analysis one slide was treated as a single sample and on the whole the sample size per season was 10. The availability of each plant species was derived by the formula Availability = number of plants of each species + average height of each species/2. The density and height were recorded in 1m x 1m quadrats together with ~~other~~ other phenological data. The availability and utilisation of each of these plant species was expressed as proportions which when summed equalled one and could not be considered independent from each other (unit sum constant). These proportions were made independent from each other by 'logratio' transformations or In (p/q) where q=1-p used as a standard in the analysis of proportions. In this study the proportions of availability and utilisation were obtained by dividing the proportions of the seven food types by the proportion of the eighth. The results obtained were independent of the plant species used as the denominator. The hypothesis to be tested by this analysis was that if there was no food selection then the logratio difference across all the sample slides would be zero. This was tested by using the multivariate analysis of variance, Wilks Lambda (λ), the significance of which would indicate a non-random use of the food plants. The preference and avoidance of each plant species was calculated by considering all the logratios of each plant species and by subtracting matching logratios for availability and utilisation of each plant species used. The signs of logratio difference were set into a matrix from which the different plant items were ranked. A complete row of + signs indicated a high preference for that plant item and a row of - signs indicated an avoidance of that plant item. To test for significant deviation of logratio difference from zero a t- test was used.

5.3 Results

5.3.1. Food resources availability: Food was available to the Satyr Tragopan in the form of plant materials and invertebrates. The over all availability (density and height of ground cover) differed across the seasons (density $F_{3,128} = 2.782$, $p=.044$; height $F_{3,128} = 8.626$, $p < 0.0001$) and also between the predominant species of ground cover (density: $F_{10,121} = 16.73$, $p =$ ~~.000;~~ <0.001 height: $F_{10,121} = 8.269$, $p =$ ~~.000)~~ <0.001. The density and height of some annual species of ground cover plants fluctuated across the four seasons (Table 5.1). Ground cover density was maximum during the monsoon and post-monsoon months and scarce in late winter and early pre-monsoon (Fig 5.1).

Insects, mites and spiders were available as animal food items to the Satyr Tragopan. These were either Dipterans (flies), Coleopterans (beetles), Hymenopterans (ants) and Arachnids (spiders) (Table 5.2)

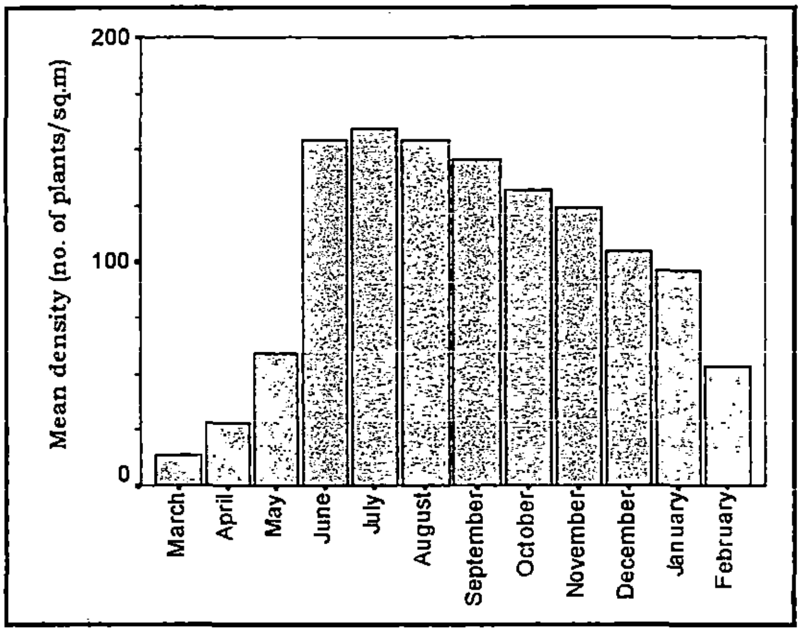
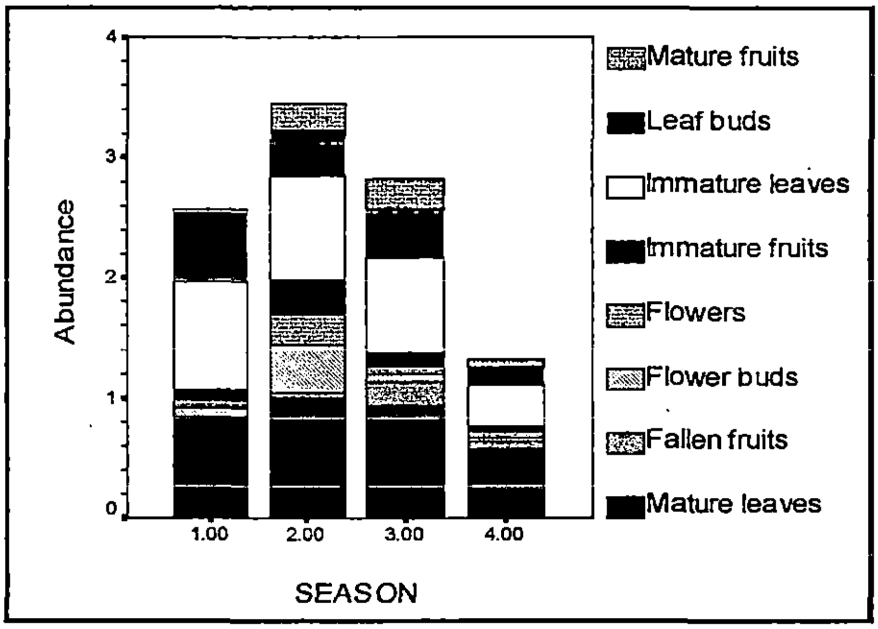


Fig. 5.1: Monthly availability (density) of dominant cover ground cover in the Singhalila National Park



Legends: Season: 1= pre-monsoon, 2= monsoon, 3= post-monsoon, 4 = winter
Abundance: 0= none, 1 = few, 2= many, 3= abundant

Fig. 5.2 Showing the different phenological phases of dominant ground cover species across the seasons

Table 5.1: Showing F values (df 3,8)obtained by One Way ANOVA on density and height of ground cover food items across four seasons in Singhalila NationalPark.

Species	Density (stems/km^2)	Height (cm)
Erigeron sp.	5.714*	1.396
Fern	1.308	4.915*
Impatiens sulcata	3.707	1.256
Pilea scripta	2.427	3.881*
Poa annuae	5.081*	8.257*
Primula sp.	3.909*	.745
Stachys sericea	2.874	8.257*
Senecio sp.	11.067*	2.874
Theropogon pallidus	3.153	6.044*
Vaccinium nummularia	3.153	6.044*
Valeriana jatamansi	4.393*	11.672*

* = $p < .05$. Rest ~~insignificant~~ non-significant

Table 5.2: Showing the various orders and families of arthropods available to the Satyr Tragopan as animal food items in the SNP.

Order/Family	Family
Diptera	Tipulidae
	Biblionidae
	Sciaridae
	Mycetophilidae Phoridae
	Tephritidae
	Muscidae
	Calliphoridae
	Tachinidae
Coleoptera	Carabidae
	Cerambycidae
Hymenoptera	Ichneumonidae
	Brachonidae
	Formicidae
Arachnida	Clubionidae
	Agelenidae

5.3.2 Direct observations: In the field I observed the Satyr Tragopan to be ground feeders and they were observed to feed on plants like *Pilea scripta, Theropogon* *pallidus, Stachys secricea, Saxifraga nutans* and ferns. On one occasion I found the seed of *Symplocos theifolia* in the droppings.

5.3.3 Diet from faecal analysis: A total of 23 food items were identified from the faecal droppings of the Satyr Tragopan in all the four seasons of the year. The highest variety in the diet was found in the post-monsoon season and the monsoon season when 23 and 20 items were present respectively in the diet. In the colder and drier seasons i.e. the pre-monsoon and winter 17 and 18 food items were present respectively which perhaps indicated a slightly greater variety of food items consumed by the birds during the wet and moist seasons of the year than in the drier ones. *Arundinaria maling* was the most important food component identified from the diet of the Satyr Tragopan in all four seasons. Besides this other perennial plants like *Pilea scripta, Theropogon pallidus, Vaccinium nummularia, Cotaneaster microphyllus*, annuals like ferns and non-plant material in the form of quartz fragments were the major components identified in the droppings of the Satyr Tragopan (Table 5.3). Based on the percent composition of each food item identified from the droppings, the food items of Satyr Tragopan can be categorised into three groups (i) Major food components or those food items forming more than 10% of the total composition; (ii) Minor food components or those food items forming less than 10% but more than 1% of the total composition and (iii) Trace food items which form less than 1% of the total composition.Kruskal Wallis One Way ANOVA showed that out of the 23 food items in the diet of the Satyr Tragopan, the percent composition of only 7 food items fluctuated across the four seasons (Table 5.4). This perhaps indicated that although the main food components in the diet remained the same some of the minor components of the diet changed with the seasons .

On the other hand, apart from the seven food items the percent composition of four other food items varied significantly between two seasons. This indicated that the diet of the species may vary between any two given seasons (Table 5.5) although this variation may not be apparent across all the seasons.

Table 5.3: showing the seasonal Food Importance Indices (FII) of different food items identified in the faecal droppings of Satyr Tragopan in SNP, Darjeeling.

Food items	PRM	MON	POM	WIN
Arisaemia griffithii	-	16.25	15.75	17.25
Arundinaria maling	75.75	70.25	64.5	68.25
Cotoneaster microphyllus	31.5	10.75	15.75	21
Erigeron sp.	5.25	10.5	26.75	26.5
Hemiphragma sp.	-	5.25	5.05	-
Impatiens sulcata	5.25	-	5.05	-
Pilea scripta	64.25	58	58.5	68
Primula sp.	54.25	45.75	47.75	41
Poa annuae	39	27.25	32.5	26.5
Polygonum molley	10.5	10.5	27	32.25
Plantago sp.	-	16	27	-
Saxifraga nutans	10.75	15.75	5.05	5.25
Stachys serecia	-	-	16.25	21.75
Senecio sp.	-	10.5	10.5	-
"Simjhar"	5.25	16.25	5.25	29
Thalictrum virgatum	-	-	5.25	-
Theropogon pallidus	51.75	49.75	55	66
Valeriana jatamansi	5.25	17	21.5	32.5
Vaccinium nummularia	53	25.25	39.25	57.25
Fern	58.25	37.75	21.5	17.5
Moss	29	5.25	55	22.5
Grit	21.46	56.75	70.5	79
Invertebrates	-	5.25	56	15.75

Table 5.4: Showing the χ^2 values obtained by Kruskal Walis One Way ANOVA for percent composition of seven food items across four seasons in the diet of Satyr Tragopan in the SNP.

Food items	χ^2	P value
Ferns	15.59	.0014
Grit	21.15	.0001
Moss	17.85	.0005
Primula sp.	7.82	.0500
Stachys sericea	8.34	.0394
'Simjhar'	13.08	.0045
Invertebrates	20.52	.0001

Table 5.5: Showing the Mann Whitney values for difference in percent food composition between two seasons at $p<0.05$.

Food items	PRM & MON	PRM & POM	PRM & WIN
Arundinaria maling	Z= 1.95	N.S.	Z=1.97
Valariana jatamansi	Z=1.96	N.S.	Z=1.96
Theropogon pallidus	Z=1.97	N.S.	Z=1.97
Plantago sp.	N.S.	Z=2.48	N.S.

5.3.3.1 Pre-monsoon: I identified 17 food items from the faecal droppings of Satyr collected in the pre-monsoon season. Fifteen of these were plant material, 1 was grit or quartz fragments and 1 invertebrate parts. Of these the major food items were *A. maling, P. scripta*, and *Poa annuae* which comprised 55% by composition of the pre-monsoon food items identified. *Primula* sp., *C. microphyllus, T. pallidus, V. nummularia*, fern, moss, grit and invertebrates comprised 43% by composition of identified items and were categorised as minor items, while *Erigeron* sp., *S. nutans*, "simjhar", *P. molley, I. sulcata* and *V. jatamansi* comprised 2% by composition of identified food items and were categorised as trace items (Figure 5.3).

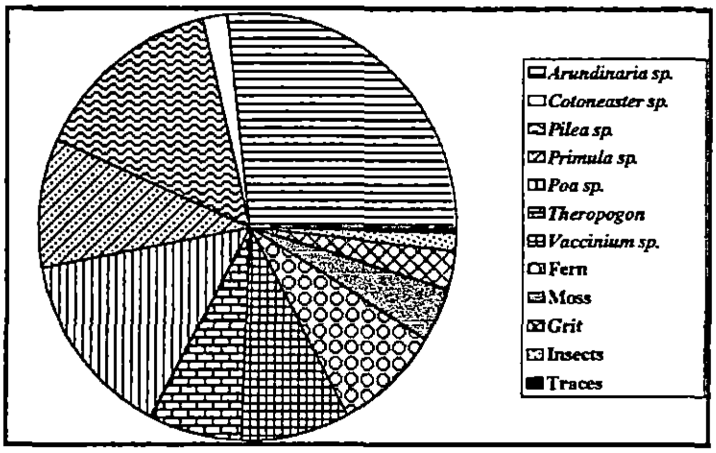


Fig. 5.3 Percent composition of food items in the diet of Satyr Tragopan (Pre-monsoon season)

Invertebrates alone comprised only 1.28 % composition of the diet during pre-monsoon and comprised of insects and annelids (Table 5.6).

Table 5.6 Invertebrate structures identified from the faecal droppings of Satyr Tragopan in the pre-monsoon season

CLASS	ORDER/FAMILY	STRUCTURE	NUMBER
Insecta	Hemiptera-Miridae	labium	3
	Hemiptera Cicadellidae	hind tibia	1
	Coleoptera-Scarabidae	front tibia	1
	Coleoptera-Scarabidae	mid tibia	1
Annelida	-------		1

During pre-monsoon season there was a non-random use of the ground cover as food items (λ= .00192, p = .008, MANOVA). Fern was the most preferred plant item besides which *Vaccinium nummularia, Primula* sp., *Theropogon pallidus* and *Pilea scripta* were also significantly preferred. The Satyr Tragopan avoided *Valeriana jatamansi, Poa annuae* and others during this season (Table 5.7 and 5.8).

Table 5.7: Mean logratio differences (±1) between utilisation and availability of ground cover species identified in the diet of the Satyr Tragopan in SNP (Pre-monsoon season)

	Ferns	*P.scripta*	*P.annuae*	*Primula* sp	*T.pallidus*	*V.jatamansi*	*V.nummularia*	Others
Ferns	.	+2.79±.86**	+.92±1.35**	+1.98±0.75*	+2.02±0.90*	+6.79±0.56**	+1.98±065*	+7.74±1.02**
P.scripta	-2.79±.0.86**	.	+3.18±.99**	-0.80±.0.27	-0.81±1.41	+4.09±.77**	-2.05±1.29	+5.46±1.12**
P.annuae	-6.92±1.35**	-3.18±0.99**	.	-4.40±1.16**	-4.94±1.74*	-.021±1.29	-5.61±1.84*	+1.92±1.49
***Primula* sp**	-1.98±0.75*	+0.80±0.27	+4.40±1.16**	.	+0.36±1.44	+4.56±.84**	-1.51±1.31	+5.75±1.05**
T.pallidus	-2.02±0.90*	+.81±1.41	4.94±1.74*	-0.36±1.44	.	+3.97±1.02**	-0. 71±0.79	+5.78±1.62 **
V.jatamansi	-6.79±0.56**	-4.09±0.77**	+.021±1.29	-4.56±0.84**	-3.97±1.02**	.	-5.50±0.87**	+1.96±0.90
V.nummularia	-1.98±0.65*	+2.05±1.29	+5.61±1.84*	+1.51±1.31	+0. 71±0.79	+5.50±0.87**	.	+4.42±0.61**
Others	-7.74±1.02**	-5.46±1.12**	-1.92±1.49	-5.75±1.05**	-5.78±1.62**	-1.96±0.90	-4.42±0.61**	.

