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THE ECOLOGY AND FEEDING BEHAVIOUR OF THE HIMALAYAN TAHR (*HEMITRAGUS JEMLAHICUS*) IN THE LANGTANG VALLEY, NEPAL

by

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ABSTRACT

Himalayan tahr (Hemitragus jemlahicus) were studied for thirteen months in the upper Langtang Valley, Nepal, between 3,500m and 4,600m. Two populations, numbering about 170 and 50 goats, each occupied areas of $7km^2$. Both populations appeared to be reproducing well. Density varied between 5 and 46 animals km^{-2} depending on habitat and the amount of competition with livestock. Mean group size was 14.8, based on a total of 239 sightings. The largest number of animals seen together was 77. Groups mainly consisted of adult males or adult females and juveniles (both sexes), except during the rut when groups of mixed sex and age categories predominated. Adult females and juveniles maintained the same home ranges throughout the year; they often migrated about 700m vertically every day. Adult males tended to range laterally. Over the year an average of 70% of daylight hours were spent feeding, but adult males spent significantly less time feeding than adult females and juveniles during the rut. Animals fed most intensively in the early morning and late afternoon and rested around midday. This pattern of daily activity varied seasonally with day-length. Juveniles showed more aggression than adults of either sex; adult females were antagonistic during courtship; adult males were never seen fighting each other. The rut lasted from about November until mid-February; most mating probably occurred in December. Young were born between mid-June and mid-July.

The diet was investigated by faecal analysis. The mean composition of the faeces over the year was 34% grasses, 21% sedges, 27% dicotyledons, 4% ferns, 4% mosses and 11% unknown species, but there were significant seasonal differences. Although domestic animals competed with tahr for grazing grounds certain rugged terrain,

inhabited by tahr, was inaccessible to livestock. Thus, conservation measures are not considered to be necessary in the immediate future.

CONTENTS

1. INTRODUCTION TO THE GENUS HEMITRAGUS (TAHR)

1.1 Taxonomy

The three forms of tahr which comprise the genus Hemitragus Hodgson, 1841, are the Arabian tahr (H. jayakari Thomas, 1894), the Himalayan tahr (H. jemlahicus Smith, 1827) and the Nilgiri tahr (H. hylocrius Ogilby, 1838). The subspecies of Himalayan tahr from Sikkim, H.j. schaeferi Pohle, 1944, is not generally recognized because it is based on minor differences in horn shape and pelage colour; moreover, Sikkim falls within the continuous range of the subspecies jemlahicus (Caughley 1970d; Schaller 1977). In fact, Charles (1957) maintained, on zoogeographic grounds, that until more material became available the three species were best considered as three different subspecies of the nominate form H. jemlahicus but his evidence is not convincing (Schaller 1977).

The genus Hemitragus is placed in the Tribe Caprini along with the goats, genus Capra, and the sheep, genus Ovis (Simpson 1945). It is believed that the calprids evolved from the short-horned rupicaprids or goat-antelopes (Thenius and Hofer 1960). Hemitragus resembles both caprids and rupicaprids (Geist 1971).

Tahr differ from goats in many respects. The males lack beards, the muzzle is naked, the horns are short and curve sharply backwards. Such features together with the presence of four teats, small occipital condoyles, narrow pointed ears, a thick hide, a neck ruff and hair pants are characteristic of the rupicaprids (Geist 1971).

Together with the aoudad (Ammotragus lervia), tahr are exceptional among the Caprini in that the females possess large horns relative to males. In this respect there are again similarities to the rupicaprids which show little or no sexual dimorphism (Schaller 1977).

Tahr resemble goats in having a keel on each horn, the absence of preorbital, inguinal and pedal glands on the feet and a strong body odour.

The chromosome number of *H. jemlahicus* (2n = 48) differs from that of true goats (2n = 60) although in general morphology both sex chromosomes of the former resemble those of *C. hircus*, *C. ibex* and *O. aries* (Nelson-Rees, Kniazelf, Malley and Darby 1967).

In *H. jemlahicus* only two teats tend to be functional because the anterior pair are rudimentary (Anderson and Henderson 1961; Rammell 1964); this is an intermediate condition between caprids and rupicaprids. *Hemitragus* also resembles both these tribes in its patterns of courtship and aggression (Schaller 1970, 1973).

1.2 Nomenclature

Inconsistent spelling in the literature of the specific and common name of *H. jemlahicus*, Himalayan tahr, has caused a certain amount of controversy. *H. jemlahicus* was first described as *Capra jemlahicus* by Smith in 1827 and so this spelling of the specific name is the correct form. In the literature it is often incorrectly spelt as *H. jemlaicus* (e.g. Beddard 1902; Donne 1924; Flower and Lydekker 1891; Riney 1955, Wodzicki 1950) which dates from Gray in 1847 (Christie and Andrews 1964).

The common name, TAHR, is also spelt in the literature as THAR. In New Zealand the spelling of the vernacular name is generally accepted as THAR, following the informal scientific rule of using the transliteration adopted by the author(s) of the first major study of the species. This was made by Anderson and Henderson (1961) who selected THAR as being the spelling generally accepted, after Riney (1955). Caughley (1971b) points out that both spellings were in use before H. jemlahicus was introduced to Woburn Abbey at the turn of this century. TAHR is more common than THAR in English publications but the reverse is true in French and German literature.

After some extensive research into the literature, Banwell (1970) concluded that TAHR should be adopted as the standard spelling for H. jemlahicus. THAR is, in fact, the native name in Nepal of the serow (Capricornis sumatraensis thar) which is a goat-antelope. The serow inhabits montane forest, the upper limits of which are frequented by H. jemlahicus. Seen fleetingly or from a distance in thick forest, the serow might easily be confused with H. jemlahicus by an inexperienced observer. In fact, H. jemlahicus has been mistakenly described as a forest animal (Prater 1971) which, as Caughley (1970d) suggests, was probably based on the hunting records of Kinloch (1876) and Burrard (1925) without due acknowledgement. These men both shot specimens of H. jemlahicus, probably wandering adult males, in the forest. In the light of such information it is easy to visualize how the confusion between the two species arose in the field and then entered European literature. Clearly on seeing a large, goat-like animal while trekking through montane forest in Nepal, any foreigner will be informed by his sherpa or porter that it is a THAR. The foreigner is quite likely to interpret this to mean H. jemlahicus when, in fact, the animal is Capricornis simatraensis thar! If the animal is H. jemlahicus then locals would use the words jharal (Nepali) or nyang ghin (Tibetan).

Caughley (1971b) maintains that both spellings of the common name of H. jemlahicus are correct since they are two different attempts at transliteration from Sanskrit into Roman script. He mentions that the words TAHR and THAR are a combination of three sounds, the first of which is a hard "t" and may be transliterated by the symbol "th" or more simply by "t". The second sound is a vowel which is transliterated as "a". The third may be denoted either by "r" or "rh". Thus, the words TAHR and THAR should be pronounced similarly, as in target.

It appears, therefore, that European languages are lumbered with an inappropriate common name for H. jemlahicus, which arose as a result of confusion with the Nepali term[1] for the serow, Capricornis sumatraensis thar. Since both TAHR and THAR are equally correct transliterations, either may be applied to H. jemlahicus. As the spelling THAR has been adopted for the subspecific name of the Nepalese serow it is, therefore, less confusing to use TAHR for H. jemlahicus, particularly since this spelling is universally used for the Arabian and Indian species of Hemitragus.

1.3 Worldwide Distribution and Status

Hemitragus is a very old genus which was formerly distributed as far west as Europe (Schafer 1950), following two separate invasions during the Pleistocene by H. Stehlini and then probably H. bonali (Kurten 1968). Its disappearance from Europe between 17,000 and 10,000 years BP cannot be fully explained by the warmer climate which became established towards the end of that period because tahr can tolerate a wide range of climatic conditions, as indicated by the contemporary

1 Caughley (1971b) asserts that this word (TAHR or THAR) means "a wild goat-like animal", which may be generally ascribed to a Capricornis, Hemitragus or Nemorhaedus (goral). He thereby contradicts his previous claim that no ethnic group uses THAR for Hemitragus (Caughley 1970d).

distribution of relict populations. Schafer (1950) suggested that tahr may have been pushed up into mountainous regions as a result of competition with other animals.

The Arabian tahr formerly ranged throughout hilly and mountainous areas in Oman. Numbers have diminished due to excessive hunting. The species is listed as "endangered" in the Red Data Book (Goodwin and Holloway 1972) and its distribution is restricted to three ranges. In the proposed Jebel Akhdar National Park numbers are low (Harrison and Gallagher 1975). Some 50-100 tahr reputedly exist in the recently established Jebel Aswad Tahr Reserve, which covers an area of 264km^2 (Anon 1977b). The size of the tahr population in the Jebel Hafit is unknown.

The distribution of the Himalayan tahr extends along the southern flanks of the Himalaya from the Pir Panjal Range in northern India eastwards through Nepal to Sikkim. It is also reported as being "not uncommon" at 1,500-2,100m in southwest Bhutan (Holmes 1970). Its formerly continuous distribution in Nepal has been disrupted by increasing traditional practices of land-use, due to an expanding human population, and some hunting. The localities of 14 populations of tahr known to exist in Nepal have been mapped by Schaller (1977) but many more are undoubtedly present.

The Himalayan tahr has become common in South Island, New Zealand, following its introduction in 1904, when three females and two males, from the Duke of Bedford's park at Woburn, England, were released into the Mt Cook area. A further two females and six males, from the Woburn population, were liberated into the same region in 1909. Three and four more tahr were released in 1913 and 1919 respectively but, as Caughley (1970c) points out, "Both liberations were probably of animals descended from the 1904 and 1909 liberations and would not have introduced new genes. Thus the New Zealand population has a gene pool contributed by 13 animals, all of which came from a population whose gene pool was restricted to the contributions of 29 animals [1]." After an initial period of establishment, female tahr spread at an approximately constant rate, 3.2-4.8km annually at the most, and by 1966 occupied 3,600km^2 in the Southern Alps (Caughley 1970c). This range does not account for the extensive wanderings of adult males which have been found up to 97km from the nearest known breeding range (Anderson and Henderson 1961). Initially the species was completely protected but in the 1920's the licensed shooting of adult males was permitted. As numbers increased the habitat, particularly the alpine tussock grasses and sub-alpine scrub, began to deteriorate owing to excessive grazing. In 1936 the government commenced shooting operations to control the expanding tahr population (Anderson and Henderson 1961). Christie and Andrews (1964) reported over 24,500 animals being shot since 1937. This method of control proved ineffective and so poisoning techniques were developed using sodium monofluoroacetate, compound 1080 (Douglas 1967). As from 1971 the game-meat industry has developed an export market for tahr using helicopters from which to shoot the animals and recover the carvasses. The work is conducted in the winter when the animals' movements are handicapped by deep snow. In just a few years an enormous reduction in the tahr population has been achieved. "Between 1971 and 1975 some 35,000 carcasses were exported, with a peak figure of about 10,000 in 1974. In some areas the population has been reduced by more than 90%." (Anon. 1977a). In 1975 K. G. Tustin estimated a population of 20,000 to

1 The Woburn herd was started in 1894 and by 1909 a total of 29 tahr had been introduced to this population.

30,000 tahr in a breeding range of 4,400km^2 (Schaller 1977).

Apart from the populations in England and New Zealand which occur outside their native habitat, another exists on Table Mountain in South Africa. This population, which numbers about 50 animals, consists of the progeny of individuals that had escaped from Pretoria Zoo in the 1930's (Christie and Andrew 1964). Himalayan tahr have also been introduced to Ontario and California (Schaller 1977).

The Nilgiri tahr is restricted to the mountainous regions of Kerala and Tamil Nadu in southwest India. Its former range, which probably never exceeded 5,500km^2, has been reduced by about a tenth (Schaller 1977). Numbers have declined as a result of hunting and habitat destruction. The species is now listed as "vulnerable" in the Red Data Book (Goodwin and Holloway 1972). Walther and Rice (1977) estimate a total of 1,000 to 1,300 animals which is based on census work by Daniel (1970), Davidar (1963, 1968, 1971, 1975, and 1976) and Schaller (1970). They conclude that the two largest populations in the High Range (N = 500) and Nilgiri Plateau (N = 300+) are stable or increasing slightly.

1.4 Habitat

In so far as a preference for cliffs is concerned, "... the tahr seems to be the quintessential goat... "(Schaller 1977) for it selects about the most inaccessible terrain in which to live.

Arabian tahr inhabitat the rocky summits of steep mountains which rise up to about 3,000m. The terrain is arid, often tree-less, and in some areas tahr may descend to drink at dawn from pools at the base of the mountains.

Himalayan tahr occupy mountainous habitat between 1,500m

(Stockley 1928) and 5,300m (Caughley 1969). According to Prater (1971), they are "... never found above the tree-line, that is above 10,000 to 12,000ft. (3,050 to 3,660m), ..." Caughley (1969) observed tahr within the Trisuli watershed in central Nepal, and concluded that "... the habitat of this species is the subalpine zone between 3,900m and 5,200m". In the Kang Chu area of eastern Nepal, Schaller (1973) observed tahr in a variety of vegetation types between 2,500m and 4,400m. In the present study, also done within the Trisuli watershed, tahr were commonly seen in the subalpine and alpine zones between 3,500m and 4,600m. They were infrequently seen in the montane zone as low as 2,700m, and in the alpine zone as high as 5,000m. This species, therefore, occupies a wider altitudinal range of habitat than suggested by either Prater (1971) or Caughley (1969).

The Nilgiri species inhabits mountainous uplands between 1,200m and 1,600m. The lower slopes are densely forested, surmounted often by sheer granite cliffs. The formerly forested plateaux were mostly grasslands but many have now become cultivations or plantations. The high annual precipitation, up to 7,500mm, is responsible for an extremely lush environment. The tahr forage particularly on the grass-covered hills, dotted with copses of stunted evergreen forest, in areas adjacent to precipitous cliffs (Schaller 1970).

1.5 Physical Attributes

The Arabian tahr is one of the smallest living wild goats. It has a brown coat with a dark dorsal stripe and elongated hairs around the jaw, nape and withers. The legs are black and the belly is white. One male measured 62cm at the shoulders and weighed 23kg; its horns measured 29cm (Harrison 1968).

An adult male Himalayan tahr measures 91-102cm at the shoulders and weighs about 90kg (Lydekker 1924). Three males from Sikkim averaged 97cm at the shoulders and 101kg in weight (Schafer 1950). In New Zealand they may weigh up to 160kg (Anderson and Henderson 1961). Females are much smaller; those in New Zealand measure 84-89cm at the shoulders and weigh up to 36kg (Anderson and Henderson 1961), although one 5½ year old female weighed 48.5kg (Schaller 1977). A female from Sikkim, at least 10 years old, weighed 59kg (Schafer 1950). The record length for male horns is 41.9cm with a basal circumference of 25.4cm; the horns of females seldom exceed 25cm in length (Prater 1971). Two patterns of horns, which may be genetically determined, have been described by Anderson and Henderson (1961). The horns commonly curve outwards until a point of maximum spread from which they turn inwards towards the tips. In some cases the tips may be only 2.5-5.0cm apart. In the second type the horns continue straight backwards from the point of maximum spread. As one horn ring is laid down every year following the first winter (Caughley 1965), individuals can be easily aged. Both the Arabian and Himalayan species have a prominent keel along the front of the horn in contrast to the Nilgiri tahr, in which it is almost flat (Schaller 1970). The coat of the Himalayan tahr is much longer than in either of the other two species. It is particularly well-developed in adult males and forms a prominent ruff and mane which may attain a length of 25-30cm. Elsewhere the body hair is 10-15cm. In females the coat length is 5-15cm (Anderson and Henderson 1961). The feet consist of soft pads which are surrounded by a hard outer rim. The well-developed dew claws, 4cm long in one male measured by Schaller (1977), enable this species to inhabit precipitous terrain and exhibit a degree of agility which surpasses even the chamois, _Rupicapra rupicapra_ (Anderson and Henderson 1961). The sternum bears a broad pad covered in short, dense hairs which, together with callous pads on the knees, may provide additional traction when scrambling up or down precipitous, and often smooth, rock surfaces (Christie and Andrews 1964; Schaller 1977).

The Nilgiri tahr is the largest of the three species. Adults measure 100-110cm at the shoulders (Prater 1971). There are no records of weights in the literature. The record lengths of horns for males and females are 44.5cm, with a girth of 25.1cm, and 35.6cm respectively (Prater 1971). Adult males have an almost black pelage apart from a grizzled white back, sides and sometimes rump. The mane is short and bristly in contrast to the long ruff of the adult male Himalayan tahr. Females have a greyish brown pelage and a white belly (Schaller 1970).

1.6 Research to Date

There had been no long-term ecological research concerning any species of Hemitragus in its native habitat prior to the present study, although projects on the Arabian tahr (Harrison and Gallagher 1976) and the Nilgiri tahr (C. G. Rice, pers. comm.) are now underway.

The Himalayan and Nilgiri tahr were studied by Schaller (1970, 1973) for periods of six and seven weeks respectively. Caughley (1969) surveyed the mammals, including Himalayan tahr, in the Trisuli watershed of central Nepal but gave little quantitative information. Within the same area ticks were collected from this species and identified as Haemaphysalis (Allophysalis) warburtoni Nuttall (Hoogstraal 1971). Other studies have been limited to census work in the case of the Nilgiri tahr (Daniel 1970; Davidar 1963, 1968, 1971, 1975, 1976).

Considerable research has been undertaken on Himalayan tahr in New Zealand. A general account of the ecology of this introduced species is given by Anderson and Henderson (1961). Using growth rings on the horns to age a sample of females from a population with a stationary age distribution, Caughley (1966) presented a life and fecundity table. Based on the frequency of pregnant and lactating females, the season of births was estimated to have a standard deviation of 18.5 days with a median at 30 November. Testis weight, used as an index of reproductive condition of males, was found to attain a peak in May. These data suggest a gestation period of 6½ months (Caughley 1971a). The rate of dispersal of the breeding population was found to be linear, rather than geometric, with time which suggests that dispersal was a product of diffusion, rather than population pressure (Caughley 1970c). A kidney-fat index provides a good measurement of fat reserves in tahr (Caughley 1970b). This, together with mortality and fecundity parameters, was used to identify increasing, stationary and declining phases of an eruptive fluctuation in the New Zealand population. Food supply (snow tussocks - Chionochloa spp.) probably influenced such phases (Caughley 1970a). Following the recent spectacular decrease in tahr numbers, due to the game-meat industry (Section 1.3), the New Zealand Forest Research Institute is now engaged on behavioural and habitat-use studies to monitor the consequences of the present eruptive decline in the population (Anon 1977a).

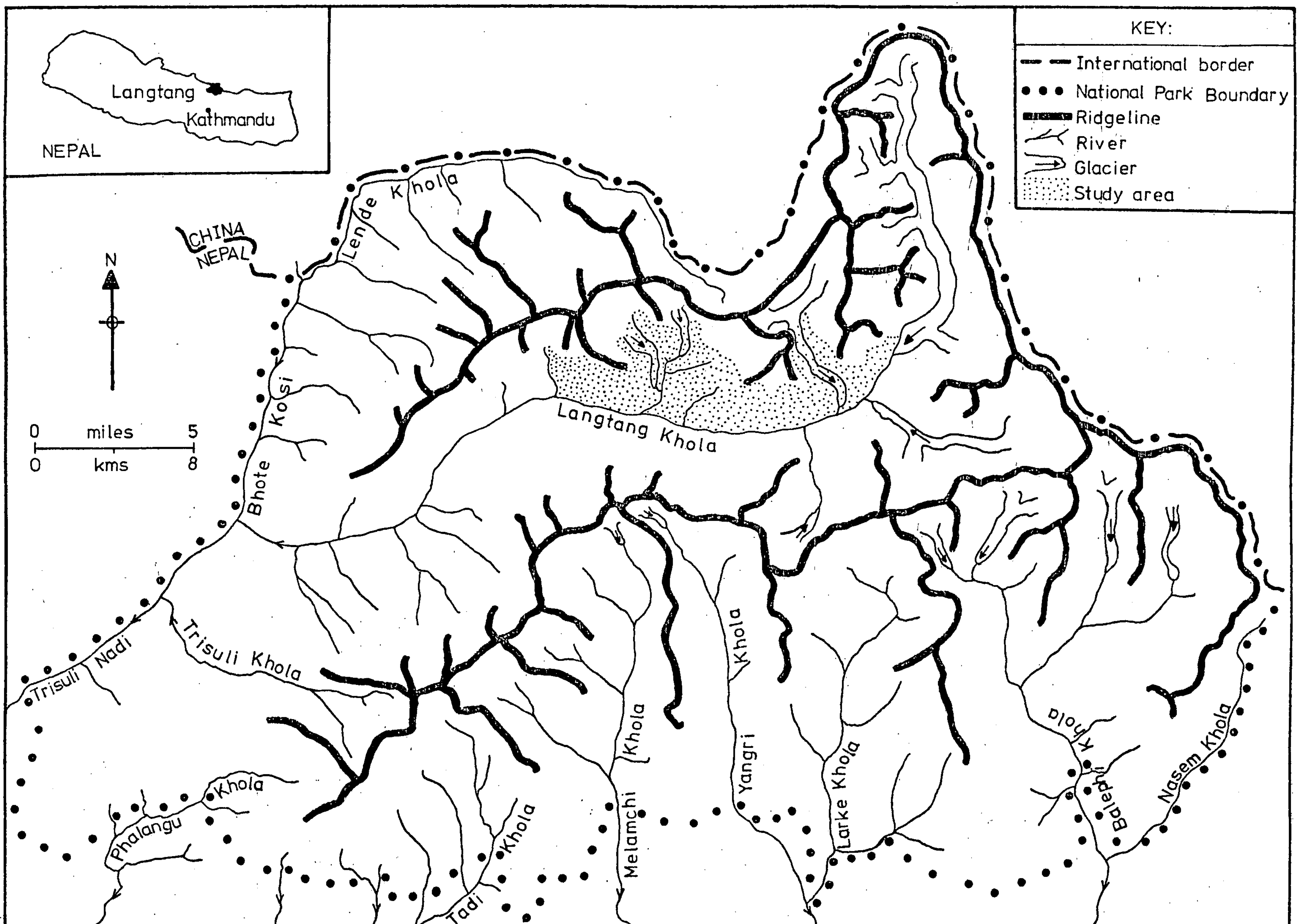


FIG. 1 Map of Langtang National Park. Based on satellite photographs (Fox 1974b).

2. THE PRESENT STUDY

This study of the Himalayan tahr was undertaken as part of the Durham University Himalayan Expedition's (DUHE) research programme in the Langtang National Park, Nepal. DUHE worked in collaberation with the National Parks and Wildlife Conservation Project, Kathmandu, which is supported by His Majesty's Government, the United Nations Development Programme and the Food and Agricultural Organization. DUHE, a privately sponsored and organized venture, spent 15 months in the field and subsequently produced a management plan for the Langtang National Park (DUHE 1977b).

The Himalayan tahr was studied principally in the upper Langtang Valley between April 1976 and April 1977, although a little information presented here pertains to visits to other areas in the Park. During the course of this research certain periods of absence from the study area, lasting several weeks at a time were unavoidable as other unrelated work had to be undertaken for DUHE. Also periodic visits to Kathmandu were necessary, both to replenish food supplies and for official matters.

2.1 Langtang National Park

The Park was officially established in April 1976. It is about 1,710km^2 in area and lies approximately between latitudes 28°N. and 28°20'N. and longitudes 85°15'E. and 86°E., extending from just 32km north of Kathmandu right up to the Chinese (Tibetan) border (Fig. 1). A road runs northwards from Kathmandu to Trisuli. Thereafter it is necessary to walk and Langtang Village can be reached by the fifth day. Altitudes range from 792m to 7,245m. The highest peak in the Park, Langtang Lirung (7,245m), is visible from Kathmandu. The climate is monsoonal, becoming progressively drier northwards. Eight vegetation zones, ranging from upper tropical to upper alpine, are present (Dobremez, Jest, Toffin, Vartanian and Vigny 1974). Some 1,000 plant, 160 bird and 30 mammal species are known to occur within the Park (DUHE 1977b).

The mammals of the Nepal Himalaya[1] are a mixture of species derived from the Oriental (i.e. India and S.E. Asia) and Palaearctic regions (i.e. Eureasia excluding S.E. Asia). Caughley (1969) reported that, "The number of mammalian species in the Himalaya of central Nepal is lower than that to its east and west ... The red deer occurs in Kashmir and Bhutan but does not occur in the Himalayan zone between. Similarly, the marmot occurs in west Nepal and Sikkim but is missing in the intervening range. The distributions of several hoofed mammals that occur in the western Himalaya of Ladak, Kashmir and Kumaon (the ibex, markhor, wild goat and urial) halt short of Nepal. Likewise the takin of the Bhutan Himalaya east of Nepal does not extend into the Nepal Himalaya. None of these species is replaced by an ecologically equivalent form in Nepal." According to Caughley (1969), this species gap in the central region of Nepal may be "... the result of a forked post-Pleistocene route of dispersal from the north ..." Most mammalian species present in Nepal are Oriental. Although Das (1966) refers to the Himalayan tahr as being a Palaearctic species, Caughley (1969) maintains that this species was present in two or more faunal regions, which concurs with the fossil evidence of a formerly more widespread distribution (Schafer 1950).

1 This biotic province is defined as the Himalayan-Karakoram by Dasmann (1973).

The Himalayan tahr and the common langur (<u>Presbytis entellus</u>) are probably the commonest species of the larger mammals which occur within the Park. Caughley (1969) considered the tahr to be the "... dominant[1] species of the sub-alpine zone of the Nepal Himalaya.", although the Himalayan musk deer (<u>Moschus moschiferus moschiferus</u>) may once have been as numerous. Populations of this primitive cervid have been drastically reduced throughout the Park, and elsewhere in Nepal, due to intense hunting for its valuable musk (Green 1978). Other ungulates occurring in the Park are the brown goral (<u>Nemorhaedus goral</u>), muntjac (<u>Muntiacus muntjac</u>), serow (<u>Capricornis sumatraensis thar</u>) and wild boar (<u>Sus scrofa</u>). The abundance of these other species has diminished as a result of hunting and habitat removal. The only wild ungulates which occur above about 3,400m are tahr and musk deer. However, their habitats are ecologically different as musk deer, which occur up to about 4,300m, predominantly occupy birch-rhododendron forest and rhododendron scrub. Below 3,400m ecological separation from other wild ungulate species is shown by the tahr's preference for cliffs. In some parts of their range tahr compete directly with livestock for food.

The Park's human population is estimated to number 4,300 residents. However, its natural resources are used by about 16,250 people, since many non-residents enter the Park from peripheral areas to the south and west. Livestock are also brought into the Park from outlying districts in the monsoon. Considerable areas of forest have been cleared throughout the Park for agricultural, pastoral, timber and fuel requirements. Moreover, regeneration of the forest is impaired by the perpetual grazing of its understorey by livestock. The advent of tourists and pilgrims to the area has accelerated this degenerative

1 "Dominant is interpreted as meaning "most abundant".

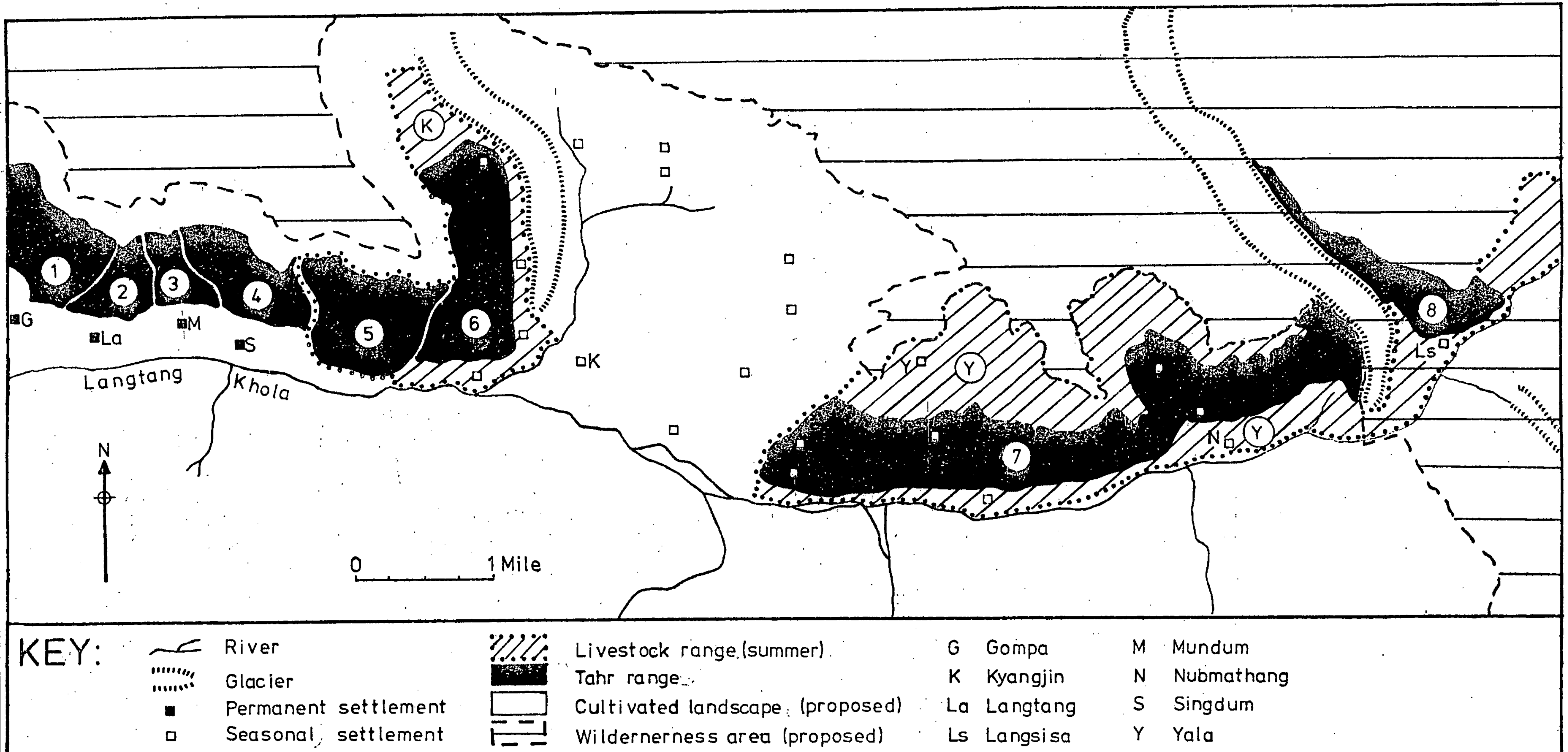


FIG. 2 Map of upper Langtang Valley showing livestock and tahr ranges. Based on One Inch Survey of India Series 1956-66.

process since visitors, together with their accompanying porters and sherpas, require fuelwood for cooking and warmth. At present about 2,000 tourists annually visit the Park and a much greater number of pilgrims attend religious festivals within its confines (DUHE 1977b).