** = p < .01, *= p < .05, others not significant

Table 5.8: Ranks of plant species in the diet of Satyr Tragopan during the Pre-monsoon season

	Ferns	*P.scripta*	*P.annuae*	*Primula* sp	*T.pallidus*	*V.jatamansi*	*V.nummularia*	Others	Ranks
Ferns	.	+++	+++	++	++	+++	++	+++	7
P.scripta	---	.	+++	+	-	+++	-	+++	3
P.annuae	---	---	.	---	--	-	--	+	1
Primula sp	--	+	+++	.	+	+++	-	+++	5
T.pallidus	--	+	++	-	.	+++	-	+++	4
V.jatamansi	---	---	+	---	---	.	---	+	2
V.nummularia	--	+	++	+	+	+++	.	+++	6
Others	---	---	-	---	---	-	---	.	0

+++/- - - = p <. 01, ++/- - = p< .05, +/- = not significant.

5.3.3.2: Monsoon: In the monsoon season the major food items were *Arundinaria maling, Pilea scripta, Theropogon pallidus* and grit comprising 68 % of the total food composition. The minor food items comprised 28 % and were represented by *Arisaemia griffithii, Primula* sp., *Poa annuae, Plantago* sp., "simjhar", *Valeriana jatamansi, Vaccinium nummularia* and fern. Trace items comprised 4 % and ~~was~~ were represented by *Cotoneaster microphyllus, Erigeron* sp., *Hemiphragma* sp., *Polygonum molley, Saxifraga nutans, Senecio* sp., moss and insects (Fig 5.4). Invertebrates formed only 0.31% of the food composition during this season and were represented by spiders and annelids (Table 5.9).

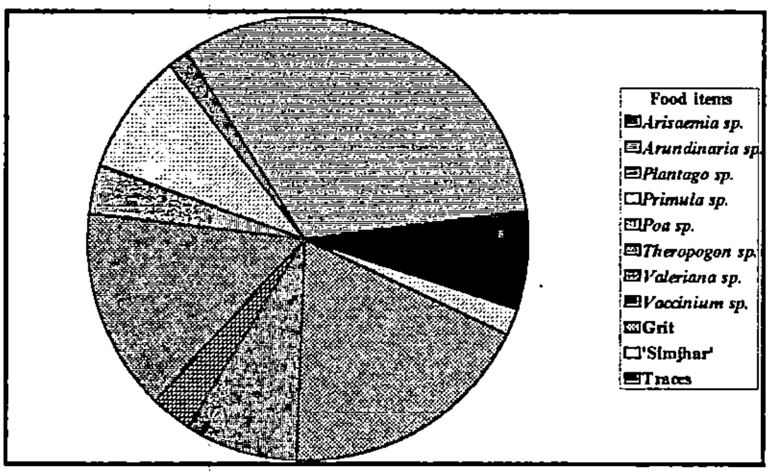


Fig. 5.4 Percent composition of food items in the diet of Satyr Tragopan. (Monsoon season)

Table 5.9: Invertebrate structures identified from the faecal droppings of Satyr Tragopan in the monsoon season.

CLASS	ORDER/FAMILY	STRUCTURE	NUMBER
Arachnida	Opiliones (harvestman)	fang	1
Annelida	-----		3

Table 5.10 : Mean logratio differences (±1) between utilisation and availability of ground cover species identified in the diet of the Satyr Tragopan in SNP (Monsoon season)

	Ferns	*P.scripta*	*P.annuae*	*Primula* sp	*T.pallidus*	*V.jatamansi*	*V.nummularia*	Others
Ferns	.	+0.51±1.51	+4.97±2.24	+0.02±1.65	-1.09±0.58	+2.32±2.14	+1.17±0.94	+-4.32±1.85*
P.scripta	-0.51±1.51	.	+4.70±1.22**	+-0.23±0.67	-1.82±1.57	+3.28±1.17*	+0.48±1.81	+5.47±1.18**
P.annuae	-4.97±2.24	-4.70±1.22**	.	-6.39±1.22**	-6.47±1.94**	-0.96±1.07	-4.36±2.09	+0.83±1.67
Primula sp	-.02±1.65	-0.23±0.67	+6.39±1.22**	.	-0.43±1.77	+4.30±1.08**	+1.01±1.95	+5.96±1.01**
T.pallidus	+1.09±0.58	+1.82±1.57	+6.47±1.94**	+0.43±1.77	.	+5.30±1.68*	+2.051±0.98	+7.02±1.14**
V.jatamansi	-2.32±2.14	-3.28±1.17*	+0.96±1.07	-4.30±1.08**	-5.30±1.68*	.	-1.02±1.99	+1.92±1.03
V.nummularia	-1.17±0.94	-0.48±1.81	+4.36±2.09	-1.01±1.95	-2.051±0.98	+1.02±1.99	.	+4.89±1.45**
Others	-4.32±1.85*	-5.47±1.18**	-0.83±1.67	-5.96±1.01**	-7.02±1.14**	-1.92±1.03	-4.89±1.45**	.

** = p < .01, * = p < .05, rest not significant.

Table 5.11: Ranks of plant species in the diet of Satyr Tragopan during the Post-monsoon season

	Ferns	*P.scripta*	*P.annuae*	*Primula* sp	*T.pallidus*	*V.jatamansi*	*V.nummularia*	Others	Rank
Ferns	.	+	+	+	-	+	+	++	6
P.scripta	-	.	+++	+	-	++	+	+++	5
P.annuae	-	---	.	---	---	-	-	+	1
Primula sp	-	-	++	.	-	+++	+	+++	4
T.pallidus	+	+	+++	+	.	++	+	+++	7
V.jatamansi	-	--	+	---	--	.	-	+	2
V.nummularia	-	-	+	-	-	+	.	+++	3
Others	--	---	-	---	---	-	---	.	0

+++/- - - = p <.01, ++/- - = p< .05, +/- = not significant.

The mean difference in availability-utilisation logratios during this season was $\lambda = .0237$, $p = .092$ (ns) indicating more of a random use of ground cover species. *Theropogon pallidus* and ferns were the most highly preferred items in proportion to others. *Pilea scripta, Primula* sp. were next in preference while *Vaccinium nummularia, Valeriana jatamansi, Poa annuae* and others were significantly avoided (Table 5.10 and 5.11).

5.3.3.3: Post-monsoon: In this season *Arundinanaria maling, Pilea scripta*, moss and grit made up the major food items which comprised 59% of the food composition. The minor food items consisted of *Erigeron* sp., *Primula* sp., *Poa annuae, Polygonum molley, Plantago* sp., *Theropogon pallidus, Valeriana jatamansi, Vaccinium nummularia*, fern and insects that comprised 36% of the food items. The trace items made up 4.5% of composition of food items and were represented by *Arisaemia griffithii, Cotoneaster microphyllus, Hemiphragma* sp., *Impatiens sulcata, Saxifraga nutans, Stachys sericea,* "simjhar", *Thalictrum virgatum* (Fig 5.5).

The invertebrates comprised 6.82% of the diet during the season which was the highest amongst all the seasons and were represented by a larger number of families (Table 5.12)

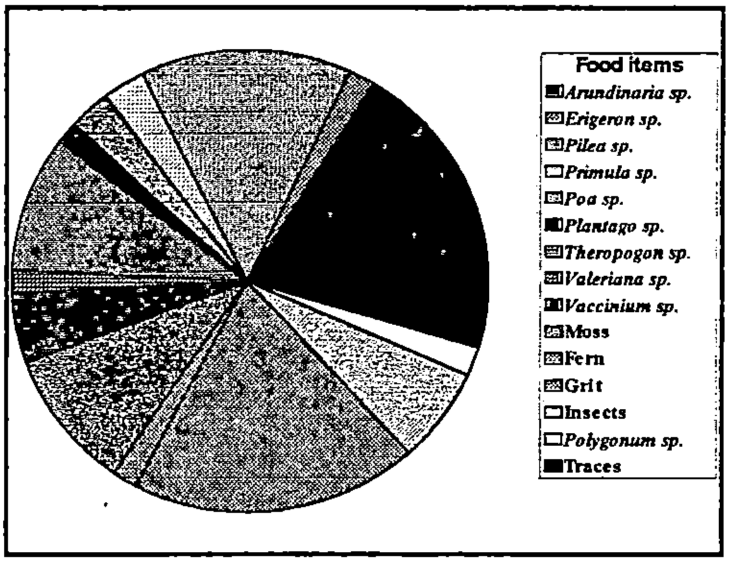


Fig.5.5: Percent composition of food items of Satyr Tragopan (Post-monsoon season)

Table 5..12: Invertebrate structures identified from the faecal droppings of Satyr Tragopan in the post-monsoon season.

CLASS	ORDER/FAMILY	STRUCTURE	NUMBER
Arachnida	Araneae	pedipalp	2
	Araneae	legs	20
	Opiliones	fang	2
Insecta	Hemiptera-Homoptera Cicadellidae	hind tibia	1
	Hemiptera--Homoptera Aphidae	tibia	3
	Hemiptera-Neuroptera	mandibles	1
	Diptera-Tipulidae	leg	1
	Coleoptera-Carabidae	mandibles	1
	Hymenoptera-Ichneumonidae	leg	1
Annelida			2

There was a significant difference in availability -utilisation ratios during this season (λ = .010, p = .039, MANOVA) indicating non-random use of the ground cover species available to the Satyr Tragopan in its habitat. *Theropogon pallidus* was the most preferred species after which *Vaccinium nummularia, Pilea scripta,*

Table 5.13: Mean logratio differences (±1) between utilisation and availability of ground cover species identified in the diet of the Satyr Tragopan in SNP (Post-monsoon season)

	Ferns	*P.scripta*	*P.annuae*	*Primula* sp	*T.pallidus*	*V.jatamansi*	*V.nummularia*	Others
Ferns	.	-1.32±1	+3.44±.11**	-2.21±0.81*	-3.05±1.59	+0.343±0.917	+2.821±1.41	+1.82±1.5485
P.scripta	+1.32±1	.	+4.56±1.02**	+0.11±1.78	-3.11±1.28**	+2.19±1.09	+0.92±1.41	+3.61±1.78
P.annuae	-3.44±.11**	-4.56±1.02**	.	-4.85±1.27**	-7.98±1.22**	-2.70±1.10*	-6.378±1.44**	-1.96±1.69
***Primula* sp**	+2.21±0.81*	-0.11±1.78	+4.85±1.27**	.	-1.82±0.98	+2.00±0.86*	-1.18±0.92	+3.75±1.01**
T.pallidus	+3.05±1.59	+3.11±1.28	+7.98±1.22**	+1.82±0.98	.	+4.80±1.05**	+1.371±0.94	+5.88±1.37**
V.jatamansi	-0.343±0.917	-2.19±1.09	+2.70±1.10*	-2.00±0.86*	-4.80±1.05**	.	-2.82±1.365	+1.41±1.51
V.nummularia	+2.821±1.41	-0.92±1.41	+6.38±1.44**	+1.18±0.92	-1.371±0.94	+2.82±1.365	.	+4.47±1.13**
Others	-1.82±1.5485	-3.61±1.78	+1.96±1.69	-3.75±1.01**	-5.88±1.37**	-1.41±1.51	-4.47±1.13**	.

** = p < .01, * = p< .05, rest not significant

Table 5.14: Ranks of plant species in the diet of Satyr Tragopan during the Post-monsoon season

	Ferns	*P.scripta*	*P.annuae*	*Primula* sp	*T.pallidus*	*V.jatamansi*	*V.nummularia*	Others	Ranks
Ferns	.	-	+++	--	-	+	-	+	3
P.scripta	+	.	+++	+	--	+	-	+	5
P.annuae	---	---	.	---	---	--	--	-	0
Primula sp	++	-	+++	.	-	++	-	+++	4
T.pallidus	+	++	+++	+	.	+++	+	+++	7
V.jatamansi	-	-	++	--	---	.	-	+	2
V.nummularia	+	+	++	+	-	+	.	+++	6
Others	-	-	+	---	---	-	---	.	1

+++/- - - = p <.01, ++/- - = p< .05, +/- = not significant.

and Primula sp. were the next batch of preferred species. Ferns, *Valeriana jatamansi,* Others and *Poa annuae* were significantly avoided (Table 5.13 and 5.14)

Winter: The major food items in winter were *Arundinaria maling, Pilea scripta, Theropogon pallidus* and grit or quartz fragments, which comprised 70% of the total composition. The minor food items were represented by *Arisaemia griffithii, Erigeron* sp., *Primula* sp, *Polygonum molley, Stachys sericea,* "simjhar", *Valeriana jatamansi, Vaccinium nummularia,* fern and moss that together comprised 28% of food composition. *Cotoneaster microphyllus, Saxifraga nutans* and insects made up the trace items and they comprised 2% of the food composition identified (Fig. 5.6).

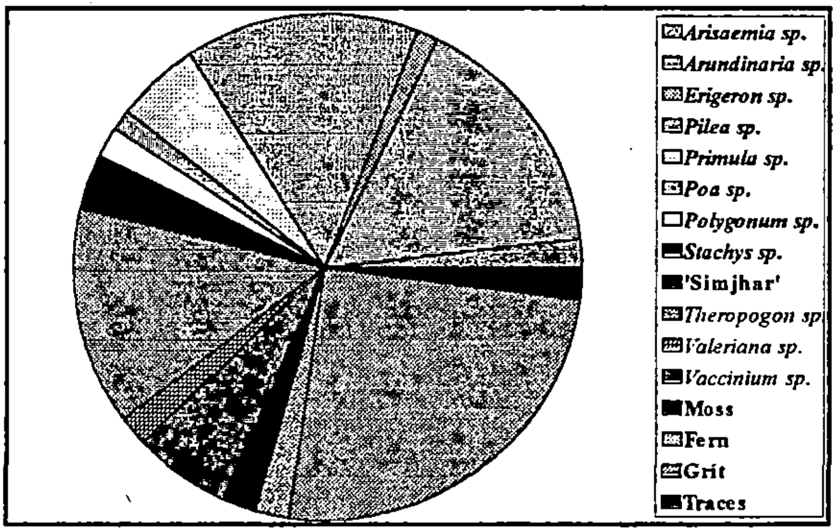


Fig. 5.6: Percent composition of food items of Satyr Tragopan. (Winter season)

Invertebrates alone comprised 0.66% of composition of the Satyr Tragopan's winter diet and was formed of spiders and annelids (Table 5.15).