2.2 Description of the Study Area

The Langtang Valley is east-west orientated and lies within the Inner Himalayas. In its upper section to the east, that is above 3,000m, it has a U-shaped cross-section which indicates that it was once glaciated. Much of this region has been settled for some 300 years by people of Tibetan origin. Today 69 households are dispersed among the permanent settlements at Gompa, Langtang, Mundum and Singdum (Fig. 2). On average there are 5.1 people per household (DUHE 1977b). Higher up the valley there are numerous temporary settlements, locally known as goths. These are occupied for periods of time of varying length during the summer by local residents when they take their livestock up to the alpine pastures.

The floor of the Langtang Valley probably used to be forested up to 3,900m, as far east as Kyangjin (Fig. 2). This forest no longer extends above 3,000m, a point five kilometres west of Langtang Village. The intervening land between this point and Kyangjin is largely cultivated.

The north-facing sides of the upper Langtang Valley are forested up to 4,100m by birch (<u>Betula utilis</u>) and rhododendron (<u>Rhododendron campanulatum</u>), providing typical musk deer habitat. These slopes are much less precipitous than the south-facing cliffs on the opposite side of the valley, which are bare except for some forested gullies.

PLATE Ia The main grazing grounds, a 30-35° slope (foreground), in Area 1 with moraines, glaciers and the peak of Ghenge Liru (6,581m) behind.

PLATE Ib The east-facing cliffs, northwest of Kyangjin, in Area 6 with lateral moraines in the foreground.

Two populations of tahr were present in the upper Langtang Valley during the study period. One, which is called the Langtang population, frequented the south- veering to east-facing cliffs between Langtang Village and Kyangjin. The other, which is referred to as the Yala population, occupied a similarly orientated range of cliffs from east of Kyangjin to the Langsisa goth (Fig. 2). Most time was spent studying the Langtang population, in particular that portion which ranged in Area 1 (Fig. 2). The main grazing grounds in Area 1 consists of a relatively uniform 30-35° slope which lies about 600m immediately behind and above Langtang Village and extends from about 4,100m to 4,600m (Plate Ia).

2.2.1 Habitat types

In the upper Lantgang Valley tahr were observed in the following variety of vegetation types described by Dobremez et al (1974):

3,500-3,600m (Lower Subalpine)	Dense thickets of *Caragana nepalensis* (dominant species), *Berberis* spp., *Rosa* spp. and *Rhodendron lepidotum* covering the lower slopes. This is believed to be a plagioclimax community where the forest has disappeared and overgrazing by livestock has occurred for many years.
3,600-4,000m (Upper Subalpine)	Precipitous cliffs sparsely covered with vegetation. Forbs, grasses and sedges restricted to ledges and crevices. *Juniperus* spp. and *R. lepidotum* present on gentler slopes.
4,000-4,300m (Lower Alpine)	On drier south-facing slopes the dominant shrubs are *Cotoneaster microphylla*, *Ephedra gerardiana*, *Juniperus* spp. (e.g. Area 1 in Fig. 2). *R. anthopogon* and *R. setosum* predominate on damper, east-facing slopes (e.g. Area 6 in Fig. 2). Forbs are common; tussocks of grasses and sedges are abundant.
4,300-5,000m (Upper Alpine)	Forbs, grasses, sedges and cushion plants are common.

Outside the main study area, in the lower Langtang Valley, tahr were also seen in Abies spectabilis and Quercus semecarpifolia forests which are part of the subalpine and montane zones, respectively.

2.2 Climate

Meteorological recordings were taken in Langtang Village (3,429m) throughout the study period. Monthly precipitation is given in Figure 3 and mean maximum and minimum temperatures in Figure 4. Fuller details appear elsewhere in the reports of DUHE (1976a, 1976b, 1977a).

Precipitation was greatest between June and September (Fig.3). Being an Inner Himalayan Valley, shielded from southerly airstreams by a major ridge to the south (Fig. 1), Langtang experienced the monsoon later and for a shorter period than areas further to the south of Nepal and the amount of precipitation was less. In Langtang Village 1,027.4mm was recorded over a twelve month period, June 1976-May 1977, less than a third of the mean annual precipitation of 3,363.0mm at Sermathang in 1973-76, which lies at 2,625m, just outside the Park's southern border.

Between the beginning of June and the end of October the mornings were often clear but by midday low cloud from the west completely enshrouded the valley. For this reason it was seldom possible to observe tahr after midday between June and September. Occasionally cloud cover was total on consecutive days (e.g. 12-14 May, 16-18 August) with visibility reduced below 100m. Visibility was worst in August when low cloud often obscured the south-facing cliffs by 0930 hrs. Mean maximum temperatures reached a peak in June and July (Fig. 4). The maximum daily temperature was highest, 21°C on 8 July.

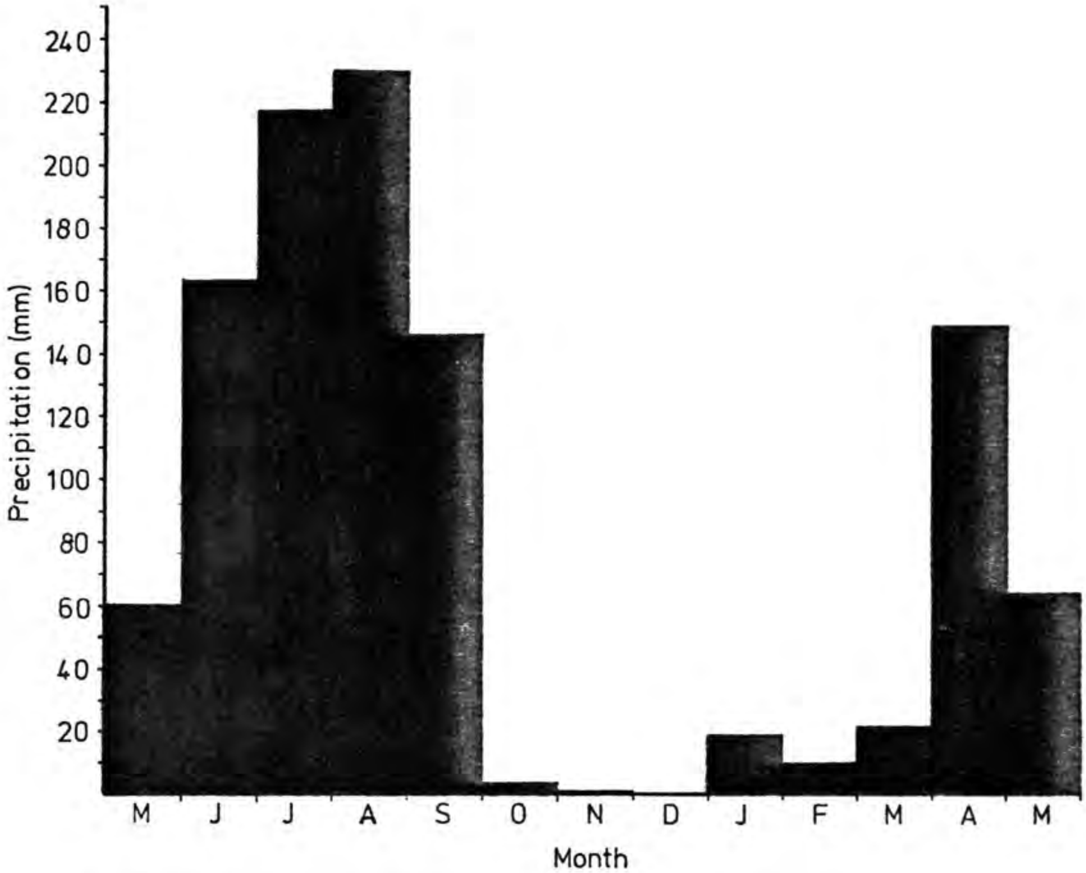


FIG. 3 Total monthly precipitation at Langtang Village (May 1976 - May 1977).

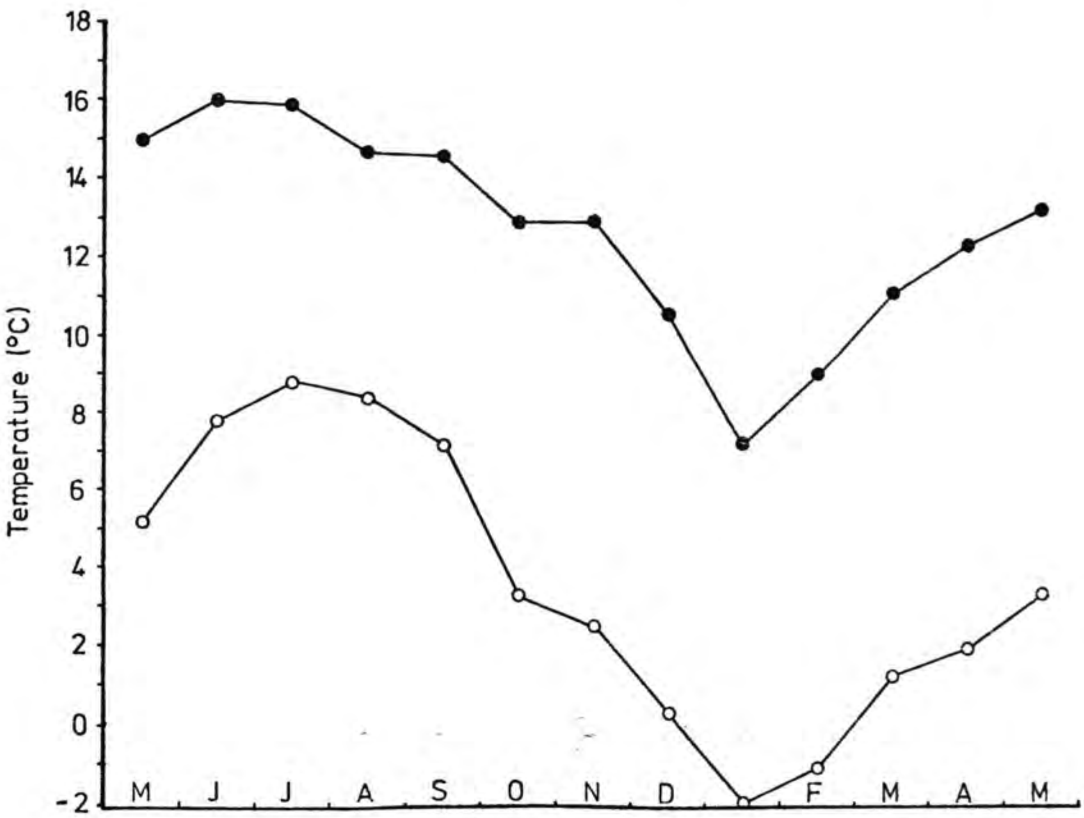


FIG. 4 Mean maximum and minimum temperatures for each month at Langtang Village, May 1976 - May 1977.

●—● maximum temperature

○—○ minimum temperature

By the end of September the vegetation, particularly grasses and sedges, had turned brown. Within Areas 1-6 only Caragana nepalensis remained green, apart from a few evergreens such as Cotoneaster microphylla and Juniperus spp. Towards the end of October the weather became progressively finer, and throughout the autumn and winter clear blue skies predominated. Precipitation only occurred once between 8 October and 19 January. Reduced glacial melt-water, combined with the lack of precipitation, caused many small streams to dry up. Heavy snow is normally expected towards the end of November but in the winter of 1976-77 the first snow fell near the end of January. Snow which fell overnight usually melted by midday, except on north-facing slopes where it tended to accumulate because of less insolation. In summer the snowline was at about 5,500m; in winter little snow settled below 4,000m. Mean maximum and minimum temperatures were lowest between 15 January and 13 February, when the temperature regularly dropped below freezing point at night and never exceeded 10^{o}C in the day. Minimum daily temperatures were lowest, -7^{o}C, on 28, 29 and 30 January and 6, 7 and 8 February. According to locals this winter was particularly mild.

Maximum and minimum temperatures began to rise significantly in March. The first green shoots were noticed on 16 March following a heavy bout of rain. Spring 1977 was atypical, due to a period of exceptional cold with rain and snow in late April and early May. The precipitation recorded in April 1977 (149.0mm) was characteristic of a monsoon month and, in fact, approached that for June 1976 (163.8mm).

3. METHODS

3.1 Fieldwork

Tahr were often viewed on the south- and east-facing cliffs from the floor of the Langtang Valley, using binoculars (8 x 30) to locate them and a zoom telescope (x 15 to x 60), mounted on a tripod, for more detailed observation. In this manner it was possible to observe individuals from up to 1,500m away, although recognition of specific age and sex categories was not necessarily achieved at this distance.