Table 5.16 : Mean logratio differences (±1) between utilisation and availability of ground cover species identified in the diet of the Satyr Tragopan in SNP (winter season)

	Ferns	*P.scripta*	*Primula* sp	*T.pallidus*	*V.jatamansi*	*V.nummularia*	Others
Ferns	.	-2.26±1.18	-1.58±1.99	-4.53±1.52*	-2.25±1.528	-3.75±1.38*	+0.27±1.36
P.scripta	+2.26±1.18	.	-3.59±1.43*	-3.42±0.77**	-0.51±1.34	+2.13±0.86*	+2.80±0.86**
Primula sp	+1.58±1.99	+3.59±1.43*	.	-2.00±1.17	+3.31±0.90**	-3.891±1.46	+2.67±1.32
T.pallidus	+4.53±1.52*	+3.42±0.77**	+2.00±1.17	.	+2.50±0.95*	+2.13±0.27**	+3.70±0.80**
V.jatamansi	+2.25±1.528	+0.51±1.34	-3.31±0.90**	-2.50±0.95*	.	-1.60±1.15	+0.88±1.53
V.nummularia	+3.75±1.38*	-2.13±0.86*	+3.891±1.46	-2.13±0.27**	+1.60±1.15	.	+4.08±0.79**
Others	-0.27±1.36	-2.80±0.86**	-2.67±1.32	-3.70±0.80**	-0.88±1.53	-4.08±0.79**	.

$** = p < .01$, $* = p < .05$, rest not significant

Table 5.17: Ranks of plant species in the diet of Satyr Tragopan during the winter season

	Ferns	*P.scripta*	*Primula* sp	*T.pallidus*	*V.jatamansi*	*V.nummularia*	Others	Rank
Ferns	.	-	-	--	--	--	+	1
P.scripta	+	.	--	---	-	--	+++	2
Primula sp	+	++	.	-	+++	-	+	4
T.pallidus	++	+++	+	.	++	+++	+++	6
V.jatamansi	+	+	---	--	.	-	+	3
V.nummularia	++	++	+	---	+	.	+++	5
Others	-	---	-	---	-	---	.	0

+++/- - - = p <.01, ++/- - = p< .05, +/- = not significant.

Table 5.15: Invertebrate structures identified from the faecal droppings of Satyr Tragopan in the winter season.

CLASS	ORDER/FAMILY	STRUCTURE	NUMBER
Arachnida	Araneae	fang	2
	Myriopod	leg	3
Annelida	--	--	4

During winter there was a significant difference between availability- utilisation of the ground cover diet of Satyr Tragopan (λ = .032, p = .029). *Theropogon pallidus* ranked as the most preferred among the species. *Primula* sp. and *Vaccinium nummularia* were the other preferred food plants while *Valeriana jatamansi*, ferns and others were avoided (Table 5.16 and 5.17).

5.4. Discussion

Despite the constraints of techniques, which prevented detailed quantitative work on the diet of the Satyr Tragopan, the results of this study are vital in determining the diet of the species and the relative abundance of different food items in the diet during different seasons. According to Stewart (1967) the possibility of identifying all the species eaten in the faeces of herbivores is inconclusive. Martin (1954) was able to identify only 16 out of the 40 species of plants suspected to be ingested by sheep (*Ovis aries*) from faecal and stomach content analysis. Similarly Croker (1959) could not identify in sheep faeces 1 out of every 25 species of grass in a pasture. Likewise in the present studies on the diet of Satyr Tragopan there may have been a number of plant and invertebrate species present in the study area that were not recorded from faecal analysis. All these observations can have three implications:

(i) Many of the plant and invertebrate species consumed by the Satyr may have undergone complete digestion or may have been reduced to such small fragments that they were not identifiable. This is possible in the case of soft-bodied plant and animal parts. In ~~case of~~ the present study, th~~is~~ese types of plant species (ephemeral) formed either the trace food items or ~~was~~ were inconsistent in their appearance in the droppings and compositional analysis showed that they had low ranks in all the seasons of the year. The bulk of the diet in the Satyr Tragopan consisted of hard bodied or fibrous perennials and *Arundinaria maling* which have been identified as top ranking food plants in the study by compositional analysis and by food importance indices in the case of *Arundinaria maling* and have appeared predominantly as expected in the droppings. Most of the soft bodied herbs were annual species and thus their availability was restricted to certain seasons of the year. However these species cannot be ranked as less important.

(ii) The bird might not have eaten the unrecorded species recently enough for fragments to be represented in the faeces. If the unrecorded species formed an important part of the diet of the species they would be expected to be consistently present in the diet of the species and thus in the droppings. All the high ranking food plants in the diet of the Satyr Tragopan have appeared consistently across all the seasons therefore the unrecorded species may have been eaten inconsistently and cannot rank as an important of the diet of the species.

(iii) The unrecorded species may not have been eaten in sufficient amount for traces to appear in the faecal droppings. If the unrecorded species formed a major part of the diet of the Satyr Tragopan they are expected to be eaten in sufficient amount to be represented in the faecal droppings of the species. Some of the food items may have appeared as trace items in the diet of the satyr Tragopan but these may be important to the animals in various ways.

Therefore the food items identified from the faecal droppings of the Satyr Tragopan reflect the general if not exclusive diet of the species in the wild.
The food important indices allotted gives a general importance gradient for each food item recorded in the diet of the Satyr Tragopan through different seasons of the year.

Studies on the diet of Satyr Tragopan in the Singhalila National Park by faecal analyses revealed that vegetable matter formed the bulk of the diet in all the four seasons indicative of the primarily herbivorous habit of the species. The results of my studies thus corroborated the findings of other workers (Table 5.18) about the diet of the Satyr Tragopan in other areas of its distribution.

Arundinaria maling was the most dominant plant species identified from the faecal droppings of the Satyr in all the seasons of the year. As an understorey cover the spread of this bamboo species is quite extensive throughout the National Park and being a perennial plant which dies after flowering its leaves were available throughout the year in abundance as revealed by its phenophases. The fragments of the species could be identified even macroscopically from the droppings. This is probably because like all bamboos, *Arundinaria maling* has a very high content of indigestible fibre and is loaded with abrasive siliceous compounds which are difficult to eat and digest (Roberts 1992). The undigested parts are excreted out from the gastrointestinal tract of the Satyr in a highly identifiable form.

Table 5.18: Food items of Satyr Tragopan derived from various observations.

Sites	Food items	Reference
unknown	leaves and flowers of paper laurel, rhododendron petals, earwigs, ants cockroach, spiders and centipede.	Beebe (1918-1922)
Sikkim	leaves and fern materials of *Diplazium* sp. and *Polypodium* sp.	Meinertzhagen (1926)
--------	insects, bamboo shoots, onion like bulbs	Hume and Marshall (1879-1888)
---------	wild fruits, aromatic leaves, bastard cinnamon and *Daphne* sp	Hodgson (in Hume and Marshall 1879-1888)
Central Nepal	fruits of *Berberis* sp., *Symplocos* sp., *Rhododendron* sp.; leaf, moss, grass, roots, buds and insects.	Lelliott and Yonzon (1979)
Central Nepal	moss, lichen, leaves, grass, roots, buds and few insects	Yonzon (1981)
Central Nepal	moss, grass, leaves and insects	Bhandary *et al.* (1986)

In Pipar *Arundinaria* sp. along with other species of plants like *Meconopsis* sp., *Potentilla* sp. and *Fragaria* sp. formed the second group of important food items in the autumn diet of pheasants, which included the Satyr Tragopan (Bhandary *et al.* 1986). *Fragaria* sp. and *Potentilla* sp. which were found as one of the main ground cover species of the Satyr Tragopan habitat in Singhalila National Park were not observed in the diet (droppings) of the species. Ground cover species, which formed the major food items of the Satyr after bamboo, were all perennial and thus there appeared to be no dearth in the availability of food items in any of the seasons of the year. Annuals like *Poa annuae* and ferns were also listed among the major food items in my studies but their absence in certain seasons would not perhaps affect the Satyr, as the perennials, which formed the major diet items, were always available thus ensuring food to the species. Another very significant component found in the diet of the Satyr Tragopan were grit or quartz fragments. According to Greely (1962) the major source of calcium and magnesium in the diet of birds like pheasants is grit and levels of 1.09% of calcium in the diet was necessary for full egg production by hen pheasants. Kopischke and Nelson (1966) in their studies in Minnesota and South Dakota observed that laying hens consumed about 50 percent more grit by weight than non-laying hens and they could selectively pick calcium and magnesium bearing grit. Besides, the action of grit in a bird's gizzard grinds the food into a digestible paste. *Grit is important if grass forms an important part of the* diet (Howman 1993). The presence of grit or quartz fragments in such high percent composition in the diet of the Satyr Tragopan in all seasons may be attributed to the fact that being mainly vegetarians these fragments help in the grinding of the vegetative matter in the gizzard for proper digestion.

In the present studies invertebrates and small arthropod components formed a minor and seasonal portion in the diet of the Satyr Tragopan. It is however known from studies in Britain that in galliforms for good survival rates of chicks a protein rich diet is essential (Green 1984, Hill 1985) and this is largely obtained from their invertebrate intake (Moreby 1992). Being primarily herbivorous, invertebrates formed a very small component in the diet of Satyr Tragopan. Kaul (1989) observed a total lack of insect food in the adult droppings of Cheer Pheasant while in Pipar insects comprised a very small (0.1%) portion of the autumn diet of pheasant species (Bhandary *et al.* 1986). I analysed only adult droppings of Satyr Tragopan for food items and it is apparent that these did not contain a high proportion of invertebrates. However analysis of chick droppings might have revealed a much higher animal content in the diet of the species (Green 1984, Hill 1985 and Green 1986). A large portion of the soft-bodied invertebrates is digested and therefore the likelihood of their remains appearing in the droppings is remote and liable to be missed.

During all the seasons of the year major food items of the Satyr Tragopan except ferns remained the same. Only the minor and trace food items of the species changed according to their availability and the diet showed the widest variety during the monsoon and the post-monsoon season as these were the wettest seasons with abundant growth of ground cover species. Although most birds complete their entire breeding cycle during one season the timing of breeding is closely associated with food supply (Perrins and Birkhead 1983). Breeding in birds is so timed that the chicks hatch and develop at a time of maximum food availability (Lack 1968) and for this they have to forage in habitats that provide most food (Baines *et al.* 1996). Little is known about the breeding of Satyr Tragopan in the wild except this event probably occurs during May and June (Ali and Ripley 1983).

During the pre-monsoon season the ground cover species in the diet of the Satyr Tragopan were not utilised by the bird in proportion to their availability. At the onset of this season especially the early part of March, dry conditions were still prevalent and all the annual plants were dead and many of the perennials withered. Evergreen perennials like *Vaccinium nummularia, Primula* sp. and *Theropogon pallidus* thus provided an important food resource which were utilised as shown by their higher ranks and greater preference relative to the other species. Annual plants like *Poa annuae, Erigeron* sp., *Impatiens sulcata* and *Senecio* sp (others) and *Valeriana jatamansi* though present in abundance were not in their full growth forms which probably attributed to their low ranks or avoidance in the pre-monsoon diet. The high preference for ferns probably coincides with the diet of the species towards the middle or the end of the pre-monsoon season. As the phenological recordings of ferns show that ferns in various phenophases were present for the birds at this part of the season. Ferns were known to be eaten by the Satyr Tragopan (Meinertzhagen 1926).

In the monsoon season extremely wet conditions prevailed in the study area. The major food items did not change much and instead 6 more secondary and trace food items were identified in the droppings of the species probably indicating a greater variety of food consumed during the season. All the important ground cover food items were utilised more or less as expected relative to their availability. Ferns and *Theropogon pallidus* were still highly ranked in the diet with *Pilea scripta* as the next important species instead of *V. nummularia* as in pre-monsoon. Perennial herbs seemed to once again form an important part of the diet of the species even during this season though many other species were available. However there was no overall difference in their utilisation and availability reflecting the absence of a real preference or avoidance of any particular group of plant species.

The largest number of food items was identified from the post-monsoon faecal droppings. This is perhaps because there was an increase in the availability of both plant and animal food resources. The phenological data for all these species revealed that all plants were in their full growth forms and phenophases but there was a non-random pattern of use of ground cover species by the Satyr Tragopan. The bird showed marked preferences for species like *Theropogon pallidus, Vaccinium nummularia, Primula* sp. and *Pilea scripta* during this season. There was an increase in the percent composition of invertebrates in the droppings. This may be attributed to the increase in invertebrate biomass during the wet seasons (Kaul 1989). The food items during the post-monsoon appeared to be more and such trends have also been reported from Nepal (Yonzon 1981, Bhandary *et al.* 1986).

In winter there was a marked increase in the percent composition of perennial plants because most of the ephemeral species were either in a dormant stage or dead, especially by midwinter. Invertebrates were found as trace items only. Though there was less diversity in the winter diet, the differential use in the ground cover species was significant. As expected the evergreen perennial plants were the most important components of the diet of the Satyr Tragopan while annuals like ferns, others and *Poa annuae* were either avoided or totally absent from the study area in that particular season..

Faecal analyses is one of the best and most widely used techniques for diet determination especially in a threatened species like the Satyr Tragopan because of its non invasive character. However some inherent problems, which I experienced with the technique, were:

1. Though faecal droppings are considered to be easily collected and stored (Fitzgerald and Waddington 1979) the situation was quite different in Singhalila National Park for birds like the Satyr Tragopan. Droppings could be collected fairly easily in the pre-monsoon and the winter season but during the wet seasons the collection of these samples reduced drastically. Likewise it was quite easy to preserve and store the samples collected during the drier months by simply air drying whereas during the wet seasons the samples were very prone to fungal growth rendering them useless.

2. Preparation of reference slides of different parts of plants in areas having a very large number of species can be very tedious.

3. Many of the soft- bodied annuals and ephemerals may undergo complete digestion or are reduced to such small fragments that they are not recognisable at the microscopic level and hence are not recorded.

4. On the other hand those plant species which are high in indigestible fibre content will tend to occur constantly during observation and will be over represented in the diet of the species.

5. Many of the soft bodies and easily digested groups like Collembola, Dipterans, larvae and nymphs of certain groups may escape records and may be not be represented in the samples. Meanwhile species with indigestible parts (spiders, bugs, beetles etc) may be over represented amongst the invertebrate food items.

6. The quantitative estimation of the diet is quite difficult because the proportion in which the various items represented in the diet may or may not be similar to the proportions in which they were eaten. This is because the digestive processes in the animal's body and the processes of preparing the sample for observation may alter the proportions.

7. Analysis through faecal droppings requires knowledge and expertise, which takes a long time to acquire.

Many of the authors have used crop and stomach draining or dissection methods (Davison 1940, Beck 1952, Kopischke and Nelson 1966, Prys-Jones 1974, Allen 1980, Dahlgren 1982) and feeding trials (Stewart 1966, Fitzgerald and Waddington 1979 and Holchek and Valdez 1985), for differential digestion indices in their dietary studies. None of these methods were practicable in my field conditions and therefore I chose to do dietary studies by faecal analysis. In spite of its many difficulties this method was simpler and less time consuming. If reference slides for the plant species of the study area can be prepared then fairly good results can be obtained about the plant species ingested by the species. If the frequency data are treated to some proportions then other extrapolations and analyses can be carried out.

8. Conclusions:

Like all its other congeneric species the Satyr Tragopan was found to be primarily a vegetarian/herbivore in its food habits although animal matter in the form of invertebrates also formed a minor and seasonal part of its diet. The major food items of the species comprised of perennial herb species and their percent composition in the diet was consistent throughout the year, while the percent composition of some of the minor and trace food items fluctuated. As expected, during the two wettest seasons of the year i.e. monsoon and the post-monsoon, there was an increase in the number of plant food items and invertebrates ingested by the Satyr Tragopan. Most of the food items especially the perennial ones were available throughout the year and perhaps accordingly the bird chose its diet. *Arundinaria maling* was found to be the most important component in terms of its percent composition and occurrence in the droppings through all the seasons. In all the seasons except monsoon there was non-random use of the available major ground cover species. Lack of appropriate methodology and detailed quantitative estimation compounded by practical problems made it difficult to identify the exact diet of the species as well as the importance of each food item comprising the diet of the species. Therefore the results that I have obtained represent the general diet of the species in the Singhalila National Park and the food importance indices give an indication of the importance of various food items in the diet of the species. The present studies also clearly reveal that the Satyr Tragopan specialise in vegetative matter and is not an exclusive feeder on any one or two species but the diet of the species depends on whatever is available to the bird in its habitat. Since more accurate but highly invasive methods like crop and stomach draining are not practicable on such threatened species, studies through feeding trials would perhaps be one of the ways for more detailed quantitative estimation of the diet of the Satyr Tragopan.

CHAPTER 6

CALLING BEHAVIOUR AND SOCIAL ORGANISATION

A. Calling behaviour

6A.1. Introduction

Vertebrates use a variety of signals to pass on information about status, alarm, food, breeding, territories etc to other individuals of their species. Plumage patterns, calls and songs in birds and scent marking and calls in mammals are some of the important channels of communication. Among acoustic signals in birds less attention has been paid to bird calls (Guttinger and Nikolai 1973, Thielcke 1976, Baker and Bailey 1987, Baptista 1990) although, some work has been done on bird song (Morse 1970, Emlen 1971, Lein 1971, Catchpole 1973, Krodosoma 1976, Mace 1986, Moller 1988, Birkhead and Moller 1992, Welling *et al.* 1995, Mountjoy and Lemon 1996).

Calls appear to be the usual form of communication in galliformes in addition to displays. A wide range of calls may be used for communicating in different situations. Some of the vocalisations that are known and have been described are advertisement calls, alarm calls, display calls and contentment calls. Among pheasants, vocalisations of the Common pheasant, *Phasianus colchicus* (Heinz and Gysel 1970), Red Jungle Fowl, *Gallus gallus* (Collias and Collias1967), Cheer, *Catreus wallichii* (Young *et al.* 1987), Malaysian Peacock Pheasant, *Polyplectron malacense* (McGowan 1992) and the *Tragopan* pheasants (Islam and Crawford 1996) have received some attention. Vocalisations of most pheasant species are poorly known. An advertisement call is loud and can be heard over a large distance and is variously referred to as territorial calls, crowing and female attraction calls (Gaston 1980, Lelliott and Yonzon 1981, Johnsgard 1986, Islam and Crawford 1997).

Satyr Tragopan are highly territorial birds (Johnsgard 1986) and during their pre-breeding period in spring, the males give out loud calls especially in the morning and form part of the dawn chorus. Besides the advertisement call three other calls are known to be emitted by the species (Lelliott and Yonzon 1981, Islam and Crawford 1997). According to Beebe (1918-1922) the birds are silent during winter unless the hen communicates with the nearly grown up young by low clucking calls. In case of sudden flight or distress, both the male and the female give a series of loud raucous notes. Beebe (1918-1922) described the call note of the Satyr Tragopan males to be distinct from its alarm call as the former call was a high quavering sound, which could be heard over long distances. The hen was reported to have comparable calls, which were higher and shriller, uttered when separated from the nearly grown young. Wayre (1969) stated that the call of the male consisted of 12 –14 notes which gradually rose in volume until it became almost a shriek and the whole sequence lasted for 20-25 seconds. Jerdon (1935) described the wailing call of the Satyr as a deep bellowing sound while according to Hume (1879) it was a loud bleating cry chiefly heard in spring. Lelliott (1981b) distinguished four types of calls, which he considered to be an incomplete description of the species vocalisations.

1. The first call was a repeated monosyllabic note reportedly uttered by both the sexes at any time of the day during spring and autumn. The functions of these calls were probably courtship and possibly male to male aggression.
2. The second call was the less audible alarm call uttered by both the sexes when alarmed by humans and other animals. This call was commonly uttered during flushing.
3. The third call recognised was the short monosyllabic 'bleat' note similar to the bleat of sheep and goats, which preceded wailing. The call was heard only during the breeding season suggesting that it functioned in pair formation or courtship.
4. The fourth call recognised by Lelliott (1981b) was the drawn out mammal like call made by the male only and consisted of repeated series of notes ranging up to 33 seconds in length. Calling was greatest at dawn and the initiation was closely related to the time of sunrise. Lelliott (1981b) was uncertain about the function of this call but thought that it might be related to territorial advertisement.

Islam and Crawford (1996) in their work on Tragopan vocalisations described and acoustically analysed four types of calls of Satyr Tragopan.

1. Wing whir call: A single note performed on the ground or a perch and associated with a wing whir.
2. Alarm call: Emitted by both the sexes when the birds were disturbed and consisted of several single notes that were repeated *ad nauseum* in quick succession.
3. Advertisement call: Emitted by male birds while perched.

4. Metallic clicking sounds: Produced during frontal display and were audible as a single click metallic sound.

During my studies on the Satyr Tragopan in the Singhalila National Park I found that the most distinct/prominent call of this species was the wailing (Lelliott 1981b) or advertisement call (Islam and Crawford 1996). The alarm calls were recorded every time the birds were flushed and were quite difficult to quantify systematically as they had no regularity of occurrence over any specific time period/season.

Other less pronounced calls were not audible. In this chapter I have discussed the calling behaviour of the Satyr Tragopan with reference to its advertisement call which formed a distinct chorus during the breeding season. The ~~F~~ollowing were the aims and objectives of my studies on the calling behaviour of the Satyr Tragopan.

1. To study the general pattern of dawn calling in the Satyr Tragopan.
2. To assign probable functions to calls.

6A. 2. Methodology

Call counts as described in Chapter 3 were conducted to collect data for studies on calling behaviour. A total of 27 mornings of sampling in 1995 and 18 each in 1996 and 1997 were spent to collect data on calling. The whole exercise was mainly spread over the months of April and May in 1996 and 1997 although June was also included in 1995. Calling was mainly monitored between 0430h – 0600hrs.

6A.2.1 Analyses: The entire dawn chorus comprised of several bouts/sequence of calling and each sequence/bout consisted of several calls, while each call comprised of several notes. A 'bout' or sequence was defined, as the duration in which there was more or less continuous calling and counter calling with an interval (silent period) not exceeding 15 minutes. A call was defined as the component within the calling bout/ sequence, which comprised of several continuous notes. Calling rate was defined as the number of bouts/unit time (hr) and the calling effort was defined as the number of calls/unit time (10 minutes). The calling frequency for a particular day was expressed as the percentage of the number of birds heard calling on a given day from a particular point divided by the maximum number of birds heard calling from that particular point. Duration of chorus was recorded on the basis of a bout, as there were long periods of silence between bouts, which if considered in the analyses would give spurious figures for the length of dawn chorus. Pearson and Spearman Rank Correlation Coefficient were used for all correlation analyses. Mann Whitney U tests and Wilcoxon Signed Rank tests were used to compare sets of independent and related data respectively. Parametric and Kruskal -Wallis One Way ANOVA were used for differences in more than two variables. All tests were two way unless when specified. Weather conditions were categorised into clear, clearing, cloudy, mixed clear and foggy, approaching fog and rainfall. These were ranked according to the increase in deterioration in weather conditions with clear weather having the lowest rank and rainfall the highest.

6A. 3. Results

A typical dawn chorus from an observation point would consist of calls and counter calls of birds from all directions at various distances around that observation point.

6A.3.1 Calling period: I conducted some dawn call counts in March on a trial basis and found that calling was very sporadic and the chorus was not well

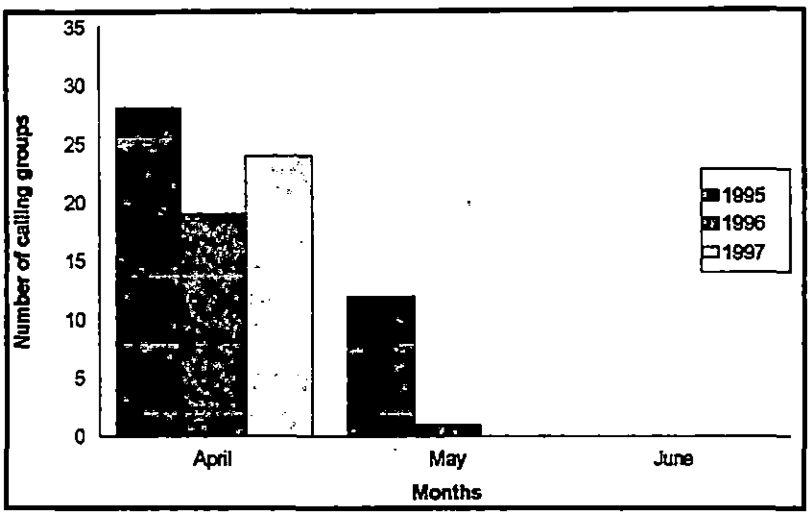


Fig 6.1: Number of calling groups of Satyr Tragopan during the breeding season

established until early April. I also eliminated data collected in June from my analyses because I never heard Satyr Tragopan calls during this month.

In all the three years of observations maximum groups of calling birds for all the years were recorded in April (28,19,24). Chorusing declined through May (12,1,0) and there was no chorus by the end of May or beginning of June

(Fig. 6.1). The calling frequency varied from 33% to 88% mornings. This indicated that in very few cases do birds call every morning even in April when calling was maximum. April was the most vocal month both in 1995 and 1996 ($U = 2.69$, $p = .0071$; $U = 3.38$, $p = .0007$, Mann Whitney U test) while there were no records of calling birds in May 1997.

6A.3.2 Duration of chorus: The mean duration of chorus was 20.7 minutes (± 1.27, n =129) over all the trails. The mean length of chorus in April was 20.9 minutes (± 1.38, n = 114) and in May the mean length of chorus was19 minutes (±3.27, n =15). There was no significant difference between the length of chorus in the two months ($t = .482$, d.f.= 127, $p = .630$, t test). There was no significant change in the length of chorus between 15 day time periods in April and May ($F_{2,24} = .991$, $p = .374$, 1 Way ANOVA) . The length of chorus was positively correlated to the number of calling groups, ($r = .446$, $p = .000$, n = 129) indicating that the activity of calling and counter calling increased with the increase in the number of calling males (Fig. 6.2)

6A.3.3 Bouts: The mean number of bouts across all the trails was 1.40 (± .05, n=159) which indicated that the dawn chorus usually comprised of one main bout through which functions of either attraction of mates or territory defence or both were accomplished. After this the calls became sporadic and there was no pronounced chorus. This pattern of chorusing with one main bout was

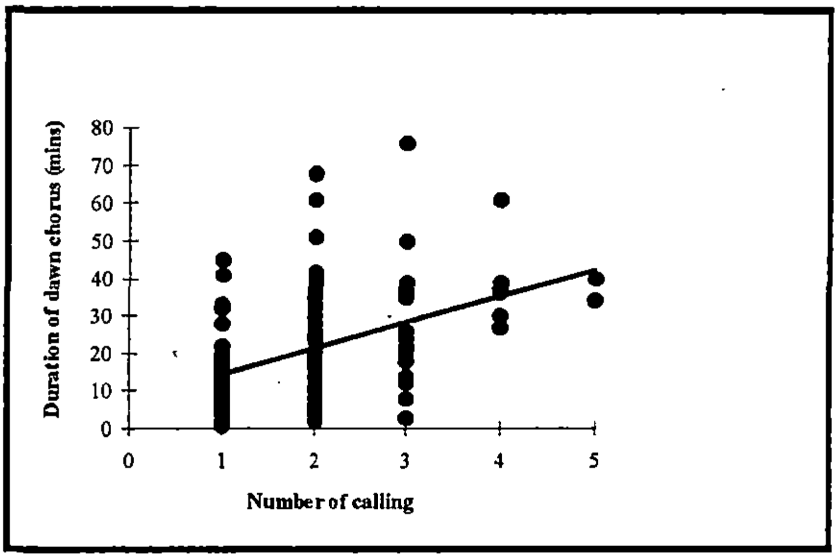


Fig 6.2: Relationship between the length of dawn chorus and the number of calling groups of Satyr Tragopan

uniform over all the trails ($F_{2,155}$ = 2.389, p = .0956 n.s. 1 Way ANOVA) and in both the calling months (Z = - .9019, p =.2671 n.s., Wilcoxin Signed Rank Test). The bouts of calling increased with increase in the number of calling groups across the trails (r = .2443, p = .002, n = 159, Pearson Correlation Coefficient) indicating the increase of calling activity in the presence of rival males.

6A.3.4. Calling effort and calling rates: The mean calling effort across all the trails was 4.05 (± 0.32, n = 129) and this was higher at the end of the calling period (April = 3.70, ± 0.23, n = 115; May = 6.77.42, ± 2.26, n = 14). The mean calling effort of the Satyr Tragopan differed significantly between April and May (t = -2.927, df = 127, p = .004). The mean calling rate of Satyr Tragopan was 6.63 bouts/hr (±. 0.61, n = 129) and the calling rate decreased in May when the duration of chorus was shorter and lesser number of birds were calling (April = 6.76, ±

0.674, n = 115; May = 5.69, ± 1.011 n = 15). There was no heterogeneity in the calling rate of Satyr Tragopan across the three trails (t= .555, df = 127, p = .580, t test).

6A.3.5 Calls according to sunrise: The Satyr Tragopan were early callers and in all the trails the dawn chorus was initiated any time between 3-52 minutes before sunrise while the maximum number of calls were heard 30-40 minutes before sunrise. The initiation of chorus was negatively correlated to the intensity of light/adverse weather conditions ($r_s = -.273$, $p < 0.001$ $\cancel{\leq .000}$, n = 226, Spearman Correlation Coefficient). Here the intensity of light was categorised by the weather conditions. A foggy and cloudy condition depicted conditions of low light intensity which resulted in a late initiation of dawn chorus, while initiation of chorus was early in clear conditions due to the good light conditions. Thus the results indicate that weather conditions affect initiation of dawn chorus in Satyr Tragopan. A mean of 13.75 calls (± 1.97, n = 32) were heard before sunrise as compared to 3.03 calls (± 0.63, n =32) after sunrise. There was significant difference in the number of calls heard before sunrise and after sunrise in April (U = -3.9624, p= .001, n= 21 Mann Whitney U Test) and May (U = -.26502, p = .0080, n = 11 Mann Whitney U test) implying that the actual chorusing was completed before sunrise. The maximum number of calling groups was recorded in the 0445 - 0500 hrs time period (Fig 6.3). After this there was a decline in the number of calling groups and no calls were heard after 0600 hrs probably implying that the birds begin calling from their roosts or close to it before they move out for their other activities.