Following the end of the monsoon, the Langtang population was regularly censused each month by walking up the valley from Langtang Village to northwest of Kyangjin and back on the same day or a few days later, scanning the south- and east-facing slopes en route. In order to standardize the method and to minimize observer bias, this section of cliffs was divided up into six areas (Fig. 2) which were easily defined by natural landmarks such as streams, screes and bluffs. Vantage points along the valley floor were selected for surveying the respective areas for about 10 minutes each. If a group of tahr was sighted it was then watched for at least half an hour, in order to determine its size as accurately as possible. The distance covered on foot was about eight kilometres and a census took from between two to eight hours each way. Normally the south-facing cliffs were surveyed by midday, en route up-valley, and then the east-facing cliffs, northwest of Kyangjin, were scanned in the afternoon. In a thorough survey of all six areas in the same day census work could not be confined to the early morning and late afternon, although at these times tahr tended to be more active and, therefore, easier to see than during the middle of the day. In the monsoon poor visibility precluded complete surveys of all the areas within one day.

Visibility permitting, the following age and sex categories, based on descriptions by Schaller (1973) and Tustin (pers. comm.), were recognized:-

i. Mature males (Class III) (more than 4 years old) These are handsome animals (Plate Va) with their narrow, black face and conspicuous ruff and mantle of flowing hair which drapes from the neck, shoulders and chest down to the knees, and from the back and rump down to the flanks and thighs. The ruff and mantle tend to be straw-coloured. The rest of the body is dark copper brown, except for a lighter underside, a rusty rump patch and a dark mid-dorsal stripe. The horns are dark and distinctly corrugated.

ii. Young adult males (Class II) (3-4 years old) These are similar in size to Class III males but are less robust and the mantle along the back is not well-developed (Plate Vb)

iii. Adult females and sub-adults (both sexes) These are similar in size but much smaller than adult males and lack a mantle or well-developed ruff. The pelage is a uniform brown colour apart from a dark mid-dorsal stripe. Class I or subadult males (two to three years old) are lighter in build, darker in colour and have a more conspicuous neck ruff than adult females. Such features were found to be inadequate to distinguish between these two categories with any degree of certainty. Both Schaller (1973) and Tustin (pers. comm.) separate subadult males from adult females on the basis of the above characteristics, although neither distinguish between sub-adult and adult females. In this study adult females were only confidently recognized when accompanied by their young, or observed from close-quarters (Plate IIa).

iv. Yearlings (both sexes) (1-2 years old) No distinction was made between males and females as they are similar in size to each other, although the former have a ruff which is absent in the latter. Yearlings are smaller than adult females-subadults (Schaller 1973) though Tustin (pers. comm.) considers that they "... are very similar to mature females in build and colour and are difficult to tell apart from them in most conditions. The horns are often more solid in appearance and they have not only a ruff around the top of the neck (mature females can have this) but also on the brisket and the top of the shoulders, which the females do not have. They are lighter in colour in the muzzle and the legs than mature females." (Plate IIb).

v.	Young (less than 1 year old)	These are smaller than yearlings but similar in overall appearance. During the first few months after birth the pelage is pale or greyish. (Plate IIIa)

The ease with which the above age and sex categories could be recognized depended very much on light conditions and distances. All five categories were confidently recognized at about 200m; at greater distances it was not always possible to distinguish between Class II and Class III males, or between adult females-subadults and yearlings, in which case these two pairs of categories were amalgamated. Animals were not recognized individually.

It was possible to observe tahr from close quarters on the main grazing grounds in Area 1. This was reached by climbing 300m up a narrow gorge and then ascending a steep slope for a further 300m. Here it was possible to approach tahr to within 200m provided the observer was not scented. When disturbed the tahr left this slope and either moved up onto the adjacent west-facing cliffs or traversed the moraine and glacier to the west (Plate Ia). On a few occasions tahr were stalked to within 50-100m, in order to age individuals by counting the number of growth rings on their horns. Such encounters were brief, as the tahr soon noticed the observer and dispersed. Area 1 was visited from one to five times each month. A total of 31 days and 5 nights were spent there.

A similar procedure was adopted whether tahr were viewed from afar (e.g. the valley floor) or nearby (e.g. Area 1). Once a group had been seen it was watched until either all of its members disappeared from sight or its observation became curtailed by the advent of cloud or darkness. A group seldom remained in sight for a whole day. Group

PLATE IIa An adult female tahr which subsequently fell off a cliff, killing itself.

PLATE IIb A yearling tahr, probably a male owing to its slight ruff.

size and composition were determined whenever possible. Daily movements and behavioural interactions were noted. The former could not be plotted, as there was no large scale map of the upper Langtang Valley. The only available map covering this area was the One Inch to One Mile Survey of India series[1].

The pattern of daily activity was determined by recording, at five minute intervals, the number of animals engaged in particular activities. The number of sightings for each type of activity was lumped together for the six points in each half-hour period and expressed as percentages. The following types of activity were recognized:

<u>Aggression</u>	Various types of aggressive behaviour have been described by Schaller (1973) and more detailed comments appear in Section 5.2.
<u>Courtship</u>	This term is applied exclusively to those sexual displays of adult males which were directed towards females. Various patterns of courtship behaviour have been described by Schaller (1973). During the rut adult males spent a large proportion of their time just standing near females. Although such behaviour was preliminary to courtship, it was recorded as standing. Courtship is discussed in Section 5.3.
<u>Drinking</u>	Tahr often drank from the several streams in Area 1. These flowed the whole year round, whereas all the streams in Area 6 were dry during the autumn and winter. When streams were not nearby tahr drank from water trickling over rock surfaces. This was achieved by cupping the lower lip against the rock face to collect the water, or by lapping it up with the tongue.
<u>Feeding</u>	No distinction was made between grazing and browsing because it was often difficult to determine which plants were being eaten. For example, in thickets of <u>Caragana nepalensis</u> the head of the animal was often out of sight while feeding. At the higher altitudes, at distances exceeding 200m, it was often difficult to determine whether an animal was browsing dwarf shrubs, such as <u>Cotoneaster microphylla</u>,

1 The relevant sheet (No. $71\frac{H}{12}$) was published in 1965 under the authority of the Surveyor General of India. It is not readily obtainable in Nepal.

or grazing tussock grasses because both types of vegetation grew together. Sometimes tahr were recorded feeding from rock surfaces, as it was assumed that they were deriving nutrients from either crustose lichens and mosses or rock salts (Section 6.1). Individuals usually stood in order to feed but sometimes they knelt, reached up on their hind legs or even fed while lying down. Between late October and mid March tahr made large holes (30cm in radius and 15cm in depth) while digging up roots with their hoofs. When foraging in snow the hoofs were used to scrape it aside.

Grooming

Individuals groomed themselves and each other while standing or lying down. Females-subadults often licked the muzzle, flanks or rump of yearlings and young. Reciprocal grooming between individuals of the same age category was observed, but only occasionally was an older individual groomed by a younger one. Hoofs and horns were used to scratch different parts of the body. Individuals also rubbed their horns against rocks, dead juniper bushes and other vegetation. The horns of an old female, which died after a cliff fall, were noticeably worn away at the base, presumably due to continuous rubbing over the years (Plate IVa).

Moving

When on the move tahr normally walked, unless disturbed. While negotiating precipitous terrain, individuals followed each other in single file along definite trails. Tahr were adept at jumping, ascending the steep sides of lateral moraines (Plate IIIa) and crossing icy glacial streams. Tahr of all ages and sexes appeared to enjoy running down smooth rock faces or steep grassy slopes.

Such characteristic prancing was accompanied by a series of twists and jumps in the air, often landing sideways onto the slope. Once an individual appeared to actually summersault in the air. Steep slopes were descended by a series of diagonal turns. Such behaviour was commonest towards late afternoon, when tahr moved downslope.

Standing

This posture, as opposed to lying down, was often adopted between periods of more intense activity. Individuals frequently chewed the cud while standing. Anderson and Henderson (1961) state that tahr commonly post sentinels to warn the others of impending danger. There was no evidence of this social role, as sometimes all the members of a group were either feeding or lying down; none was standing vigilant. Undoubtedly individuals were more watchful while standing than when busy feeding, but so also were they while lying down, unless they had fallen asleep.

The pattern of daily activity of maternal groups (i.e. adult females-subadults, yearlings and young) was recorded throughout the study period. In July, following parturition, the activity of new-born young and in the post-monsoon months, from October until April, that of adult males was recorded independently. Poor visibility during the monsoon, from June until September, handicapped observational work (Section 2.2.2). This precluded any chance of observing mother-young behaviour around the time of parturition.

Few carcasses, skulls or horns were found. A skull and one horn were collected in the field and on one occasion an old female, depicted in Plate IIa, fell off a cliff just behind Langtang Village. By the time it was reached it had been stripped of its meat by locals; only the skull, horns, hide and stomach contents were available for inspection. Its horns and molar teeth were kept for aging.

Each month two to six samples of fresh faeces were collected from Area 1. A sample numbered about six pellets, which were considered to be fresh if still covered with mucus. For fear of disturbing the tahr, it was not practical to follow them in order to collect faecal samples from different individuals. Since the number of samples collected in any one month was small compared with the number of individuals (N=77) known to frequent Area 1, it is likely that each of these in a given month came from a different individual.

Each sample was divided into two sub-samples in the field. These were stored in two different ways in case either one proved unsatisfactory. In the first method the sub-sample was boiled in 10% sodium hydroxide for about 20 minutes to clear the plant fragments. Excess alkali was then decanted and the sub-sample was preserved in 70% ethyl alcohol until analysed. In the second method the sub-sample was baked in the sun for several days until thoroughly dry. It was then stored in a plastic bag and sealed by drawing a hot wire across the opening. Faeces were stored for up to 21 months before being analysed. A few pellets in the plastic bags became mouldy during this intervening period but this was superficial and did not jeopardize identification of the plant fragments. The second method proved to be the more satisfactory way of storing faeces (Section 3.2.2).

A reference collection of the plants growing in Area 1 was obtained to enable plant fragments within the faeces to be recognized. The species in the reference collection were subsequently identified at the herbarium in Kathmandu and at the British Museum (Natural History).

3.2 Laboratory Work

3.2.1 Aging of molars

The first molars were removed from two lower jaws and sectioned vertically using a hack-saw. One face was then polished, using an electric diamond-impregnated grinding stone, and viewed under a binocular microscope with reflected light. This method of aging molars, used for example by Aitken (1975) for roe deer (*Capreolus capreolus*), relies on the formation of distinct layers in the dentine or cementum in response to sharp seasonal changes in climate and, hence, food supply (Rudge 1972).

It was found that layering within the cementum of molar teeth was not distinct but it was prominent within the dentine (Section 4.6).

3.2.2 Faecal analysis

The literature contains a plethora of techniques concerning the analysis of faeces after the pioneering work of Baumgartner and Martin (1939) whereby plant fragments in the faeces were identified by means of epidermal features. Various methods have been reviewed by Hansson (1970), who concludes that volume as well as frequency of occurrence should be estimated because the importance of species occurring as large fragments might otherwise be underestimated and vice versa. This review did not consider the work of Sparks and Malechek (1968) who estimated percentage composition dry weight from recording the frequency of occurrence of plant fragments. It was not necessary to estimate the volume of individual plant fragments, since they were all reduced to a uniform size by grinding over a one millimetre screen. This microhistological technique has been adapted by Hansen (1969, 1977) to determine the botanical composition of faeces and it provides the basis to the present analysis.

Two pellets from each of the air-dried sub-samples were crushed between hard surfaces and their contents crumbled with the fingers. Grinding to a uniform size was not possible in the absence of a suitable mill, but when viewed under a microscope the faecal fragments were found to be of similar sizes, except in the case of mosses. The faeces were heated at 75°C for 12 hours in 20ml Hertwig's solution[1] and then washed gently with warm water over a 0.125mm sieve prior to storing in 5ml glycerol. Heating with chloral hydrate and hydrochloric acid dissolved the starch and rendered the tissue translucent for identification purposes.

The same procedure was also adopted for the sub-samples which had been preserved in alcohol, but it proved unsatisfactory as little

1 Hertwig's solution consists of 500g chloral hydrate, 36ml concentrated hydrochloric acid, 110ml glycerol and 300ml water.

plant material remained by the time that the sub-sample had been cooked in Hertwig's solution and washed over a sieve. Treatment with Hertwig's solution was necessary as previous boiling in the field with 10% sodium hydroxide did not clear the plant fragments sufficiently. It is likely that the plant fragments in these sub-samples were more fragile due to their earlier treatment with 10% sodium hydroxide and their prolonged standing in alcohol.

The plant reference collection was prepared similarly to the faecal material and mounted permanently onto slides. Dried plants were cut up into 1-10mm lengths and treated with Hertwig's solution. One or two hours heating was normally sufficient. Fragments were then mounted onto slides using gum chloral. Staining was unnecessary.

While in the field some fresh plant material was prepared by manually scraping the leaf surface, using dissecting needles and dilute nitric acid to clear the cuticle. Sections were then dehydrated before mounting in DPX.

Slides of the reference plant collection were photomicrographed. Using a pipette, a single drop of the faecal material was placed on a slide and observed under a binocular microscope (x 125). Plant fragments were identified by comparison with the photomicrographs. Epidermal features such as cell size and shape, the distribution of stomata, silica bodies, hairs, short and long cells and the crenellated or uniform pattern of cell walls were used to identify fragments to the level of genus or species. Approximately one hundred fragments were identified in each drop of faecal material, although not always to species level. A single drop was found to be representative of the whole sub-sample. The numbers and types of fragments identified in two drops, taken from the same sub-sample, were tested for heterogeneity using X^2. This was repeated several times with different sub-samples but there was never any significant difference at the 5% level of probability.

4. POPULATION DYNAMICS

A population is considered to be a number of animals which form a discrete breeding unit. In the upper Langtang Valley the areas occupied by the Langtang and Yala populations were separated from each other by a distance of about three kilometres. A small glacial valley crosses the intervening area and terminates in the vicinity of Kyangjin (Fig. 2), which is inhabited by local people with their livestock during the summer and visited by trekkers (tourists) in the other seasons. Any barrier separating the two populations of tahr was likely to be due to human rather than topographical factors. As maternal groups maintained definite home ranges (Section 4.1) and since none was ever seen in this intervening area, it is assumed that the Langtang and Yala populations represented fairly distinct breeding units although lone adult males may have wandered between the two.

The term "herd" is applied to that portion of a population which occupied a specific area for a given period of time and behaved as a unit. With maternal herds this area may be referred to as the home range, since it was occupied throughout the year. This was not the case for adult males, which aggregated into herds and frequented a given area for part of the year only, following the rut. All the members of a herd were not necessarily seen at the same time, since they often split up into "groups". A group is defined after Schaller (1973) as any number of individuals which are separated from other individuals by at least 200m. Groups were fluid social units which often changed in size and composition on a daily basis.

4.1 Population Size

Much difficulty was experienced in accurately estimating the size of the Langtang population. Detailed census data are given in Appendix I. Based on these, several estimates are considered below.