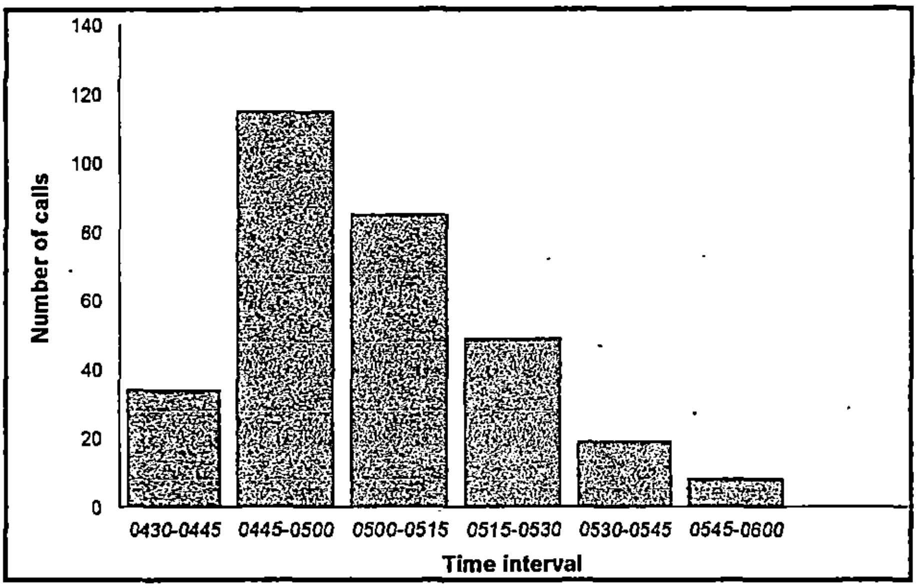


Fig. 6.3: Number of calls heard at different time periods in the morning
in 1995, 1996, 1997.

6A.3.6 Effect of weather conditions: Calling groups were negatively correlated with adverse weather conditions ($r = -.306$, $p = .001$, $n = 225$, Pearson correlation coefficient) and wind conditions ($r = -.134$, $p = 0.044$, $n = 225$, Pearson correlation coefficient).

6A.4. Discussion

The dawn chorus is a well-known phenomenon in several bird species where the males begin their vocal activity for sometime before sunrise and then stop or decrease it for the rest of the day (Hinde 1952, Morton 1975, Mace 1987b). This activity does not make sense immediately that song birds which cannot feed overnight should indulge in an energy consuming activity like dawn chorus, unless there are strong selection pressures favouring dawn advertisement activity (Horsfall 1983). The dawn chorus in passerine birds has been explained variously as a means of extra energy consumption, sperm competition and mate defence

(Mace 1987b). One characteristic feature of the advertisement call of the Satyr Tragopan was that it occurred very early in the morning and comprised a dawn chorus established before sunrise. In fact, in the study area this species was one of the first birds to break into a chorus in the morning. This is perhaps because the chances of efficient transmission of calls can change during the course of the day as many other background noise and sounds rise and fall. Kacelink and Krebs (1982) suggested that territorial Great Tits (*Parus major*) sing at dawn because that is the relatively quiet part of the day. Numerous studies have documented that wind and air turbulence increase after dawn, which produce noises that attenuate bird songs. Moller (1991) linked the higher singing activity of birds at dawn to the ability to signal to its neighbours about its defensive capabilities. Apart form this other necessary and exclusive behaviour may change with the passage of the day as in the Great Tit besides singing, the major competitive activity is feeding which is unprofitable in poor light at dawn (Kacelink and Krebs1982). According to Welling *et al.* (1997) in Willow Tits (*Parus montanus*) dawn could be the best time to sing for mate defence even if there were other functions. This is because singing would have low costs early in the morning, as once the females emerge males would spend much of their time in mate guarding. Thus early calling in territorial birds like Satyr Tragopan could be linked to efficient projection of messages over a fairly large area as well as to the unprofitability of other activities at those early hours of the day. Besides efficient transmission, song activity at dawn is linked to the fertile period of the female (Mace 1986, Cuthill and Macdonald 1990) as females are believed to be fertile early in the morning

(Birkhead and Møller 1992). These studies suggest that the dawn chorus is a part of a strategy by males for paternity assurance.

The dawn chorus of the Satyr Tragopan lasted a little over 20 minutes and comprised a single main bout. Later in the morning the chorus consisted of shorter but sporadic bouts. This first bout was probably the most important and efficient component of the species communication either for mate attraction or territorial defence or for both. The duration of chorus during the pairing might have been affected by the emergence of the female birds. If the function is mate attraction then the dawn chorus shows a relationship with the emergence of females as suggested by Welling *et al.* (1995). Their experiments showed that delay in emergence of females prolonged singing activity of Willow Tits while there was appreciable decrease in singing with the approach of females. Calling during the first bout which occurred in the first 20-25 minutes of the dawn chorus were also important indicators to assess the density of calling and therefore breeding male Satyr Tragopan around any particular point.

In Pipar (Central Nepal) most of the surveys were conducted in late April and early May (Lelliott and Yonzon 1980, Piccozzi 1987) whereas in SNP chorusing peaked in April after which there was a sharp decline and only sporadic calls were heard in the later half of May. Location of SNP at the more eastern longitudes where the monsoon sets in earlier probably contributes to a much-reduced calling period of the Satyr Tragopan. Also the calling period appears to start earlier at eastern longitudes. Such instances were observed in western Blyth's Tragopan (*Tragopan* *blythii*) in the Phwangpui National Park, Mizoram India, which is at more eastern longitudes. Here the calling period lasted even less than one month (Ghose 1997) because the rains set in even earlier in this area.

Cloud cover, relative humidity and amount of dew show no effect on crowing counts whereas extremes of temperature would perhaps show some rare effects like decline in calling or reduced audibility but counts would be severely affected by rain or snow (Kimball, 1949). On the other hand Little and Crowe (1992) found no correlation between the calling and the ambient temperature in the calling activity of Grey Wing Francolin (*Francolinus africanus*) whereas they found relative humidity to be positively correlated with the calling activity. They suggested that this might indirectly stimulate calling because of the triggering effect of precipitation on the onset of reproductive activity on South African game birds (Crow and Siegfried 1978; Berry and Crow 1985). In SNP weather conditions like thick fog and heavy rainfall affected the calling of Satyr whereas temperature, cloud cover and relative humidity appeared to have no measurable effect. Windy conditions like gales probably had more effect on the hearing capacity of the observers than calling by distorting the intensity and direction of the calls. A negative correlation was obtained between the wind speed and calling activity of Grey wing Francolin (Little and Crow 1992). Apart form weather and wind conditions acoustical signals may also be absorbed by the vegetation (Alcock 1989) and physical features like valley bottom, cliff and folds in the topography may distort the quality of sound and reduce the number of receivers they reach.

Three inferences can be drawn about the functions of dawn calls of the Satyr Tragopan:

1. Function of calls is the defence of a reproductive territory. Therefore calling should occur throughout the breeding period. Song quality was known to serve as a cue to the females of many passerines in providing information about the territory quality of the male (Moller 1983, Radesater and Jakobsson 1989). In SNP the Satyr Tragopan called in a pronounced dawn chorus during the onset of pairing and then called intermittently towards the end of the breeding season. The calls probably communicated their highly territorial conditions during the breeding season.

2. If the main function of calling is the attraction of females, then calling should occur only in the initial stages of the breeding season (Puglisi *et al.* 1997). Many studies on European birds (Catchpole 1980, Yasukawa *et al.* 1980, Searcy 1984, Gottlander 1987, Mountjoy and Lemon 1995) have shown that the female mate choice was based on male song quality (repertoire and rate). These studies imply that the song in these species served as a measure of male fitness and provided the function of attracting females during the breeding season. In the Satyr Tragopan there was an initial peak in calling during the onset of pairing. This was not confined to the initial stages of the breeding season but extended beyond, perhaps up to the nesting, laying and hatching season suggesting that the function of the calls was not exclusively mate attraction.

3. If these two functions co-exist, there should be a pronounced initial peak followed by the maintenance of a certain territorial calling activity. Studies on the calling activity of the genus *Tragopan* (Johnsgard 1986, Islam and Crawford 1996) and the results of the present studies suggest that both the functions coexist in the calling behaviour of the Satyr Tragopan.

Searcy and Anderson (1986) reviewed many studies that provided evidences that the predominant role of singing in birds was mate attraction. However studies have shown that individual birds who acquired mates tend to sing throughout the breeding season suggesting therefore that song may have further functions (eg. Greig-Smith 1982 and Moller 1988). There is very little information on the breeding season of the Satyr Tragopan in the wild but according to Johnsgard (1986) it evidently occurs during May and June or about a month after the peak of male calling. Satyr Tragopan are known to be territorial species and the males give out loud calls especially in the morning exclusively during their pairing period in spring. These observations suggest that the dawn chorus functions as a female attractant as well as a reproductive territorial defence mechanism in the species. The dawn chorus of advertisement calls probably has dual functions in the Satyr Tragopan. It serves to attract potentially receptive females or intersexual selection (Moller 1991) as well as to ward off other male competitors or territory intruders (Welling *et al.* 1997) and may have evolved in the context of female choice and male-male contest (Islam and Crawford 1996). Merila and Sorjonen (1994) observed the song of blue throats to peak before or during pairing and ceased after that, which suggested a primarily mate attraction function. Song of the same species was observed to be used also in territory defence (Goransson *et al* 1974) and since some birds sang during the egg-laying period it was suggested that the song might be used in mate retention. Similar pattern of call function can be inferred in the case of the Satyr Tragopan. The calling pattern in terms of effort and rate were uniform throughout the three trails but there were slight differences in these aspects during the two calling months as would be expected.

These observations on dawn calling of Satyr Tragopan suggest that calling does not remain confined to perform an exclusive function rather the context of calling changes over the calling period. At the beginning of the season the calls in the morning may be used for attracting female birds by advertising fitness and resources available in the territory. Once pairing has been accomplished the context of calling perhaps shifts from being primarily mate attraction to intra sexual so that the calls advertise the identity and fitness of the paired male to the unpaired ones (male-male conflict). The same calls when performed during the laying period perhaps functions as a female retention function for protecting paternity assurance.

6B. SOCIAL ORGANISATION:

6B.1 Introduction

The Satyr Tragopan is a shy solitary species (Lelliott and Yonzon 1980), and even during winter there is little evidence of gregariousness in these birds though females may be found in family parties through winter (Beebe 1918-1922). Though there are very few evidences from studies in the wild the male Satyr Tragopans are believed to remain with a single female only until egg-laying or early incubation after which the male birds may remate with a different female (Lelliott 1981b, Ridley and Hill 1987). Gaston (1980) assumed an equal sex ratio in many Himalayan pheasants including the Satyr Tragopan which were considered to be monogamous species and suggested that a total breeding population could be obtained by doubling the number of calling males. Islam and Crawford (1992) in their studies on the Western Tragopan as well as from other studies suggested a 60:40 (male:female) sex ratio in the species. The following problems were addressed while studying the social organisation of Satyr Tragopan in the Singhalila National Park.

1. The sex ratio of Satyr Tragopan in the study area.
2. The group size and composition.
3. To verify any changes in group size and composition of the species.

6B.2. Methodology

As mentioned in Chapter 2, the intensive study area comprised of 12 trails that were walked for routine monitoring to obtain evidences of the Satyr Tragopan.

Monitoring parties consisted of one to four people who recorded the date, time, locality, general vegetation, number, sex and age category (adults, juveniles, chicks) for all visual encounters with Satyr Tragopan.

6.B.2.1. Analyses: The sample sizes for the visual evidences were small and as the sampling was done in frequencies, I used non-parametric tests (Siegel, 1956) for the entire data set. Chi-square goodness of fit test was used to determine the differences in group compositions across the seasons while Mann- Whitney U test was used to determine the differences between any two independent samples. Descriptive statistics were performed on the frequencies to obtain mean values.

6B.3 Results

Fifty seven separate visual evidences of the Satyr Tragopan in the form of solitary birds, paired birds and family groups were obtained while monitoring the trails demarcated in the intensive study area. The frequency of visual evidences of males was far higher (70%) than those of females (42%) and juveniles/chicks (5%). These visual evidences comprised of 74 individuals of which males made up 54% (40), females 36.5% (27) and juveniles and chicks 9.5% (7). The high frequency of male sightings should not necessarily indicate a higher number of males in the study area. This may occur because of the difference in detectability of the male and female birds in the study area. When encountered during monitoring the birds were found to be solitary i.e. group size = 1 most of the time. The mean group size during pre-monsoon was 1.069 (± .047, n= 31), monsoon 1.64 (±.187, n = 25), post- monsoon 1.5 (± .354, n = 2) and winter. The group size across the trails were no different than those across the seasons (Table 61).

The groups encountered comprised mainly of solitary birds. I encountered more solitary males (72%) than solitary females (28%) probably indicating a highly solitary behaviour of the males except when paired with the females during the breeding season. The females on the other hand were observed in same sex paired groups, family groups or paired with males. There was a significant difference in the frequency of group composition across different seasons $\chi^2 = 19.167$ (d.f = 9, p = 0.05) for all birds i.e. all sexes combined. Chi-square test showed no difference between observed male : female ratio and the hypothetical 50 : 50 or equal ratio suggested by Gaston (1980) for the species.

Table 6.1: Showing the overall sightings and group size of Satyr Tragopan across monitoring trails in SNP.

Trails	Number of sightings	Number of individuals	Mean group size
0	4	6	1.5 (±.25)
1	3	3	1
2	18	20	1.11 (±.108)
3	3	3	1
4	9	13	1.44 (±. .228)
5	12	19	1.58 (± .275)
6	6	10	1.67 (±.192)
8	2	2	1
9	1	1	1
12	1	1	1

Sex ratios were obtained by pooling data across the four years (1994- 1997). The unweighted sex ratios for 57 instances of sightings was 60:40 or 1:1.5 (males = 40, females 27). In the pre-monsoon season this frequency was 2.2:1, monsoon 1.2:1, post-monsoon 1:2 and winter 1:1. These figures may not, however predict the accurate sex ratio of the species because of the low sample sizes. Though the frequency of observing the male was much higher than the female the number of individual males and females sighted across the trails showed no significant difference (U = 41.500, p = .517, n = 100). implying that the sighting of females was rare . This was probably because of the dull mottled plumage of the female Satyr Tragopan, which gets *well cam~~aflaouged~~* ouflaged *in its surroundings* rendering its detectability difficult.

6B.4 Discussion

The frequency of sightings of male Satyr Tragopan was much higher than sighting of females or juveniles and chicks which implied a probable skewed frequency of visual evidence in favour of the males. A similar trend was observed in a population of the Western Tragopan in Pakistan (Islam and Crawford 1992). These observations may suggest that males were easier to sight and thus were more frequently encountered during monitoring the study area. The higher frequency of male sighting may also occur because of a bias in the sampling technique. Unlike the method used by Islam and Crawford (1992) where the birds were flushed by hunting dogs and both males and females had equal chances of being seen, in my studies at SNP, I used the non-invasive technique of trail monitoring. The male Satyr Tragopan has very bright and conspicuous plumage and similar to other birds it may be advantageous for sexual selection (Hill 1990, 1991, Anderson 1993) or anti- predator related behaviour (Gotmark1994, 1997) and also an easily sighted specimen . Chances of sighting or locating the male birds were further enhanced by the calls they emit during the breeding season in contrast to females whose behaviour is cryptic due to mortality risks associated with incubation (Brown and Gutirezz 1980). The male: female ratio showed a slight decrease in skew as compared to the sighting frequency and this ratio was almost equal across the trails and seasons in the study area.

Sex ratio studies are of primary importance in population dynamics of species and also for predicting abundance of populations from call count indices (Dale 1952). Johnsgard (1973, 1983) suggested that there was an excess of adult males (55-59%) especially in a monogamous galliform population. The 1.5 : 1 male: female ratio therefore agrees with the sex ratio obtained by Islam and Crawford (1992) of the Western Tragopan and that suggested by Johnsgard (1973,1983). An almost equal sex ratio was however obtained in a population of Cabot's Tragopan in China (Zhang Junping and Zheng Guang-Mei 19890.

Inglis (1930), Gaston (1980), and Lelliott and Yonzon (1980) found the Satyr Tragopan to be solitary; forming pairs during breeding and in small family units after the chicks are hatched. Delacour (1956), Ali and Ripley (1980) and Johnsgard (1986) believe that Tragopans live in groups of 3-4 birds except during the breeding season. In SNP the male Satyr Tragopan except when paired with the female were observed singly and were never found in family units. The female birds were found in family units comprising of chicks or juveniles or sometimes in all female groups. Solitary males are considered to be highly territorial during the breeding season as was evident from their response to the playback of tape-recorded calls (Lelliott and Yonzon 1980, Islam and Crawford 1992). In SNP the male birds were observed to respond very aggressively to such playback of calls and approached the source of the sound. On the other hand birds do not respond to any advertisement call of another congeneric species either in the wild or in captivity (Islam and Crawford 1996). This also clearly corroborates the earlier hypothesis that calling does not function simply in sexual attraction but also in territory defence.

Conclusion: A predominantly solitary species, the Satyr Tragopan uses four different types of vocalisations for inter and intra sexual communications of which the advertisement call was the most pronounced and audible. This vocalisation can therefore form an important and non-invasive technique by which scientific investigation about the presence /absence and abundance can be conducted. The calling activity of male Satyr Tragopan probably helps in female choice, reproductive isolation, fitness announcement, and announcement of individual identities

Considered to be a solitary species by some authors and also living in family units by some others, the Satyr Tragopan in the SNP were mainly observed as single birds. Conventionally considered a species with equal sex ratio the observations made in SNP support the 60:40 (1.5:1) ratio obtained for the Western Tragopan. The need for intensive studies to develop reliable techniques for obtaining pheasant sex ratios was felt more than four decades ago (Dale 1952). As of now sex ratios studies on Himalayan pheasants lack any reliable methods because for such rare and threatened species population harvest technique is neither applicable nor possible.

CHAPTER 7

THREAT STUDIES

7.1 Introduction

The threats facing the family Phasianidae are highest in the forests of southeast Asia, the Himalaya and China (McGowan 1996). The proportions of pheasants that are threatened as a result of man's activities is amongst the highest in any bird family

Of all the families of Galliformes, pheasants have probably made the most profound impact on man. As they are large birds, all along their range they have been shot and snared for food and sport, their eggs collected for high protein food and have also been a religious and cultural influence on man. Many of the threats faced by the pheasants is partly because of this close relationship with man.

Most of the Himalayan pheasants belong to the narrow temperate zone (50-100 km wide and 2000 km long) intermediate between the tropical and the palearctic zone (Gaston *et al.* 1983). This narrow temperate zone is fragmented by extremities of topography and anthropogenic pressures. During the past 150 years changes in agricultural practices, intensive grazing by domestic livestock and increased demand for timber due to increase in population has led to an increase in the loss of forest cover throughout the Himalaya (Cronin 1979, Schaller 1980). This reduction in forest area, together with the fragmented nature of the ecosystems has made wildlife species like pheasants of these Himalayan forests particularly vulnerable to local extinction (Diamond 1974, Terborgh and Winter 1980).

There are 5 types of threats to pheasants identified by the WPA/Birdlife and SSC Pheasant Specialist Group (McGowan & Garson 1995). Out of these habitat loss and fragmentation and hunting for food, sport and trade are the ones that affect the Satyr Tragopan all along its distribution range.

Lying at the northwestern extremity of Darjeeling, the Singhalila National Park constitutes one of the most important forested areas of the already depleting forest cover of the Darjeeling district. These forests, prior to their protected area status were under fairly intense anthropogenic pressures in the form of removal of large quantities of timber, large scale construction of roads, presence of numerous cattle or yak stations and rampant poaching.

While studying the probable threats to Satyr Tragopan in particular and Singhalila National Park as a whole I have attempted to fulfill the following objectives:

1. Describe the socio-economic conditions of inhabitants in settlements around the Singhalila National Park.
2. Describe probable threats that may affect ~~to~~ the environment of Singhalila National Park.
3. Identify factors that may pose ~~to be~~ threats to the Satyr Tragopan .
4. Recommend measures that may serve as guidelines for formulating management plans.

7.2 Methodology

Details of anthropogenic activities of the past were obtained by interviewing local people residing in the various settlements all around the Singhalila National Park. Habitat disturbances like grazing, browsing, lopping and other pressures (vehicular disturbance, constantly used thoroughfare etc.) were measured by their levels of intensity i.e. none = 0, low = 1, medium = 2, high = 3 and intense = 4. These were measured at each animal and random habitat plots over a distance of 10 m from the centre of the plot. Presence of cattle dung piles were counted along the four compass bearings from the centre of the plots for 5 paces each on a bearing. Distance to the nearest human settlement, distance to any road or trail from the centre of each habitat plot were also approximated.

Analysis: Since all data collected on disturbance was by intensity measures or ranks I mostly used nonparametric stastistics to analyse data. Mann Whitney U tests were performed to test if the various disturbance factors were significantly different between the animal and random plots. Spearman rank correlation coefficient was used to correlate the different disturbance activities in the habitat plots with distance from human habitation. Kruskal Wallis One Way Anova was used to compare the levels of disturbance at different distances from the nearest human settlements. T tests were used for differences between the ground cover species diversity and shrub cover species diversity across the animal and random plots. Frequency tables were created to get an over all idea about the possible disturbance activities in the Satyr Tragopan habitat.

7.3 Results

7.3.1 Socio-economic observations: The western border which fell within the core zone of Singhalila National Park also marked the International border with Nepal. This was represented by a 42 km unmetalled road built in the pre-independence times and was marked all along its course by small hamlets in the Nepalese territory. Towards the eastern border which is the buffer zone there were several settlements dotting the National Park border in the Indian territory. There were 2 forest villages within the core zone and 2 within the buffer zone of the National Park. Following were the activities carried on by the inhabitants of the settlements bordering Singhalila National Park for economic sustenance:

7.3.1.1 Cattle and Yak owners: Every family residing in the settlements owned a few heads of cattle while many owned up to 100 heads of cattle and yak. The yak mentioned here is a hybrid between the wild yak and the domestic cow and is locally known as "chauri". These animals were kept at yak stations high up in the mountainous territories of Nepal and Sikkim. Some were brought in the Park elevation during winter while many owners keep them permanently in the settlements. The cattle and yak were mainly kept for their milk and meat and the male of the 'chauri" is used as an excellent carrier of load. The milk of cows and yaks is used for churning out butter but mainly for making hardened cheese locally known as "churpi". The butter fetched a price of Rs. 80-100 per kg while the hardened cheese sold for Rs. 100-150 per kg. Sale of these commodities was brisk especially as business dealings were made through middle men and there were buyers from Nepal, Bhutan and Arunachal Pradesh apart from catering to the demand of the urban population of the Darjeeling district.

7.3.1.2 Agriculture: In villages bordering the core zone of the National Park agriculture was the main occupation while most of the settlers bordering the core zone were small land owners. The main crops grown for their subsistence were millet, maize and potatoes. Potatoes, cardamom and vegetables like cabbage, carrots and peas were some of the cash crops that fetched a fair amount of money. Some of the people also farmed plants like *Swertia chirata* which was considered to have medicinal value and *Daphne cannabina* which was used for making paper.

7.3.1.3 Labourers: The residents of the settlements bordering Singhalila National Park also served as easily available cheap labour force. Some of them were involved in construction and maintenance of the existing road by the Public Works Department. The Forest Department used the labourers in their plantation making and maintenance, building construction and in construction and maintenance of forest paths and trails. The Tourism Department used this labour force for constructing and maintaining their trekking huts. Many of the people also worked as shepherds in the cattle stations of wealthy cattle and yak station owners.

7.3.1.4 Tourism: The Singhalila National Park served as one of the most popular trekking routes in West Bengal and attracted a fairly large number of domestic and foreign tourists. To cater to tourists the facilities provided by the Tourism Department were not always adequate. Therefore small tea shops, lodging and boarding places were set up by the people in the settlements which did quite good business. Besides, many of the men folks also worked as porters and tourist guides some times earning as much as Rs 200 per day in peak seasons.

7.3.1.5 Liquor making: Almost every house in the fringe area was a tiny distillary brewing and distilling the local liquor which was quite high in demand. This was especially consumed by travellers from the surrounding villages involved in small business, tourists and also the residents themselves.

7.3.1.6. Government employment: Very few of the people in the settlements served as government employees. Teachers, soldiers in the armed forces, caretakers in the Tourism and Forest Departments, policemen, Forest Guards were some of the vocations observed among the settlers.

7.3.1.7 Trade: In most of the settlements here were shops set up to cater to the daily demands of the people. Business in these shops was lucrative because people from distant places in the Nepal where there were no proper communication and transport facilities often came to buy their supplies on a fairly regular basis.

7.3.2 Pressures: Presence of human settlements around any protected area is bound to result into some kind of pressures irrespective of the intensity and extent of such pressures. Enumerated here are some activities that probably influenced the habitat and animals of Singhalila National Park.

7.3.2.1 Grazing and browsing by livestock: All the cattle and yak present in the settlements were graszed in the National Park forests. Grazing and browsing was especially intense in areas which were less than 1 km from human settlements and in areas which had a good network of roads and trails enabling the easy movement of cattle and their herders. Yaks are stocky and sturdy animals with the ability to negotiate any type of terrain. While browsing yaks were observed to force themselves through thick clumps of bamboo, the main understorey of the Singhalila forests. In doing so clumps of bamboo were pulled down and the mature stems broke and eventually dried up. Thus the forest understorey and ground cover were severely affected by the grazing and browsing of livestock especially yaks.

7.3.2.2 Firewood collection: Climatic conditions in the Singhalila National Park vary from temperate to sub-alpine thus cold weather conditions prevailed throughout the year. In all houses besides cooking, fire was kept burning for keeping warm which consumed a large amount of fire wood. The consumption of fire wood further increased by the making of milk products and liquor which required a continuous supply of heat. In almost all houses there were large stockpiles of firewood for the monsoon and the winter. Snags (dead standing trees) were cut and dry twigs were collected mainly by the women and the children. The Rhododendron forests in the upper reaches of Singhalila National Park were under severe threat of lopping for firewood collection. The subalpine forests in this area comprised of Silver Fir with Rhododendron and birch in the understorey. Since Silver Fir was not considered a good fuel wood, there were areas where the other two particularly Rhododendron were cut rampantly to meet the fuel wood demand of the area. Lopping was less severe in the mixed oak forests because of the availability of snags and twigs.

7.3.2.3 Forest produce collection: Collection of bamboo shoots, immature ferns,various kinds of mushroom and some other edible plants (*Arisaemia* sp., *Rheum australe, Actinidia strigosa* etc) by the locals were observed in the Singhalila National Park. Severe depletion of the understorey was caused mainly by the collection of mature bamboo stems. These were used for constructing houses and numerous other implements of daily use.

7.3.2.4 Poaching: During my interviews with the local people, almost everyone agreed that poaching activities were severe in the Singhalila Forests prior to the Park being declared a Protected Area. When logging activities were carried out in the Singhalila Forests by the West Bengal Forest Development Co-operation there was large scale road construction for removal of timber. This also led to the presence of a large labour force living within the forests who were involved in snaring and poaching small animals particularly pheasants. There were also reports about supply of animals like the Red Panda and pheasants like Satyr Tragopan to the local zoo.

I have seen groups of poachers with pipe guns and hunting dogs in the National Park forests during my study. I recorded many old snares for birds like pheasants and partridges and large traps for deer, wild boar and deer within the study area.

During the months of July to August butterfly and beetle collectors were reported from within the National Park area.

7.3.2.5 Tourism: The impact of tourism was not manifested directly on the environment of the Park. The impact may be indirect because to cater to the increased number of people visiting the National Park the dependence of locals on forest resources especially firewood was bound to increase.

7.3.3 Habitat pressures: It was observed that grazing, browsing and other pressures were either low or absent altogether in the animal plots while lopping of trees and bamboo appeared as the major potential disturbance activity in these plots (Table 7. 1)

Table 7.1: Showing percentage of animal plots with various levels of disturbances

Disturbances	None	Low	Medium	High
Grazing	65.8	8.8	14	11.4
Browsing	71.9	8.8	9.6	9.6
Lopping	20.2	36.8	29.8	13.2
Others	70.2	13.2	13.2	3.5

Similar to the animal plots, in the random plots levels of grazing, browsing and other pressures were absent or low (Table 7.2). Here too lopping was identified as one of the disturbance factors occurring in a high percentage of plots. Therefore lopping seemed to be one of the major disturbance activities occurring in the habitat of Satyr Tragopan as in 79.8% of the animal plots and 87.3% of the random plots this disturbance was recorded at different intensity levels.

Table 7. 2: Showing the percentage of random plots with various levels of disturbances

Disturbances	None	Low	Medium	High
Grazing	71.1	7.4	10.5	11
Browsing	82.5	5.5	6.9	4.8
Lopping	12.7	37.3	34.2	15.8
Others	85.4	9.1	5.3	0.2

Mann Whitney U tests showed significant difference in the number of cattle dung piles ($U_{109,418}$ = 20186.500, p = .000), browsing ($U_{109,418}$ = 20098.500 p = .006) and other disturbances ($U_{109,418}$ = 19259.500, p= .000) between the animal and the random plots. Thus lopping was a major source of disturbance in both the animal and the random plots but browsing, other disturbances and number of dung piles was found to be higher in the bird or animal sites than in the non-bird or random sites. (Table 7.3)

Table 7.3: Ranks of various disturbances of animal and random plots.