The results of the monthly census of the Langtang population are given in Table 1. These results are inconsistent from month to month. They also vary between up-valley and down-valley surveys which were made within a few days of each other. The importance of censusing tahr in the early morning or late afternoon is exemplified by the mid-day census of 1 March, when no animals were sighted (Table 1). It appears that only once, on 24 February, on an up-valley census, was a large proportion of the population censused. This provides a minimum estimate of 131 individuals.

Table 1: Numbers of individuals counted each month in the Langtang population

UP-VALLEY CENSUS			DOWN-VALLEY CENSUS		
Date	Time (hrs)	No. tahr	No. tahr	Time (hrs)	Date
4.10.76	0715-1440	50	19	0740-1010	8.10.76
4.11.76	0815-1650	20	-	cloud	5.11.76
14.12.76	1115-1700	38	-	dusk	18.12.76
13. 1.77	0945-1530	62	63	0745-1020	16. 1.77
24. 2.77	0850-1740	131	0	1230-1400	1. 3.77
24. 3.77	0800-1645	58	-	dusk	25. 3.77
19. 4.77	0810-1400	57	42	1300-1820	21. 4.77

Apart from the monthly census, tahr were counted in Areas 1-6 during routine observational work on many different occasions each month. Table 2, based on data in Appendix I, shows the maximum numbers of tahr seen simultaneously in each area for every month. Summation of the maximum counts for Areas 1-6, on a monthly basis, provides alternative estimates of the size of the Langtang population. Since areas were not necessarily observed on the same dates as each other, the estimates are liable to be exaggerated because they do not account for the same animals being present and, therefore, counted in more than one area in the same month. No data are available for April 1976. Adult males were seldom seen during the monsoon (Table 7) owing to their being at higher altitudes obscured by cloud. Thus, the estimates for the months of July until October are too low, as adult males were under-represented. They have been corrected by assuming that the proportion of adult males within the Langtang population was 17% during this time (Section 4.5). In May the absence of data for Areas 2-4, which had not been surveyed at that stage of the study, precluded the population's size being estimated. Tahr were never seen in Areas 5 and 6 from July until September. Although poor visibility during the monsoon may have prevented their observation, it is more likely that they had moved westwards into Areas 1-4, following an influx of livestock into Areas 5 and 6 during the middle of June (Section 4.2).

Table 2: Estimates of the size of the Langtang population, based on the maximum number of animals seen in different areas each month

Month	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Estimate	Corrected Estimate
May	56 (29)	NC	NC	NC	0	43 (21)	99+	99+
June	48 (21)	22 (16)	17 (22)	0	0	37 (8)	124	124
July	*58 (12)	16 (16)	30 (27)	0	0	0	104	125
Aug	64 (19)	*41 (15)	17 (20)	*4 (20	0	0	126	152
Sept	38 (30)	37 (29)	*22 (28)	0	0	0	97	115
Oct	66 (11)	*27 (25)	*22 (1)	0	7 (4)	19 (8)	141	163
Nov	42 (30)	19 (29)	12 (30)	0	0	12 (5)	85	85
Dec	67 (30)	0	13 (20)	32 (8)	15 (14)	9 (14)	136	136
Jan	81 (8)	* 6 (7)	*33 (16)	40 (12)	28 (13)	6 (15)	194	194
Feb	77 (19)	27 (24)	15 (23)	38 (22)	0	16 (24)	173	173
Mar	*58 (24)	18 (16)	14 (18)	*19 (18)	4 (8)	13 (8)	126	126
Apr	82 (8)	0	9 (21)	22 (19)	0	*14 (20)	127	127

NOTES:
i. Brackets indicate date of census.
ii. Asterisks indicate that more animals were known to be present than were actually counted.
iii. NC means not censused.

A more reliable estimate of the size of Langtang population was achieved on 21-24 February, when tahr were repeatedly counted in Areas 1-6. The relevant data from Appendix I is presented in Table 3. As fairly consistent numbers of tahr were seen in the same areas over several consecutive days, it is reasonable to assume that most of the population was censused and that duplicate counts, due to individuals frequenting more than one area during the census period, were minimal. On 19 and 21 February Area 1 was visited and the group(s) were censused from close-quarters. Unfortunately, on subsequent days, Area 1 had to be surveyed from the valley floor, in order to census the other areas, and a large number of individuals were not counted because they were hidden from sight. Summation of the maximum number of animals counted in each area provides an estimate of 173 tahr. This is considered to be the most reliable estimate of the Langtang population since it is based on repeated census within a short time period. Although the estimate may be slightly exaggerated, resulting from duplicate counts of individuals, such an effect is probably counterbalanced by a small number of animals which may have been missed during the census.

Table 3: Estimate of the size of the Langtang population, based on the number of animals counted in different areas between 21 and 24 February

Date	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Total
19.2.77	77	NC	NC	NC	NC	NC	77
21.2.77	77	NC	NC	NC	NC	NC	77
22.2.77	*45	17	6	38	NC	NC	106
23.2.77	*46	21	15	*16	NC	NC	98
24.2.77	*41	27	12	35	0	16	131
Maximum count	77	27	15	38	0	16	173

NOTES:
i. Asterisk indicates that more animals were known to be present than were actually observed.
ii. Underlined is the maximum number of animals censused in each area.
iii. NC means not censused.

Although the Yala population was infrequently surveyed, it was much easier to census than the Langtang population on account of its smaller size. Also members of the Yala population tended to be less dispersed. The population frequented Areas 7 and 8 but only adult males were ever seen in Area 8. Census data for the Yala population appears in Appendix I. On 21 April 1977 a total of 46 tahr were seen in two groups of 40 and 6 in Areas 7 and 8, respectively (Appendix I). It is likely that the whole population was counted on this date, bar the odd lone individual, as locals and D. Miller (pers. comm. 1976) had repeatedly reported seeing up to 40 tahr in Area 7.

4.2 Home Range

Home range is a concept which is used for convenience to describe the area within which an animal, or group, pursues its routine activities such as eating, sleeping, mating and caring for the young (Burt 1943). It differs from a territory which is an actively defended area.

It was not possible to determine the size of an individual's home range, by mapping its movements, because animals were not individually recognized. However, various herds became familiar to the observer during the course of the study as they could invariably be found within certain well-defined areas. The sizes of these areas, together with the mean numbers of animals observed within each during the study period, are given in Table 4. Summation of the means for each area gives a total of 113.2 for the size of the Langtang population which is much lower than the estimate of 173 (Section 4.1). In order to calculate mean density from the mean number of animals observed in each area, the latter values were corrected by a factor of 173/113.2 (Table 4).

Being the main study area, Area 1 was observed more frequently than any of the other areas. It was frequented by a large herd which numbered up to 77 individuals on 19 and 21 February (Appendix I). At least 38 animals, or about a half, of this herd were seen in Area 1 at some time every month. In December and February at least 40 tahr were seen in this area on 13 out of 15 occasions (Appendix I). The regularity with which a large proportion of this herd was observed in Area 1, combined with the fact that animals were seldom seen to enter or leave it, indicates that Area 1 formed a major portion of the herd's home range.

Table 4: Mean number and mean density of animals in Areas 1-6 (Langtang population)

AREA	1	2	3	4	5	6	TOTAL
Mean no.	32.3	17.2	11.3	23.8	11.0	17.6	113.2
Mean no. (corrected)	49.4	26.3	17.3	36.4	16.8	26.9	173.1
Area km^2	1.28	0.57	0.42	1.06	1.57	2.02	6.92
Mean no. km^{-2}	38.6	46.1	41.2	34.3	10.7	13.3	25.0
No. observations	95	20	33	15	5	28	196

Individuals in Areas 2-6 were observed less often and, consequently, their movements were not so well known. It was unknown whether they all belonged to the same or different herds. Table 4 indicates that the mean density of tahr in Areas 5 and 6 was much lower than in Areas 1-4. This difference is explained by the fact that maternal and adult male groups only occupied Areas 5 and 6 for part of the year. In the monsoon the occupation of the lower slopes in Area 6 and, to a lesser extent, Area 5 by livestock resulted in the tahr dispersing elsewhere. On 10 June 40 tahr were seen in Area 6. Between 16 June and 1 September this area was repeatedly used by locals for grazing their livestock. Apart from two lone adult males, no tahr were seen again in Area 6, which was twice visited in the monsoon, until 8 October, when a maternal group of 18 tahr was sighted. During the rut, from November to February, only small groups (Nmax. = 12) were ever seen in Area 6 (Appendix I), which suggests that the main rutting ground was in Area 5. A large mixed group of 28 tahr seen in the latter area on 13 January supports this notion.

A herd of adult males, numbering about 19 members, was first located in Areas 5 and 6 on 24 April 1976 as a group of 18 individuals. It was seen twice again in May, numbering 17 and 18 individuals and early in June, numbering 10 individuals. On 10 June a mixed group of 33, which included 18 adult males, was seen in Area 6. On this occasion the adult males tended to feed apart from the rest of the group and 15 of them subsequently moved elsewhere. Thereafter, the adult males were never seen together again until the following year on 24 February, when a group of 16 individuals was sighted. In March and April 1977 13 and 14 members of the herd, respectively, were seen. In the rut members of this herd must have joined maternal groups either in Area 5 or further to the west. Several reports indicate that the location and size of the herd had changed little over the past few years. The manager of the cheese factory at Kyangjin reported seeing 16-17 tahr regularly between 0800 hrs. and 0900 hrs. as they moved northwards, along the contours, from Area 5 to Area 6. M. Bolton (pers. comm.) saw a group of 10-15 tahr in this vicinity in March 1974. The east-facing slopes of Area 6, where this male herd was commonly seen from Kyangjin, are shown in Plate Ib.

The Yala population occupied a total area of $6.72km^2$. In Area 7 ($5.59\ km^2$), which approximated to the home range of about 40 animals, tahr occurred at a density of $7.2km^{-2}$. This lower density is of a similar order of magnitude to that of the Langtang population in

Areas 5 and 6 (Table 4). It may likewise be explained by the fact that the alpine pastures were grazed by livestock in the monsoon between 25 June and 1 October. Only adult male tahr were ever observed in Area 8 which was 1.13km^2 in area. A herd, numbering up to 6 individuals, was seen in this area between late February and late April 1977. In the monsoon the lower slopes of Area 8 were grazed by livestock from 13 August until 1 October. The adult male herd either dispersed or moved elsewhere prior to the influx of locals and livestock because it was not seen in the vicinity on 18 June.

From the preceding information it is evident that maternal herds occupied the same home ranges throughout the year, unless disturbed by locals with their livestock. Adult males seemed to spend the spring season, following the end of the rut and prior to the monsoon, in all-male herds which ranged within fairly well-defined areas. In the case of the Langtang population the adult male range was also used by maternal herds but in the Yala population it was exclusively occupied by adult males. Both Langtang and Yala adult male herds ranged at a density of 5.3km^{-2}. In the monsoon adult males remained at higher altitudes, possibly wandering more extensively in this season, and then joined up with maternal herds for the rut (Section 4.4). The density of tahr was lowest in areas which were also used by livestock for part of the year. This is discussed further in Section 7.

4.3 Group Size

During the study period 239 sightings of groups, observed in Areas 1-8, were classified according to group size (Appendix II). Only the initial group size was recorded; subsequent changes in group size, due to animals entering or leaving a group within the period of observation, were not incorporated into the data in Appendix II.

Separate statistical treatment of group size for the Langtang and Yala populations was not justified, in view of the small number of sightings of Yala groups (N=16).

The frequency with which different sized groups were observed is shown in Figure 5. The most frequently observed category of group size comprised one to three individuals, of which lone individuals were the most numerous (Appendix II). A convenient measure of the amount of time which tahr spent in different categories of group size is obtained by dividing the number of animal sightings for each category of group size by the total number of sightings and expressing the fraction as a percentage, as in Figure 6 which is based on data in Appendix II. This shows that tahr spent 70% of their time in groups of size 1-40 and 30% in groups exceeding 40 individuals.

Groups numbered up to 77 individuals with a mean at 14.8. Based on data in Appendix I, Table 5 shows the mean, with 95% confidence limits ($\pm$2SE), and range of group size for different months.

Table 5: Mean and range of group size for each month

Month	No. group sightings	No. animal sightings	Mean group size	Range
April	14	138	9.9 ± 3.8	3 - 21
May	20	339	17.0 ± 6.5	1 - 56
June	25	394	15.8 ± 6.1	1 - 48
July	16	215	13.4 ± 6.2	1 - 35
August	18	377	20.9 ± 10.5	1 - 64
September	16	174	10.9 ± 4.2	1 - 27
October	23	274	11.9 ± 8.0	1 - 66
November	17	204	12.0 ± 6.6	1 - 42
December	16	304	19.0 ± 11.3	1 - 67
January	16	286	17.9 ± 8.4	1 - 58
February	16	394	24.6 ± 11.0	7 - 77
March	24	177	7.4 ± 3.7	1 - 49
April	18	269	14.9 ± 8.7	1 - 59
TOTAL	239	3,545	14.8 ± 2.0	1 - 77

NOTE: Mean values are given with 95% confidence limits ($\pm$2SE). Standard errors are corrected for small sample size, where N is less than 30, using Student's t- distribution.

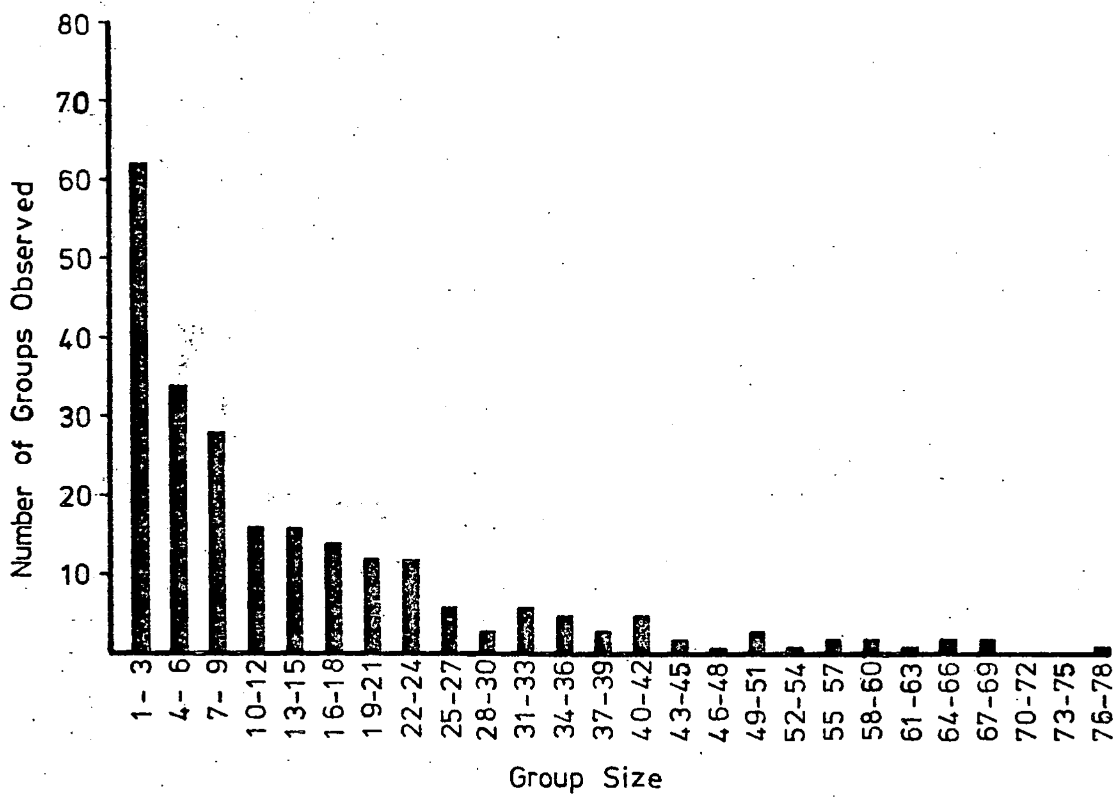


FIG. 5 Frequency of group sizes observed (April 1976-April 1977).