Disturbances	Plot type	Mean Rank
Number of cattle dung piles	Animal	287.80
	Random	257.79
Grazing	Animal	274.31
	Random	261.31
Browsing	Animal	288.61
	Random	257.58
Lopping	Animal	248.46
	Random	268.05
Other disturbances	Animal	296.31
	Random	255.58

The mean species diversity of ground cover was found to be higher for animal plots (.3182 ±0.018) than the random plots (.2628 ± 0.011) and this difference was statistically significant ($t_{525} = 2.405$, $p = .017$, t -Test). The shrub species diversity was not significantly different between the animal and random plots ($t_{525} = -0.491$, $p = .624$, t - Test) though the diversity was higher in the random plots (.3006 ± .173) than in the animal plots (.1277 ± .045).

Since all the disturbances were related to human activities it was assumed that the distance to nearest human settlements from any particular point in the habitat would be appropriate to measure the affects of these disturbances. The Satyr Tragopan habitat was located in areas that were more than 1 km form any setttlements (Fig.7. 1)

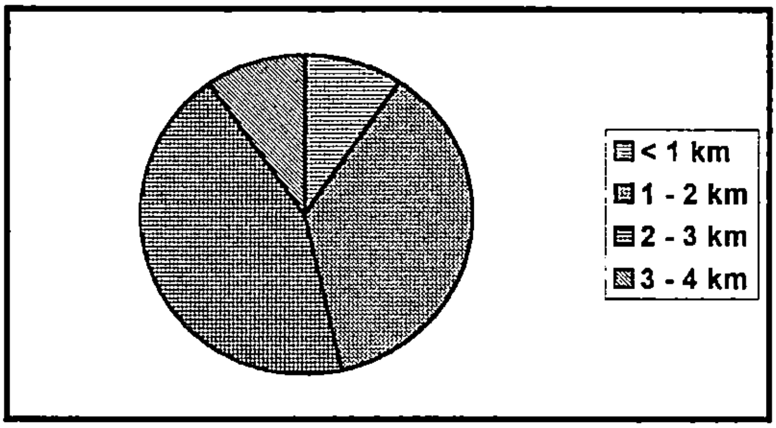


Fig. 7.1 Distance of habitat plots of Satyr Tragopan from nearest human settlements.

Levels of grazing, browsing and lopping were all found to be negatively correlated to the distance from the nearest settlement (grazing: $r_s = -.400$, p ~~= .000~~ <0·001, n = 527; browsing: $r_s = -.260$, p ~~= .000,~~ <0· 001 n = 527; lopping: $r_s = -.252$, p ~~= .000~~ <0·001, n = 527, Spearman Correlation Coefficient) indicating that the effects of these probable disturbance factors were greater near human settlements. Kruskal- Wallis One Way ANOVA showed that the levels of grazing, browsing, and lopping differed significantly across plots located at different distances from human habitation while levels of other pressures did not differ across the distances (Table 7.4).

Table 7. 4 Showing the χ^2 values (d.f. = 3) of the levels of various disturbances recorded in the habitat plots of Satyr Tragopan located at different distances from human habitation

Disturbances	χ^2	p
Grazing	91.634	.000
Browsing	42.466	.000
Lopping	35.813	.000
Other activities	6.298	.000

These results indicate that the levels of disturbance due to presence of human settlements in the vicinity of Satyr Tragopan was affected by the distance from human settlements, with the disturbances getting reduced in intensity as one moved away from these settlements.

7.4 Discussion

One interesting observation while studying the disturbances that may be potential threats to the Satyr Tragopan habitat in the Singhalila National Park was that the number of dung piles of cattle, level of grazing, level of browsing and other pressures were higher in the animal plots than in the random plots. Before making any inferences on this observation one point to be taken into consideration is that in 65-85% of both the animal and random plots there were no disturbance activities at all. The results here indicated that most of the habitat of the species was free from any pressures and the disturbances manifested in the remaining 15-35% of the plots were higher for the animal plots than the random plots. The only threat factor that seemed to be quite distinct in the habitat was lopping which occurred at medium to high intensity levels in both kinds of plots. Various studies (Grubb 1976, During and Willems 1986, Hobbs and Hueneke 1992, Howe 1994 Saberwal 1996 etc.) have shown that suppression of grazing was associated with decreasing species diversity and intense grazing was associated with high levels of floristics diversity. To explain the results of the present study in this perspective would perhaps be too immature owing to the nature of the data. Therefore the presence of greater livestock activity in the animal plots than in the random plots can perhaps be attributed to the large variety of tall and short ground cover species present in these plots. In the present studies shrub species diversity can be considered quite negligible because ringal bamboo formed the main understorey in most of the study area.

In the present study the distance from human settlements seemed to affect the intensities of disturbance in the Satyr Tragopan habitat and most of the habitat plots were between 1-3 km from the outskirts of settlements which implied that the Satyr Tragopan did not occur at close proximities to human activities. Lelliott (1981) observed that cheer pheasants lived close to human activities like livestock grazing, fuel wood collection and arable farming and suggested that the birds were adapted to all these activities. In Singhalila National Park activities like grazing and browsing occurred at close proximity to Satyr Tragopan habitat in only a few sites while the rest of the sites as revealed by the results were free from any such disturbance related to live stock. This happened perhaps because there was a very good nexus of roads, forest and bridle paths within the forests and the cattle could travel to a greater distance for foraging. Apart from this in my intensive study area there were relatively lesser heads of cattle in the settlements and the more destructive animals like yaks and goats were completely absent.

The level of grazing and browsing prevalent in Singhalila National Park did not seem have a very great impact on the habitat of Satyr Tragopan at the sites I took up for intensive studies. Gaston *et al.* (1983a) in their surveys in the high altitudes of Himachal Pradesh observed that grazing modified the understorey vegetation considerably and reduced the amount and diversity of shrubs and ground cover vegetation. Along grazing routes they observed ~~that~~ large areas of meadows which consisted of entirely *Rumex* sp. and other nitrophilous herbs. One of the reasons for the decline in the number of Western Tragopan in its range was interference from grazing livestock (Gaston *et al.* 1981b). Domestic stock are also believed to cause changes in the patch work of semi-natural habitats and produce monocultures which are typical of most agricultural areas (Hill and Robertson 1988a).

Lopping seemed to be the main disturbance activity in the Satyr Tragopan habitat and was found to occur in almost all the plots. Lopping here referred not only to cutting of trees for firewood and construction purposes but also to the harvest of bamboo stems from the forest. Bamboo harvest was observed all over the habitat of the Satyr Tragopan irrespective of the distance form the human settlements. This was probably because for harvest of mature bamboo stems collection had to be made in areas that were farther from human settlements. Habitat studies have shown that the vegetation at the understorey level was an important part of the Satyr Tragopan habitat thus harvest of bamboo may be detrimental to the Satyr Tragopan habitat. Gaston *et a.l* (1983a) in their surveys of the Western Himalayas have suggested that habitat destruction was the most important threat to pheasants. The greatest levels of pressure were observed in the lower parts of the temperate forest zone and the most susceptible were species that required dense undergrowth. On the other hand Picozzi (1985) while studying the human impact on pheasant habitats in Pipar in central Nepal suggested that bamboo harvest was important to the pheasants for the maintenance of continuous ground cover. It is also probable that the continuous presence of bamboo harvesters may cause disturbance to the birds and there is every possibility of the birds being snared. Though harvesting of bamboo at a low level may not produce much of an impact on the Satyr Tragopan repeated harvesting in the same area and cutting of yearling shoots may completely destroy the bamboo clump and clear openings may be formed in the habitat.

Among pheasants 44 taxa (64%) are currently considered to be suffering form over hunting for food and sport (McGowan and Garson 1995). Katti *et al.* (1992) observed that pheasants were among the worst hit by hunting and concluded that this may be part of the reason for the paucity of information on these birds. Studies on the Western Tragopan (Gaston *et al.* 1983b) have attribute the decline in the number of the species in its range among other factors to human predation in the form of trapping and collection of eggs. The over hunting of pheasants amongst the many large forest dwelling birds and mammals was observed to be the main problem in northeast India (Kaul *et al.* 1995).

Though hunting was not quantified or recorded in the present habitat studies it cannot be ruled out. As already mentioned elsewhere in the chapter snares and traps were wide spread throughout the study area which were probably operational prior to the protected area status of the Singhalila forests. During my tenure in the field I did not record any new snares and traps although I did see groups of hunting parties within the National Park forests. Besides, the Satyr Tragopan require very little time and effort to be caught in snares if one knows their sites of occurrence and since they are not too large the game can be easily concealed from the notice of the Park authorities

7.5 Conclusion

The current land use situation of the Darjeeling Himalaya is considered to be unviable and full of long run dangers because of high settlement densities (Sankritiyana 1997). Compared to all the northeastern states the Darjeeling Himalaya have a very high human population which is estimated to be 413/ km^2 (Anon 1996). The Singhalila National Park which comprises an important part of the already dwindling forest cover plays an important role in the environment of the Darjeeling Himalaya.

Though there were no immediate threats to the survival of the Satyr Tragopan in the Singhalila National Park the change in scenario is imminent in the coming years. Thus with increasing trend in the density of human and livestock population in the fringe areas of the National Park the anthropogenic pressures are certain to be more intensive in future. Livestock activities within the Satyr Tragopan habitat did not have much effect on the bird because of low cattle density in the study area. Lopping of wood and harvesting have however manifested themselves as threats leading to habitat destruction and were found to be quite wide spread in the habitat. Direct threats like hunting and snaring also cannot be ruled out completely. Therefore to preserve the Satyr Tragopan in the Singhalila National Park it is essential to preserve its habitat and prevent any hunting of the species. Conservation of Satyr Tragopan in the Singhalila National Park therefore will not only ensure the safety of this beautiful, rare and threatened species but will also in turn conserve the environment and biological diversity of the Singhalila National Park as a whole.

7.6 Recommendations

Important populations of birds, animals and plants are known to occur in the Singhalila National Park. It is therefore essential that within the depleting forested areas of Darjeeling Himalaya adequate areas with undisturbed forest like Singhalila National Park are conserved.

Following are some conservation and management recommendations for the Satyr Tragopan that have emerged after intensive studies on some aspects of ecology and behaviour of the species. It is hoped that by conserving the Satyr Tragopan habitat the biological diversity of Singhalila National Park would also be conserved.

1. Regular monitoring of areas through the numerous trails and paths that criss cross the forests of Singhalila National Park should be undertaken to record all animals and pheasants encountered in the area.

2. Periodic monitoring of the Satyr Tragopan through call counts during the calling season should be organised to estimate the number of calling birds and comparisons with figures obtained earlier could provide useful information.

3. Number of livestock using the National Park forest should be checked from increasing. Care should also be taken to ensure that yaks form the numerous stations all along the border are not grazed in the forests of Singhalila.

4. Harvesting of bamboo should be controlled by ensuring that they are used for personal use and not exported for sale elsewhere. Care should be taken to see that harvest does not take place from only one site as these may give rise to open patches in the forest.

5. Collection of firewood should be strictly restricted to dry twigs, fallen trees and snags. Rampant felling of trees especially *Rhododendron* spp. and *Betula utilis* in the higher reaches should be brought under control.

6. Collection of medicinal plants should be permitted only for personal use of the inhabitants and a regular check should be maintained to prevent these plants from being exported outside the Park. Collection of bird eggs especially those of pheasants should be prohibited.

7. Hunting or poaching of any animal species in the Park should be strictly prohibited. An information network should be maintained among the field staff of the Forest Department to uncover any clandestine plans of hunting and trading activities. Regular monitoring for traps and snares should be carried out and when discovered should be destroyed completely.

8. Tourism does not directly cause any threats yet indirectly to cater to the needs of the tourists and for the revenue involved the use of forest resources ~~especially~~ increases substantially especially in the form of fuel wood collection and hoarding. This is very intense in the Sandakphu area where the Rhododendron forests have almost completely been removed. Since most of the infrastructure ha~~ve~~s been set up by the Tourism Department, recommendations should be made for alternative sources and supply of fuel in this area.

9. Many aspects of the environment of Singhalila National Park are yet to be studied. Scientific research should be encouraged in the Natio~~anl~~nal Park.

CHAPTER 8

GENERAL DISCUSSION

During the course of the present studies I have collected fairly detailed quantitative data on the distribution, abundance, habitat use, diet, calling behaviour and threats of the Satyr Tragopan in the Singhalila National Park. As this is the first detailed work on the Satyr Tragopan in the wild it will benefit future studies aimed at any particular aspects of ecology or behaviour of the species.

Review of the global distribution of Satyr Tragopan showed that except for Garhwal the species was well distributed in all its historically reported areas (Jerdon 1853, Beebe 1918-1922, Meinertzhagen 1926, Whistler 1928, Inglis 1933). Additional sites have also been located in Arunachal Pradesh and China. Many surveys were conducted in the post-independence era in the Himalaya and these have enabled many specific sites in particular areas/regions to be identified. There was paucity of information from sites in Garhwal although the western limit of Satyr Tragopan has always been accepted as Garhwal since historical times. Prasad (1993) suggested Tons river catchment in Garhwal a site of Satyr distribution based on the reports and information provided by the local people. The distribution of the species across Kumaun region was fairly well documented and the Munshiari area in Pithoragarh district of Uttar Pradesh is a newly recorded site (Shah *et al.* 1998). There is still very little or no information on the presence of Satyr Tragopan from the extreme western part of Nepal although the distribution is expected to be continuous. From the west - central part of Nepal through Darjeeling, Sikkim, Bhutan and western Arunachal Pradesh the distribution of the species is continuous. Recent reports of the Satyr Tragopan from the southeastern parts of China (Zheng Guang-mei 1992, Xian 1995, Ma Shilai *et al.* 1996) has expanded the range of the species to farther eastern limits by nearly 7° eastwards. Reports of the Satyr Tragopan from China, however are not very convincing because the nature of evidence is not stated in any of them. The range of the Temmick's Tragopan also seems to have increased further west by location of new sites (Singh 1998). Hitherto Dafla Hills in East Kameng district of Arunachal Pradesh was considered to be the dividing line between Satyr Tragopan and the Temmick's Tragopan. This leaves a wide gap in the distribution of the Satyr Tragopan from East Kameng through Myanmar to the reported site of distribution of the species in China whereas the Temmick's seems to have a continuous distribution in this area (Kaul *et al.* 1992). Therefore the presence of an isolated pocket of distribution of Satyr Tragopan in southeastern China requires further verifications.