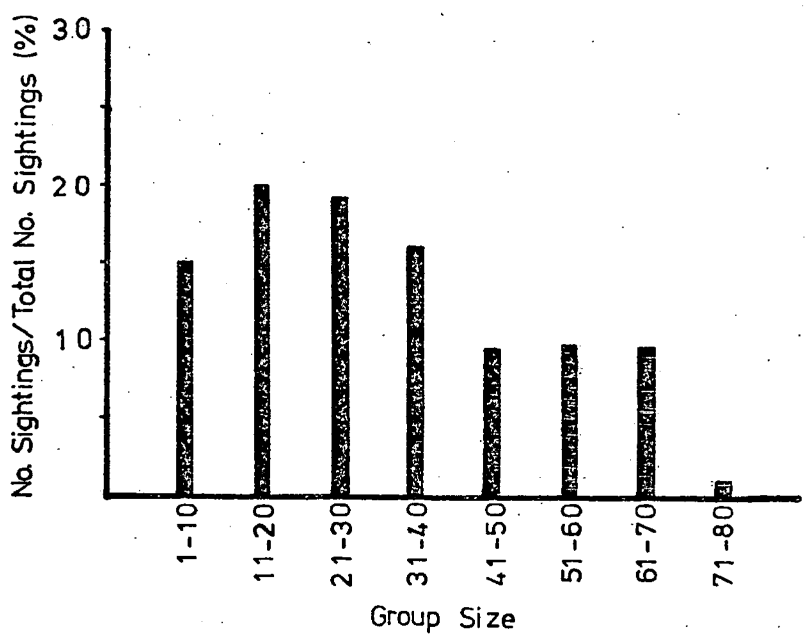


FIG.6 Proportion of animals sighted for different categories of group size.

There was no obvious trend in mean group size with the time of year. Groups might be expected to have been significantly larger in size between November and February, when adult males joined maternal groups, but the data do not justify this supposition in view of the large standard errors of the means. Although mean group size was highest by the end of the rut, in February, it was also quite high during the monsoon, in August.

A further test, using X^2, was used to determine whether or not there were significant seasonal differences in group size. It was necessary to amalgamate months into three seasons (pre-parturition, post-parturition and the rut) and group sizes into five categories for statistical purposes. Details appear in Appendix III. There is no significant difference in the number of sightings of each category of group size between the three different seasons ($X^2 = 7.27$; d.f.= 8; $P > 0.50$).

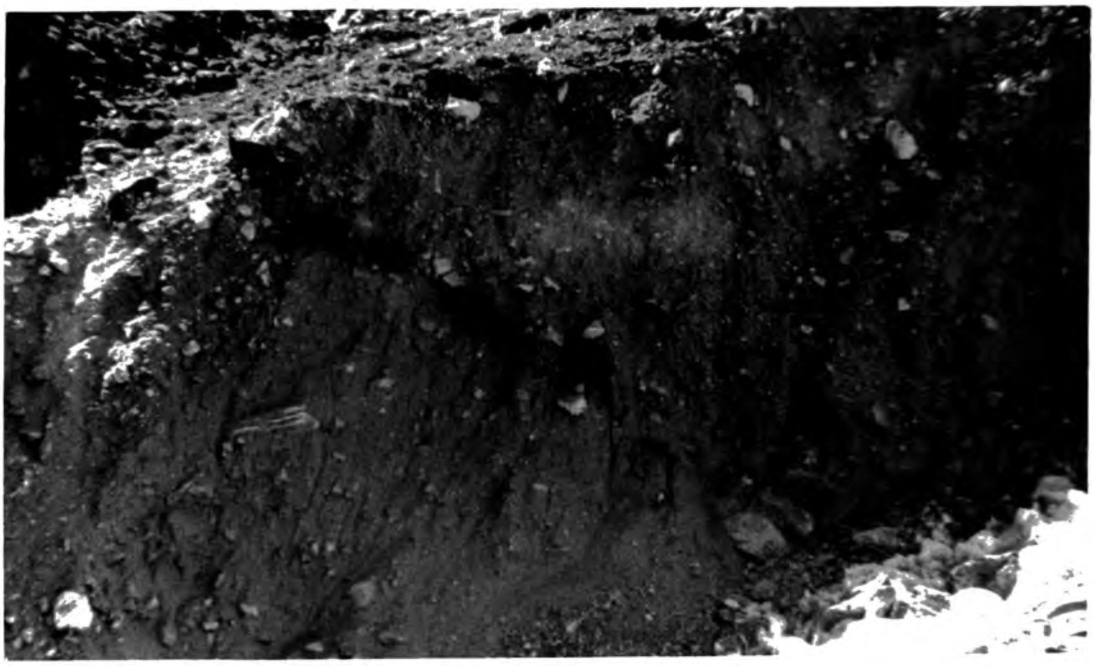
Groups were often seen to split up or merge with each other during the day. For example, on 4 May a group of 32 tahr was first sighted at 0600 hrs. in Area 1. By 1135 hrs. the group had subdivided into units of 12 and 20 individuals which later rejoined each other at 1330 hrs. On another occasion, 6 September, two groups numbering 6 and 13 individuals were watched at 0830 hrs. while they ascended the south-facing cliffs at the foot of Area 1. By 0900 hrs. they had merged into a single group; thereafter, they were obscured from sight by low cloud. In general groups often dispersed while foraging during the day but tended to converge with each other towards late afternoon.

4.4 Group Composition

Members of a group were classified into age and sex categories whenever possible. Of 238 groups, 14.3% consisted of adult males only

PLATE IIIa Female tahr, followed by their young, ascending the steep sides of a lateral moraine.

PLATE IIIb A mixed group of tahr with adult females, juveniles and a Class II adult male (seventh from the top).



(adult male groups), 36.6% lacked adult males (maternal groups) and 49.2% comprised adult males together with other age and sex categories (mixed groups). The incidence of adult male, maternal and mixed groups varied seasonally (Table 6). Mixed groups were most frequently observed during the rut (Plate IIIb), between November and February, and never seen in the monsoon months of July, August and September. The incidence of adult male groups was low during the rut but misleadingly lower in the monsoon, when they were under-represented (Section 4.1).

Table 6: Number of sightings of adult male, maternal and mixed groups each month

Month	A	M	J	J	A	S	O	N	D	J	F	M	A	Total
Ad. male	4	4	1	0	0	1	7	4	2	2	5	2	2	34
Maternal	6	8	11	16	20	16	15	3	0	0	0	12	10	117
Mixed	0	3	8	0	0	0	2	13	19	19	11	3	9	87
TOTAL	10	15	20	16	20	17	24	20	21	21	16	17	21	238

Maternal groups predominated over mixed groups outside the rutting period. The ratio of maternal to mixed groups was tested for homogeneity using X^2 and found to differ significantly between months (X^2 = 129.79, d.f. = 12, $P < 0.001$). During the monsoon, which was also the time of parturition, adult males ranged separately from females and juveniles; not once was an adult male seen anywhere near a maternal group. Mixed groups were predominant in December and January which, therefore, was likely to have been the peak period of the rut. During the rut adult males were occasionally seen alone, or in pairs, but never in large all-male groups. Towards the end of February adult males were seen together in large groups and by March more maternal than mixed groups were recorded. However, adult males did not entirely disassociate themselves from females and juveniles until about mid-June, possibly with the onset of parturition.

Of 37 sightings of lone individuals, 13 were of adult males, 11 were of adult females-subadults, 2 were of yearlings and the rest were unknown. Of 18 sightings of pairs, 5 were of adult male groups; 7 were of a female and her young and 1 was of an adult female-subadult with a yearling; the others were unknown. Sightings of small groups, numbering three to five individuals, comprised adult males on 5 out of 32 occasions and adult females with juveniles on 12 occasions, while groups of adult females-subadults and yearlings were each seen once and mixed groups, once with two adult males, six times. The composition of the other groups was not determined. Subadults and yearlings tended to remain with females, rather than aggregate in large groups of their own although, in June, eight yearlings were seen with six Class II males and on another occasion, in November, a Class III male was seen leading 12 yearlings and a subadult.

4.5 Population Structure

Tahr were aged and sexed according to the categories described in Section 3.1. The relevant data are given in Appendix I. As females were not often confidently distinguished from subadults, population structure can only be crudely estimated by extrapolation.

Data from Appendix I, relating to the Langtang population, are summarized in Table 7, which shows the numbers of adult males, adult females-subadults-yearlings and young observed each month. During the pre-parturition period (April-June) young, which were approaching one year old, were not consistently distinguished from yearlings owing to inexperience. Also, it was not always possible to separate these two categories of juveniles at other times of the year when observed at distances exceeding 1,000m. Such sightings are entered into column five of Table 7. Estimates of the proportion of

Table 7: Numbers of adult males, adult females-subadults-yearlings and young recorded each month (Langtang population).

Month	Ad.males	F-S-Yl	Yo	F-S-Yl-Yo	Yo/F-S-Yl	Total
Apr	17(32.1)	?	?	36	-	53
May	48(21.8)	?	?	172	-	220
June	45(14.2)	?	?	271	-	316
July	0 -	206	64(23.7)*	0	(23.7)	270
Aug	0 -	324	106(24.7)*	22	(24.7)	452
Sept	2 -	114	53(31.4)*	36	(31.7)	205
Oct	11 -	207	81(27.1)*	21	(28.1)	320
Nov	31(13.7)	138	37(18.0)	20	(21.1)	226
Dec	73(15.1)	127	51(20.3)	232	(28.7)	483
Jan	68(20.1)	120	53(22.0)	97	(30.6)	338
Feb	65(22.3)	162	59(20.6)	6	(26.7)	292
Mar	19(12.9)	98	30(20.4)	0	(23.4)	147
Apr	45(16.7)	162	36(14.8)	26	(18.2)	269

NOTES: i. F, S, Yl and Yo mean adult females and subadults, yearlings and young of both sexes, respectively.
ii. Brackets indicate percentages.
iii. Asterisks indicate percentages which are exaggerated because adult males were under-represented.

adult males within the Langtang population vary between about 13% and 22% for different months, apart from April 1976. This high estimate of 32% might be due to small sample size (N=53). No estimates are presented for the period July-October because adult males were under-represented (Section 4.1). In view of this biased sampling, estimates of the proportion of young within the population are exaggerated for these months. In the other months these estimates vary between 18% and 22%, except in April 1977 which is unaccountably lower. Alternatively, the number of young can be considered in relation to the number of adult females and juveniles, as in column six of Table 7. Although estimates of the proportion of adult males and young fluctuate from month to month, no trend is apparent. For instance, the ratio of young to adult females and juveniles might be expected to be lower in the months following parturition as a result of high mortality, but this is not evident.

In Table 8 the data from Table 7 is presented on a periodic basis, having amalgamated the months into pre-parturition, post-parturition and rutting seasons. The ratios of adult males to non adult males do not differ significantly between the three periods for which data are complete ($X^2 = 1.89$, d.f. = 2, $P > 0.30$). Likewise no significant difference exists between the ratios of young to adult females and juveniles for those periods in which the relevant data are present ($X^2 = 5.76$, d.f. = 2, $P > 0.05$). It is concluded, therefore, that these two age and sex categories remained constant throughout the year.

Table 8: Numbers of adult males, adult females-subadults-yearlings and young recorded each season (Langtang population)

Season	Ad. males	F-S-Yl	Yo	F-S-Yl-Yo	Yo/F-S-Yl	Total
Pre-part. (Apr-June)	110(18.7)	?	?	479	-	589
Post-part. (Jly-Oct)	13 -	851	304(26.0)*	79	(26.3)	1,247
Rut (Nov-Feb)	237(17.7)	547	200(20.3)	355	(26.8)	1,339
Pre-part. (Mar-Apr)	64(15.4)	260	66(16.9)	26	(20.2)	416
TOTAL (Nov-Apr)	301(17.2)	807	266(19.4)	381	(24.8)	1,755

NOTES: Refer to Table 7

Any high mortality acting on young animals must have occurred at, or shortly after, parturition, since mortality was not significantly higher during the winter. The stationary nature of the adult male and young categories, which must also reflect stability among the other age and sex categories, suggests that the structure of this population remained constant during the study period. As data are incomplete for the period April-October, the proportions of adult males (17.2%) and young (19.4%) within the population are derived from figures relating to the period November-April (Table 8).

Sometimes it was possible to distinguish between Class II and Class III adult males and between yearlings and adult females-subadults. Relevant data from Appendix I appear in Tables 9 and 10.

The ratios of Class II to Class III adult males (Table 9) were tested for homogeneity between months, except for April 1976 and July-October, when data are absent.

Table 9: Numbers of Class II and Class III adult males recorded each month (Langtang population)

Month	A	M	J	J	A	S	O	N	D	J	F	M	A	Total
Class II	0	23	16	0	0	0	1	8	14	24	34	5	21	146
Class III	0	25	22	0	0	0	0	20	41	27	16	0	17	168
Class II-III	17	0	7	0	0	2	10	3	18	17	15	14	7	110
TOTAL	17	48	45	0	0	2	11	31	73	68	65	19	45	424

A significant difference exists between these ratios (X^2 = 29.98, d.f. = 7, $P < 0.001$). Many more Class III than Class II adult males were observed in the first half of the rut, in November and December, than in other months. At other times of the year as many or more Class II than Class III adult males tended to be seen. Since the overall proportion of adult males within the population did not change significantly from season to season, such heterogeneity must reflect behavioural differences between Class II and Class III adult males. Perhaps fewer Class II adult males were observed in mixed groups during the first half of the rut because Class III adult males were potentially more aggressive at this time. By the second half of the rut such aggression may have waned, resulting in an increased incidence of Class II adult males in mixed groups. Summation of the numbers of Class II and Class III adult males recorded each month provides a mean estimate of their ratio which is 1:1.2.

The number of yearlings relative to adult females-subadults (Table 10) differs significantly from month to month (X^2 = 40.39, d.f.= 9, $P < 0.001$) for which there is no obvious explanation. A mean estimate of the ratio of yearlings to adult females-subadults is 1:2.7. This is obtained by summing the data for every month (Table 10).

Table 10: Number of yearlings and adult females-subadults recorded each month (Langtang population)

Month	A	M	J	J	A	S	O	N	D	J	F	M	A	Total
Y1	0	0	0	15	33	34	35	20	3	1	17	17	37	212
F-S	0	0	0	124	107	47	77	24	11	9	47	35	82	563
F-S-Y1	0	0	0	67	184	33	95	94	113	110	98	46	43	883
TOTAL	0	0	0	206	324	114	207	138	127	120	162	98	162	1,658

Life expectancy at birth (e_o) and mortality rate (q) are both functions of the number of animals just born (j) within a sample (n) of a stable population (Caughley 1967). With only one year's data it is not possible to determine whether or not the Langtang population was in a stationary state but, in the absence of contrary evidence, it will be assumed that this was so. The limited value of conclusions based on such an assumption should be borne in mind. In July and August, following parturition, there were 170 sightings of newly born young and 530 sightings of adult females-subadults-yearlings (Table 7). As adult males were not observable at this time of the year, the sample size (N= 700) should be increased by a factor of 17% (Table 8). Life expectancy at birth is calculated as follows:-

$$e_o = \frac{2n - j}{2j} \qquad \text{where } n = \frac{700 \times 100}{(100-17)} \qquad = 843$$

$$= \frac{(2 \times 843) - 170}{2 \times 170}$$

$$= 4.5 \text{ years}$$

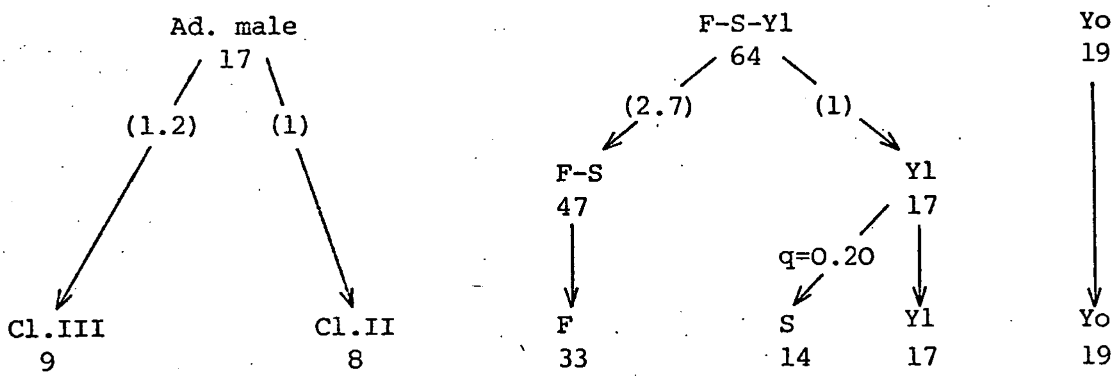
Population mortality rate is calculated as follows:-

$$q = \frac{j}{n}$$

$$= \frac{170}{843} \qquad = 0.20 \text{ per year}$$

Knowing the proportion of adult males and young within the Langtang population, together with the ratios of Class II to Class III adult males and yearlings to adult females-subadults, its structure can be approximated as in Figure 7. Applying a 20% mortality rate to the yearling category enables the proportion of subadults, which were not distinguished from adult females in the field, to be estimated. Based on Figure 7, the ratio of adult males to females is 1:1.9.

Fig. 7: Approximate composition of the Langtang population for 100 animals



NOTES:
- i. Brackets denote ratios from which figures are derived.
- ii. q is the population mortality rate from which the number of subadults is calculated.

On 30 December a group of 67 tahr were censused from less than 200m and it was possible repeatedly to age a sample of adult males and females by counting the number of growth rings on their horns. The group comprised 7 Class III and 5 Class II adults males, 37 adult females-subadults-yearlings and 18 young (Appendix I). The number of adult females (N=23) in the group was estimated from the number of adult males (N=12), based on the ratio of 1:1.9 adult males to adult females. The number of yearlings (N=8) and subadults (N=6) was calculated by subtracting the number of adult males (N=12), adult females (N=23) and young (N=18) from the total group size (N=67). It was assumed that the sex ratio was 1:1 for the young, yearling and subadult categories and that there were slightly fewer subadults than yearlings present. The age distribution of this group is shown in Table 11. In view of the small sample size and inherent extrapolations, it is a crude approximation. The relatively few yearlings and subadults were probably due to small sample size rather than a reflection of high mortality of young for which there was no evidence. The disparate sex ratio for adults indicates that mortality was higher in males than females.

Table 11: Approximate age distribution of a group of 67 tahr

Age	Class	0+	1+	2+	3+	4+	5+	6+	7+	8+	9+	Total sightings	Total animals
Ad. female	Sightings				3	2	3	5	0	1	1	15	
	Animals				4.5	3	4.5	8	0	1.5	1.5		(23)
F E M A L E S		9	(4)	(3)	4.5	3	4.5	8	0	1.5	1.5		39
Cl.III	Sightings					6	6	5	0	2	2	21	
	Animals					2	2	1.7	0	.7	.7		7
M A L E S		9	(4)	(3)	5	2	2	1.7	0	.7	.7		28

NOTE: Brackets indicate numbers extrapolated from data in Figure 7.

The Yala population was more or less completely censused on 21 April 1977, when its composition was found to be about 35% adult males, 30% adult females-subadults, 17% yearlings and 17% young (Appendix I). Assuming that no female gave birth to twins in the previous year, the proportion of females within the population must have been at least equal to that of the young (17%). Thus, the proportion of subadults is, theoretically, 13% or less. The ratio of Class II to Class III adult males is 1:1.3 and that of adult males to females is estimated to be 1:0.5. In November and December 1973, Fox (1974b) repeatedly observed about 30 tahr in groups of 1 to 16 on the slopes above Nubmathang. Of these 13% were adult males, 61% were females-subadults, 10% were yearlings and 16% were young. The proportions of young were about the same for the 1973 and 1977 surveys. Fox (1974b) probably recorded a much smaller number of adult males because he did not survey Area 8 which, in the present study period, was exclusively occupied by up to six adult males.

4.6 Mortality

There was no evidence of any large predators within the study area. Leopards (*Panthera pardus*) occurred in forest up to about 3,000m which appeared to be their altitudinal limit. Wild dogs (*Cuon alpinus* killed two calves of nak x yak on the night of 31 March at Buldagaon goth (3,900m); this lies on the south-facing cliffs about 3km west of Area 1. Wild dogs, rather than leopard, were responsible for the killing as the calves had been ripped open at the belly which, according to locals, is characteristic of the former. Although wild dog and leopard probably prey on tahr in the lower Langtang Valley, there was never any sign of them further east in the upper part of this valley. Leopard tracks were once seen at 4,500m, high up the main Langtang Valley about 4km northeast of Langsisa goth (Area 8). At such a high altitude these tracks could only have been snow leopard (*Panthera uncia*). This species has never been recorded for the Langtang National Park; if present, numbers must be very few. This particular individual may have been a visitor who had wandered across from China (Tibet). Young tahr, during their first few days of infancy, may fall prey to martens, foxes or large raptors, although these predators commonly take rodents and birds which are smaller and, therefore, much easier to carry off.

The Langtang villagers are Buddhists. On account of their religion they do not kill tahr, nor any other wild or domestic animal for that matter. Elsewhere in the Park tahr used to be hunted opportunistically by other ethnic groups for their meat and hides (Fox 1974b). Such practices have probably stopped ever since the area became a National Park. In the upper Langtang Valley tahr used to be shot by employees of the cheese factory which was first established in 1953. The last time this occurred was in the autumn of 1973, when one female and one yearling were shot (Fox 1974b). In the past hunting was probably never a serious cause of mortality and in recent years it has ceased, certainly in the Langtang Valley.

On several separate occasions locals mentioned that tahr sometimes became afflicted by an eye disease, resulting in blindness and a large number of casualties from cliff falls. The disease apparently occurs every 10-12 years and can spread to livestock. Such reports may be exaggerated but tahr have been found blind in New Zealand owing to pinkeye, or kerato-conjunctivitis (Christie and Andrews 1964).

Fighting between adult males was never observed but duelling amongst juveniles was quite common. Seldom was an individual seen to lose its balance while fighting or playing. Accidents resulting from intraspecific combat probably rarely occur (Section 5.5).

Only once was a young individual seen to lose its balance and fall; on another occasion an adult female fell about four feet down a slippery rock. A Class III adult male was once watched negotiating an iced-over glacial stream. It stopped six times along its course before finally selecting a suitable crossing point, where it was able to use a series of rocks as stepping stones, instead of walking on the ice.

On 31 March, at 0715 hours, an adult female fell off the cliffs just behind DUHE's house in Langtang Village. Locals maintained that it was an old female which had missed her footing because of bad eyesight. At the time of her fall visibility was poor, the south-facing cliffs were covered in mist. Although the animal's stomach was full of dried grasses her condition may have been weakened by protein deficiency, causing her to stumble and fall. Ruminants can starve to death on a full stomach if protein is deficient, because the bacteria which ferment the rumen content have to be maintained by plant protein contained in the forage (Geist 1971), or if digestibility is low. The weight of the kidney fat would have provided an indication of the animal's condition but it was not available (Section 3.1). The animal's coat appeared to be in fair condition with no bald patches as evidence of skin diseases. Body lice were present. Details concerning the age of this animal (Specimen No. 3) appear in Appendix IV.

Skulls and horns (Plate IVa) of three individuals, including the aforementioned adult female, were collected in the field. Horn dimensions and the number of growth rings present are recorded in Appendix IV. The age of an individual is equal to the number of horn rings plus one (Caughley 1965). Distinct light and dark bands were present in the dentine of molar teeth though the layers were not of a uniform thickness. The maximum number of layers distinguished in the dentine did not agree well with the number of growth rings counted on respective horns (Appendix IV). Only 10 layers in the dentine were recognizable in Specimen No. 2, although it was thought to be at least 14 years old, judging by the number of growth rings on its horns. In fact a further growth ring was thought to be missing as the tip of the horn had been chewed off, probably by a yak, as this skull was found lying near the Langsisa goth. Nine thin white bands of a regular thickness were recorded for Specimen No. 3, although three thicker white bands were counted in some sections between the enamel and the

PLATE IVa Tahr horns of specimens Nos. 1, 2 and 3 from right to left (Appendix IV). The keel of No. 3 is worn away at the base.

PLATE IVb

Vertical section of first molar tooth of specimen No. 3 showing 9 thin and 3 thick white layers in the dentine (Appendix IV).

PLATE IVc

Overhanging rock shelter and tahr pellets in Area 1.


2
1

last of the thin bands (Plate IVb). Judging by the number of horn. rings, this specimen was about 9 years old; according to the number of dentive layers it may have been 12 years old. The limited amount of data presented in Appendix IV indicates that males are capable of living up to 15 years and females to 9-12 years.

4.7 Populations in Other Areas

In the lower Langtang Valley about 40 tahr were seen in the vicinity of Buldagaon goth (F. Treurnier pers. comm.), thereby confirming local reports. The tahr were seen on the south-facing cliffs, between Gompa and Ghora Tabela, amidst subalpine forest (*Abies spectabilis*) and scrub.

Elsewhere in the Park a group of 13 tahr were fleetingly seen above Saraswatikund, near the headwaters of the Trisuli Khola (Fig.1), on 16 February. It may have been a male group consisting of one Class II, nine subadults and three yearlings since young, and so presumably females, were not present. This group must have been part of a larger population.

During a visit to the east of the Park, 31 tahr were observed on the south-facing cliffs above Pemasol goth, near the eastern headwaters of the Balephi Khola (Fig.1), on 24 April 1977. Groups of 3-12 individuals were seen. Of 18 individuals, two were Class III (11%) and three were Class II (17%) adult males, eight were adult females-subadults (44%), three were yearlings (17%) and two were kids (11%).

Fox (1974a) reported that tahr occur in the vicinity of Rasuwa Garhi and Ganesh Kund. The former is the border post with China (Tibet) to which access is restricted. Permission to visit this area was refused by HMG Nepal. The latter is a lake which lies at 4,800m.

It was visited on 7-13 November but no tahr were seen despite careful scanning of the valleys to the east and west, as far south as the Chimisedang Lekh. Old faeces and trails were encountered between 3,900m and 4,500m on the west-facing cliffs which overlook the junction of the Melamchigaon and Syabru footpaths. They were also seen above the tree-line at 3,870m along the west-facing cliffs of the river-valley which lies east of Ganesh Kund. In both cases the spoor was judged to be tahr as the terrain was considered too precipitous for sheep, which frequented the region in the monsoon.

Although the upper sections of the Melamchi, Larke and Balephi Valleys (Fig. 1) were visited at various times, tahr were never sighted. As tahr are evasive animals, often out of sight behind ridges or in gullies, their presence or absence cannot necessarily be confirmed by a single visit to an area. These valleys appear to offer suitable habitat for tahr and it is likely that populations are present.

4.8 Discussion

The terrain and climate were factors which handicapped field-work considerably. Experience showed that surveys are best undertaken between about November and April, when visibility is good and counts are not biased by the absence of adult males. The early morning, when tahr move up from the lower slopes (Section 5.1), is the best time of day for census work. Ideally a number of observers should be placed at intervals along the valley floor to enable each section of the south-facing cliffs to be simultaneously censused.

In this study the extent to which individuals were confidently classified depended on their age and sex. Adult males and young are easily recognized in the field but effors are liable to occur when distinguishing between adult females, subadults and yearlings. Discrepancies are apparent even in the literature. For instance, Schaller (1973) describes yearlings as being smaller than adult females, whereas Tustin (pers. comm.) considers that these two categories are similar in build and difficult to tell apart (Section 3.1). Anderson and Henderson (1961) found "... difficulty in distinguishing between young bulls from nannies...", and Fox (1974b) does not separate females from "immature males".

In the upper Langtang Valley estimates of the two populations totalled about 220 animals. A further 40 tahr were reported just west of the study area, though more may have been present. Therefore, it is quite likely that about 300 tahr were present in the Langtang Valley at the time of this study. Mean densities varied between about 5 and 46 tahr km^{-2}. In New Zealand tahr were estimated to occur at a density of 4.5-6.8 km^{-2} throughout their breeding range in 1975 (Schaller 1977) but densities must have been much higher prior to commercial hunting, which began in 1971 (Section 1.3).