In the Singhalila National Park the Satyr Tragopan was well distributed and most abundant in the 2600-3300 m altitude zone in oak dominated mixed forests. Relative density figures of the Satyr Tragopan obtained for the Gairibans-Kainyakatta-Kalpokhri area of the Singhalila National Park were quite consistent in the three years of study. As already mentioned elsewhere in the text it would be too premature to make any predictions in the population trend of the species in the area from just three year's observation. Among sites within the Park the species was distributed in more or less a continuous fashion from Gairibans through Sandakphu to Phalut Molley regions and was probably contiguous with Sikkim. Ringal bamboo was the most dominant understorey throughout its range in the study area. The Satyr Tragopan were also found to be distributed in alpine forests, pure rhododendron stands, pure bamboo stands and sometimes in plantation forests but the most preferred broad habitat seemed to be the oak dominated mixed forests. Through most seasons of the year the habitat of the Satyr Tragopan remained associated with vegetation structure present at the understorey and ground level. Among the tree variables the species was mainly associated with the tree canopy cover only, perhaps because its affects the vegetation structure at the understorey or ground level. There was however a distinct seasonal separation in habitat use of the species. During pre-monsoon the habitat comprised of open areas with dense shrub and ground cover, in monsoon the birds inhabited wooded areas with closed canopy and understorey cover, in the autumn or post-monsoon the birds were associated with dense and closed cover both at the canopy and understorey level and in winter the habitat comprised of open areas with dense ground cover. As the results showed there was not much of a separation between the animal and the random plots at the microhabitat level. This was probably as mentioned before because of the random plots not being truly random since their locations were determined by the location of the animal plots. Therefore some of the random plots during sampling may have at some other occasion fallen on animal plots also.

Satyr Tragopan was found to be more vegetarian with *Arundinaria maling* and ground cover vegetation forming the bulk of the diet. Even among these *A. maling* was by far the most predominantly encountered food item in the diet of the species. Besides vegetative matter grit or quartz fragments also formed a fairly important diet of the species. Being a predominantly, ground dwelling species it is expected that the habitat of the Satyr Tragopan remains associated with vegetation structure at the shrub and ground level which probably provide the vital food and cover required by the bird for survival. Calling period occurs in the premonsoon season and is associated with open canopy and dense understorey and ground cover habitat which probably provides perpetual food, cover for the easily detectable calling or pairing birds and open area for proper transmission of calls. Vegetation at the understorey and ground level is also expected to protect the brightly coloured conspicuous male during this season because it indulges in advertising and displaying to the female. Late premonsoon and early monsoon times are important for the birds as they are involved in nesting activities like laying, incubation and hatching. Birds are vulnerable to predation and egg loss during this period and also require easily available food. This is probably best provided by the dense shrub and ground cover prevalent in their habitat. In the post-monsoon season when the broods are raised the understorey and ground cover maintain their importance and this goes on to the harsh winter when for survival the understorey cover and ground cover provide the shelter and thermal cover to the Satyr Tragopan.

There are a number of human settlements lying scattered in the fringe area of the Singhalila National Park. Some of the possible threats to the forests due to human activities were livestock grazing and browsing, lopping of trees for fuelwood and construction, harvesting of bamboo, poaching and unmonitored movement of people and cattle within the forest of the National Park. In the Satyr Tragopan habitat however grazing and browsing were recorded in only a few plots and in greater percentage of the plots there was no disturbance from livestock. This activity of livestock was further determined by the distance of the habitat from the human habitation as all disturbance activities reduced in intensity with distance from the settlements. Lopping (harvesting of bamboo stems) was identified as the most widespread disruptive activity in the habitat of the Satyr Tragopan. Since the habitat of the species remains associated with understorey vegetation and bamboo forms the most dominant understorey cover of the Singhalila forests intensive harvesting of this plant will lead to habitat destruction of the species which is expected to have a wide range of repercussions on the Satyr Tragopan population in the Singhalila National Park.

There are certain aspects of the Satyr Tragopan ecology and behaviour that are still not known or the information available is very sketchy and requires a large amount of research. Some of these are acoustical analysis, nesting ecology, breeding behaviour (territoriality, mate attraction, display, mating, laying, incubation and hatching), population dynamics, home range and further detailed studies on diet and energetics. Many of the areas along its range of distribution need to be surveyed for confirmed sites of current distribution. These include Garhwal, western Nepal and Himalayan region of central and eastern Arunachal Pradesh.

SUMMARY

Sixteen genera (Delacour 1977) and 51 species (69 taxa) of pheasants are known to science and out of these 50 species are endemic to Asia (McGowan and Garson 1995). Of the 51 species of pheasants 17 species occur in India. Of the 69 taxa of pheasants more than half i.e. about 64% are threatened, 27% are categorised as safe and another 9% are insufficiently known.

The Satyr Tragopan (*Tragopan satyra,* Galliformes: Phasinidae) is one of the most attractive and little studied species among the pheasants. It has been categorized as Near Threatened by the Birdlife International in Birds to watch 2: the world list of threatened birds. The Pheasant Specialist Group in its Pheasant Action Plan has listed the species as "Vulnerable" (McGowan and Garson 1995).

Apart from the observations of British Naturalists and a few surveys in its range of distribution there has been no detailed and intensive work on the ecology of the Satyr Tragopan. Therefore this dissertation work is the first detailed work on the ecology of the Satyr Tragopan and was attempted with the following objectives:

- To obtain information about the presence and distribution of the Satyr Tragopan in the Singhalila National Park (SNP), Darjeeling.
- To formulate techniques for abundance indices.

- To study the habitat utilisation patterns of the Satyr Tragopan in the SNP to generate information on the broad characteristics of available and utilised and shift in habitat use.
- To study and identify the food plants of the Satyr Tragopan..
- To study the social organisation and calling behaviour of the species.
- To study the effect of human pressures on the pheasant habitat like lopping fodder collection, forest produce collection and grazing and browsing by cattle from human habitats to help in formulating conservation measures and management techniques for the Satyr Tragopan in particular and the Singhalila National Park as a whole.

The study area was located in the 108.77 km^2 Singhalila National Park (27°13'15 "N - 27°1'46"N ; 88° '5" E - 88°7'5"E) in India at the extreme north western boundary of Darjeeling district with the Singhalila spur separating the district from Nepal and Sikkim. The altitude of the Park varies from 2400m - 3650m and moist temperate conditions prevail throughout the year because of which the vegetation is of temperate to a subalpine type. Wet temperate, moist temperate and subalpine forests form the main forest cover of the Singhalila National Park (Anon 1992,).

I divided the study period into four seasons viz. the pre-monsoon season, monsoon season, post-monsoon season and winter season. The intensive study area of approximately 25 km^2 was stratified into three altitude zones of 2600-2900 m (zone 1), 2900-3200 m (zone 2) and 3200- >3600m (zone 3). Four permanent transects/ trails were marked out in each altitude zone which were monitored on a monthly basis. I collected data on abundance from call counts (Gaston 1980). Information on habitat use was obtained by monitoring trails whereas feeding ecology was studied by faecal analysis.

Univariate and multivariate statistical tests were used to analyse data following Sokal and Rohlf (1995), Zar (1984), Snecdor and Cocharan (1967) and Siegel (1957). For multivariate analysis, data variables were appropriately transformed (arcsine, lognormal, logratio) to normalise the data. All analyses were carried out manually and by the software package SPSS 7.5 for Windows (Norusis 1990).

Intensive studies yielded 55 direct encounters with the Satyr Tragopan of which 52.2% occurred in the pre-monsoon season, 40% in monsoon and 4% each in post-monsoon and winter. Altitudinally 59.2% of the encounters occurred at 2600-2900 m, 34% occurred at 3000-33000 m while in the areas above 3300 m only 4% of the encounters occurred. Encounter rates of birds in different altitude zones differed across the four seasons ($\chi^2 = 8.90$, $p = 0.05$, Friedman Two Way ANOVA).

A total of 28 calling groups were recorded from the three trails in 1995, 19 groups in 1996 and 24 groups in 1997 with a mean density index of 6.19/km^2, (±0.87) 4.52/km^2 (±0.58) and 5.71/km^2 (±0.38)for three years The number of calling groups of Satyr Tragopan only on trail 4 fluctuated between the three seasons ($F_{2,18} = 6.375$, $p = .0081$, 1 Way ANOVA).

Five broad habitat types were identified from the intensive area. Based on the location of animal plots it was found that oak forests were the most preferred general habitat of the Satyr Tragopan whereas the others were avoided or used less in proportion to their availability.

In the pre-monsoon data on random plots PCA extracted 4 factors which cumulatively accounted for 64.52% of variance in the general habitat variables. Factor 1 had high positive loadings for ground cover factor and apparently represented open areas. Factor 2 showed high loadings for shrub factor and probably reflected areas with tall and dense shrub cover with sparse ground cover.

The first axis on the animal plots for pre-monsoon had heavy positive loadings (>.5) for shrub factor and ground cover height. The second factor was heavily loaded in favour of ground cover.

In discriminant function 1 shrub cover and slope were the variables which differed significantly between the animal and random plots (λ = .944, d.f. = 2, p = .001) and this function correctly classified 80.6% of the cases in the pre-monsoon data set. According to this analysis the animal plots were characterised by lower shrub cover and more slender slope as compared to the random plots.

During monsoon PCA extracted four factors from the general habitat of the monsoon season which explained 73% of the total variation. Tree factor had high positive loadings in Factor 1 while in Factor 2 shrub factor was highly loaded. For animal plots PCA extracted 4 factors which cumulatively explained 73.&% of variance in the monsoon habitat of the Satyr Tragopan. High factor loadings were obtained for the tree factor in Factor 1 and negative loading for ground cover, while in Factor 2 the shrub factor obtained high loadings.

From the monsoon habitat data DFA extracted canopy cover, ground cover density, shrub cover density and shrub species diversity as the variables that differed significantly between animal and random plots ($\lambda = .562$, d.f = 4, p ~~=~~ < 0·001 ~~.000~~). DFA had an efficiency of 88 % in correctly classifying the animal and random plots during the monsoon season. The Satyr Tragopan seemed to be associated with lower canopy cover, ground cover density and shrub cover density in its monsoon habitat than compared to its surrounding habitat.

In the post-monsoon season, PCA extracted 5 factors which together explained approximately 70% of the variance in the available habitat. High loadings were obtained for ground cover factor in Factor 1 and shrub factor in Factor 2.

Four factors were extracted out of the animal plots which cumulatively explained a variance of 72.42%. Factor loadings were high for canopy cover, shrub factor in Factor 1. Canopy cover, ground cover, shrub height and slope obtained high loadings in Factor 2.

Discriminant function 1 separated out canopy cover, ground cover height, shrub cover, shrub density and slope as discriminating variables from the post-monsoon habitat of Satyr Tragopan ($\lambda = .735$, d.f. = 5, $p \cancel{= .000} < 0.001$). DFA had an efficiency of 83.3% in correctly classifying the animal and random plots of the post-monsoon season.

For winter season data, PCA extracted 4 factors which together explained 71.7% of the variance in the random plots. In Factor 1 high positive loadings were obtained for ground cover variables and in Factor 2 high loadings were obtained for shrub factor. Factor 1 apparently represented open areas with abundant ground cover while Factor 2 represented areas with dense shrub cover.

In the utilised habitat or animal plots PCA extracted 3 factors which cumulatively explained 78 % of variance. In Factor 1 high factor loadings were obtained for ground cover factor and in Factor 2 high positive loadings were obtained for canopy height, shrub height, shrub diversity and slope.

The habitat variables of the winter when subjected to DFA showed no discriminating variables between the animal and the random plots ~~indicating~~ suggesting a random use of habitat during this season.

Food was available to the Satyr Tragopan in the form of plant and animal material. The over all availability (density and height of ground cover) differed across the seasons (density $F_{3,128} = 2.782$, $p=.044$; height $F_{3,128} = 8.626$, $p \cancel{= .000} < 0.001$) and also between the predominant species of ground cover (density: $F_{10,121} = 16.73$, p <0.001 ~~= .000~~; height: $F_{10,121} = 8.269$, p <0.001 ~~= .000~~). Insects, mites and spiders were available as animal food items to the Satyr Tragopan. These were either Dipterans (flies), Coleopterans (beetles), Hymenopterans (ants) or ~~and~~ Arachnids (spiders).

A total of 23 food items were identified from the faecal droppings of the Satyr Tragopan in all the four seasons of the year with all 23 items in post-monsoon, 20 items in monsoon, 17 items in pre-monsoon and 18 items in winter. *Arundinaria maling* was the most important food component identified from the diet of the Satyr Tragopan in all four seasons. Besides this other perennial plants like *Pilea scripta, Theropogon pallidus, Vaccinium nummularia, Cotaneaster microphyllus,* annuals like ferns and non-plant material in the form of quartz fragments were the major components identified in the droppings of the Satyr Tragopan.

During pre-monsoon season there was a non-random use of the ground cover as food items ($\lambda = .00192$, $p = .008$, MANOVA). Fern was the most preferred plant item besides which *Vaccinium nummularia, Primula* sp., *Theropogon pallidus* and *Pilea scripta* were also significantly preferred. The Satyr Tragopan avoided *Valeriana jatamansi, Poa annuae* and others during this season.

The mean difference in availability-utilisation logratios during the monsoon season was $\lambda = .0237$, $p = .092$ (ns) (MANOVA) indicating more of a random use of ground cover species. *Theropogon pallidus* and ferns were the most highly preferred items in proportion to others. *Pilea scripta, Primula* sp. were next in preferrence while *Vaccinium nummularia, Valeriana jatamansi, Poa annuae* and others were significantly avoided.

There was a significant difference in availability - utilisation ratios during the post-monsoon season (λ = .010, p = .039, MANOVA) indicating non-random use of the ground cover species available to the Satyr Tragopan in its habitat. *Theropogon pallidus* was the most preferred species after which *Vaccinium nummularia, Pilea scripta, and Primula* sp. were the next batch of preferred species. Ferns, *Valeriana jatamansi,* Others and *Poa annuae* were significantly avoided.

During winter there was a significant difference between availability- utilisation of the ground cover diet of Satyr Tragopan (λ = .032, p = .029). *Theropogon pallidus* ranked as the most preferred among the species. *Primula* sp. and *Vaccinium nummularia* were the other preferred food plants while *Valeriana jatamansi*, ferns and others were.

April was the most vocal month both in 1995 and 1996 (U = 2.69, p = .0071; U = 3.38, p=.0007, Mann Whitney U test) while there were no records of calling birds in May 1997. The mean duration of chorus was 20.7 minutes (± 1.27, n =129) over all the trails and did not vary significantly over April and May (calling season). The mean calling effort across all the trails was 4.05 (± 0.32, n = 129) and this was higher at the end of the calling period (April = 3.70, ± 0.23, n = 115; May = 6.77.42, ±

2.26, n = 14) and this differed significantly between April and May (t = -2.927, df = 127, p = .004).

Generally levels of grazing, browsing and other pressures were absent or low. Lopping seemed to be one of the major disturbance activities and occurred in 79.8% of the animal plots and 87.3% of the random plots at different intensity levels. Mann Whitney U tests showed significant difference in the number of cattle dung piles ($U_{109,418}$ = 20186.500, p ~~= .000~~ < 0·001), browsing ($U_{109,418}$ = 20098.500 p = .006) and other disturbances ($U_{109,418}$ = 19259.500, p ~~= .000~~ < 0·001) between the animal and the random plots. The mean species diversity of ground cover was found to be higher for animal plots (.3182 ±0.018) than the random plots (.2628 ± 0.011) and this difference was statistically significant (t_{525} = 2.405, p = .017, t -Test).
Levels of grazing, browsing and lopping were all found to be negatively correlated to the distance from the nearest settlement (grazing: r_s = -.400, p ~~= .000,~~ < 0·001 n = 527; browsing: r_s = -.260, p ~~= .000,~~ < 0·001 n = 527; lopping: r_s = -.252, p ~~= .000,~~ < 0·001 n = 527).

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