Tahr do not behave territorially in any of their activities. Geist (1971) states that, "... breeding territories appear to be typical of ungulates in which adult males look alike, so that the rank (fighting potential) of each cannot be predicted from his horn or body size. The breeding territory can serve in this situation as a rank symbol (Geist 1966a)." In adult male tahr the horns are not particularly pronounced, compared with sheep, but the well-developed ruff and mantle may facilitate individual recognition.

Adult females and juveniles occupied the same home range throughout the year, unless disturbed, whereas adult males frequented higher altitudes during the monsoon. Fox (1974b) talks about there being "... some winter migration down from high summer feeding grounds...", and Schaller (1977) says that tahr use the alpine zone seasonally, but this was not the case in this study. In New Zealand adult males move to high altitudes after the rut, closely following the retreating snow-line, and have been found wandering up to 97km from the nearest breeding range (Anderson and Henderson 1961). Douglas (1967) reports that adult males leave adult females and juveniles at the time of parturition and occupy a separate adjoining range. According to Anderson and Henderson (1961), "The nanny-kid herd is normally near its upper limit in altitude for the rut." In the case of the herd occupying Area 1, most rutting behaviour was witnessed in the altitudinally higher section of the home range but this part was also frequented to the same extent in other seasons.

On average 49 tahr used Area 1 which covers 1.3km^2 (Table 4). In eastern Nepal Schaller (1973) observed a similar number within 1km^2 of terrain and Caughley (1966) noted that female tahr in New Zealand have distinct home ranges of about 1,400m in diameter. In the case of the Yala population, about 40 animals ranged over an area of 5.6km^2. This lower density is undoubtedly due to competition by livestock (Section 7).

Schaller (1970, 1973) recorded a mean group size of 23 and 6.5 for Nilgiri and Himalayan tahr, respectively. He suggested that this difference in mean group size between the two species was due to differences in habitat. Nilgiri tahr (Schaller 1970) foraged on rolling grassland near cliffs, whereas Himalayan tahr (Schaller 1973) spent much time feeding on narrow ledges which were not conducive to the formation of large groups. In the present study mean group size was 14.8. Tahr were not restricted to precipitous terrain. For example, Area 1 afforded an expansive region of pasture, albeit sloping, which was uninterrupted by cliffs. Similar but less extensive pastures occurred elsewhere in the study area. It appears, therefore, that the physical nature of the terrain influences the size of groups and may account for the differences in group size. In New Zealand, groups of 60 to 80 tahr were once common but nowadays, as a result of commercial hunting, they rarely exceed 10 animals (Anon 1977a).

During the monsoon groups normally consisted of adult males or adult females and juveniles. In the rut adult males joined adult females and juveniles. In New Zealand tahr range in three kinds of groups during the summer. These comprise adult females with juveniles, adult males and immature males (Caughley 1966). In the present study large juvenile groups (N=13-14) were only seen twice and on both occasions one adult male was present. In British Columbia feral goats, Capra hircus, do not show sexual segregation (Shank 1972), whereas this type of social organization is apparent in wild goats in Pakistan (Schaller and Laurie 1974). The latter authors suggest that sexual segregation is influenced by the environment; it only occurs when breeding is limited to a particular time of the year, as in the case of populations which live in more extreme climates. Nilgiri tahr breed seasonally and Schaller (1970) suggests that adult males probably associate more closely with females and juveniles in the rut than at other times of the year.

No precise information was collected in relation to twinning. On one occasion two newly born young were seen feeding from the same female (L. J. Borradaile pers. comm.) which suggests that they were twins. Out of 66 autopsies in New Zealand, a single foetus was present in each case (Rammell 1964). Only one pair of twins was found in about 600 embryos examined by Caughley (1970a). Tahr are potentially capable of producing twins more frequently, as indicated by an 8% twinning rate at London Zoo (Zuckerman 1953). The incidence of multiple births is due to several selection pressures such as food supply, habitat and life-span (Schaller 1977). The environment of the tahr is both rugged and lush. Food supply is fairly predictable from year to year and the precipitous nature of the terrain affords reasonably good protection from predators if present. It would seem that for a long-lived species inhabiting this type of environment, such as tahr, mortality is neither irregular nor excessive, and the population can be maintained by single births. In the case of an expanding population which colonizes new areas or a zoo, an abundant food supply may result in the production of twins (Caughley 1970a). Evidence to date suggests that twinning is a rare event in the wild. In the present study it was not known at what age females first gave birth to young but Schaller (1973) maintains that in their native habitat they have their first young at the age of three years. In New Zealand, yearlings may conceive at the age of 18 months (Anderson and Henderson 1961); a high proportion of females give birth at two years old (Tustin pers. comm.). Males do not attain sexual maturity until at least two years old (Caughley 1971a).

Causes of death amongst animal populations are often unknown. Most animals are probably the victims of poor nutrition and disease rather than of dramatic incidents such as predation and accidents. Often it may not be possible to relate a single cause because several factors may contribute to an animal's death. In the case of the Langtang and Yala populations there was no evidence of predation and only one record of a fatal accident. In New Zealand, deaths occur through accidental falls. Broken legs and horns are not rare (Douglas 1967), and falls have been witnessed when animals have been seen crossing iced surfaces (Anderson and Henderson 1961; Schaller 1977). Crossing an icy stream was the only occasion when an individual was seen to deliberate in its movements (Section 4.6). Slippery, rather than precipitous, surfaces are probably the most difficult for tahr to negotiate. In the Himalayas little is known about the parasites and diseases of tahr, except that ticks and lice are present. In New Zealand, individuals have been found with scabby mouth, mastitis and lice (Anderson and Henderson 1961). Schaller (1977) notes that wild goat, Capra aegagrus, have few parasites, possibly because they are not readily transmitted in rocky and dry terrain; the same might apply to tahr.

The Langtang and Yala populations occupied areas of about the same size but differed in size and structure; mean density was 25.0 and 6.8 animals km^{-2}, respectively. The lower density of the Yala population could be due to differences in either climate or food supply. If climate was a limiting factor then a high mortality would be anticipated in a severe winter. As the Yala population was located higher up the valley it would have experienced more extreme winters even though there was only a 500m altitudinal difference between the lower ranges of the two populations. Although the Yala population was not completely censused before the winter, a partial survey on 26 December indicated the proportion of young to have been 17% (Appendix I). The proportion of young was again 17% on 21 April 1977, when the population was completely censused. Winter mortality would be expected to affect the youngest and oldest members of a population most. Although there was no evidence of a high young mortality, it should be recalled that the winter of 1976-77 was exceptionally mild. Although climate cannot be entirely ruled out, there is good reason to believe that food supply was a limiting factor because of competition with livestock in much of the Yala population's range. This is discussed in Section 7.

The differenc in structure between the two populations is more difficult to explain. The proportion of sightings of young for the Langtang, 266/1374 (Table 8), and Yala populations, 27/161 (Appendix I), are not significantly different ($X^2 = 0.43$, d.f. = 1, $P > 0.50$). The proportions of yearlings are the same (17%). However, in the Langtang population adult females outnumbered adult males by a ratio of about 2:1, whereas the reverse situation probably applied to the Yala population. In eastern Nepal Schaller (1973) recorded a 2:1 ratio of adult females to adult males but he concluded that the latter may have been under-represented in his samples. In New Zealand there is no evidence for a disparate sex ratio (Anderson and Henderson 1961). The sex ratio did not differ significantly from 1:1 for samples of 190 (Caughley 1966) and 185 foetuses and young (Caughley 1970a). Differential mortality between adult males and adult females might be caused by inadequate nutrition during the winter rut. At this time of year adult males spend very little time feeding, as most of it is devoted to courting females (Section 5.1). Although high levels of fat accumulate in adult males prior to the winter, in anticipation of this physiologically demanding period (Caughley 1970b), adult males may be exhausted by the end of the rut, before plants have become nutritious enough to support them. In the case of the Yala population the reverse situation, in which adult males are about double the number of adult females, might either be due to chance, in view of the population's relatively small size (N=46), or past hunting practices of the cheese factory's employees (Section 4.6). The cheese factory only operates during the monsoon season; for the rest of the year its employees remain in Kathmandu. Hunting must, therefore, have been seasonal and at a time when maternal, rather than adult male, groups were most probably in evidence. Selective hunting of adult females and juveniles would result in a surplus of adult males. Following the cessation of hunting, it would take several years for the normal balance of adult females to adult males to be restored. A third possibility is that of a stagnant population in an overgrazed range. There is some evidence that the quality of the Yala pastures has deteriorated in recent years (Section 7). Stagnant populations contain a high proportion of old animals and they reproduce poorly (Schaller 1977). In the case of the Yala population, there is evidence of the former but not of the latter, as reproduction and survival are good, with about as many yearlings present as young. Thus, the present preponderance of adult males seems most likely to be due to a combination of chance events and former hunting pressures.

As the Langtang population had not been surveyed prior to this study, it is not known whether this population is increasing, declining or in a stationary state. The fact that young and adult male categories did not change significantly during the study period is compatible with a stable age and sex structure. However, this provides no evidence that the population was stationary, as each of its age and sex categories may have been simultaneously increasing or decreasing at the same rate. Environmental pressures had probably changed little and,with no reports of particularly severe winters or diseases in recent years,this population may be stable with a 20% mortality rate and a life expectancy at birth of 4.5 years. From a sample of 623 females, Caughley (1967) calculated values of 25% and 3.5 years, respectively. Less than 3% of females in this sample were older than 12 years, the oldest was 17 years. A population of about 50 tahr in eastern Nepal consisted of about 11% adult males, 49% adult females-subadults, 18% yearlings and 22% young (Schaller 1973), which is very similar to the structure of the Langtang population (17% adult males, 47% adult females-subadults, 17% yearlings, 19% young).

From previous census data concerning the Yala population (Fox 1974b), it seems that numbers may have increased in recent years. Although Fox did not survey Area 8, he recorded about 30 tahr in Area 7.

In 1977 40 tahr were seen in this same area, suggesting an increase of one third during the intervening three years. It is not known if Fox thoroughly surveyed all of Area 7 and, therefore, this conclusion may be invalid. It appears certain, however, that the structure of the Yala population has changed in recent years.

5. BEHAVIOUR

5.1 General Behaviour

Tahr generally ascended to the main feeding grounds in the early morning and then retired to the lower slopes towards the end of the day. Adult males did not adopt this pattern as they tended to range laterally and rarely descended to the lower slopes.

In Area 1 maternal groups were often seen shortly before sunrise in gullies or on ledges at 3,500-3,650m near the valley floor, just above the break of slope. In the monsoon tahr were frequently watched ascending a gully at 0630-0700 hrs as the mist cleared. By about 0800-0900 hrs groups had often ascended 600m and moved onto the main grazing grounds. Once on the move groups climbed rapidly, as noted on 3 August, when all of 32 tahr completed a 400m ascent within 50 minutes. By about 1100-1200 hrs groups reached their maximum altitude for the day (4,200-4,400m). They usually remained at about this altitude, sometimes moving laterally, until after a siesta period around midday. About mid- or late-afternoon tahr descended and reached the lower slopes and gullies by dusk. In winter tahr were often watched descending at 1500-1600 hrs. In the monsoon, although poor visibility precluded afternoon observations, occasional glimpses indicated that tahr remained on the main grazing grounds in mist. For instance, at 0700 hrs on 27 October tahr were sighted at 4,000m. By midday they were feeding at 4,400m. The weather clouded over at 1330 hrs but, through the mist, tahr were intermittently seen at this altitude until 1600 hrs. In all seasons maternal groups descended to the lower slopes and gullies during periods of bad weather, lasting one or several days, when persistent low cloud brought rain or snow.

Maternal groups also lay up in small caves or beneath overhanging rocks. Both large and small sized fresh pellets were found beneath a particular rock in Area 1 at 3,900m on 26 March, indicating that it had probably been used overnight by an adult female and young. Fresh faeces were often found at this site (Plate IVc) in winter, suggesting that it was preferred by certain groups to the lower slopes and gullies. The diurnal pattern of movement of adult male groups was usually lateral rather than vertical. In Area 1 adult males were never seen below 4,000m. In Areas 5 and 6 a herd of adult males regularly contoured at about 4,000m between the south and east-facing slopes for part of the year (Section 4.2).

For the first half of the morning individuals normally foraged within 10m of each other, sometimes in a long line with 30 or more ascending the main grazing grounds. By midday individuals tended to be dispersed, often up to 50m apart. Towards late afternoon individuals aggregated more closely together on their way down to the lower slopes. Access to the main grazing grounds was restricted to a limited number of points and so tahr moved to and fro along a number of well-defined trails. Once on the grazing grounds, movement was more irregular, although circuitous routes, which differed from day to day, were often travelled. Not only did tahr follow each other in single file along difficult trails but individuals proceeded similarly at particularly hazardous junctures. For instance, at one point along a trail individuals consecutively jumped six feet up onto a rock, then turned through 90 degrees in order to make a second jump. Each individual waited its turn and then followed suit; females were normally followed by their young.

Due to the mild winter and strong insolation (Section 2.2.2), snow seldom settled for long on the south-facing cliffs below 4,500m. On 24 February tahr were seen at 3,900m grazing amidst Rhododendron _lepidotum_ scrub. The 1cm of snow which had fallen overnight was not sufficient to cover the tussock grasses on which the tahr were feeding. On 18 March and 6 April 1977 the snow lay a few centimetres deep above 3,900m. On both occasions mixed groups were seen to move laterally, in the morning, just below the snow level, rather than vertically upwards. At 0700 hrs on 7 April 1977 a mixed group was watched as individuals walked through ankle deep snow at 4,100m. This behaviour was surprising since nearby terrain, below 3,900m, was relatively free from snow. The tahr mostly stood around until about 0830 hrs when the majority began to feed. On this occasion most of the snow melted by 1045 hrs. During the winter of 1976-77 the movements of tahr were not restricted by deep snow in Areas 1-6. Higher up the Langtang Valley, in Areas 7 and 8, the snow level lay at about 4,500m for several prolonged periods between late January and mid-May. During a visit to Yala goth (4,815m) on 9 May 1977 no tracks were seen in the 0.5m deep snow, which indicated that members of the Yala population had remained on the south-facing cliffs where the snow had melted.

Patterns of daily activity were investigated quantatively. The number of sightings of various types of activity, classified in Section 3.1, are given in Appendix V for each month. The data concerning adult females and juveniles are summarized in Table 12. As sampling was biased in the monsoon due to low cloud, it is possible that the figures in Table 12 for July-September are not an accurate estimate of the amount of daytime spent on the various types of activity because data are absent for the afternoon period (Appendix V).

The data suggests that less time was spent feeding during the monsoon, when food was abundant, than at other times of the year (Fig. 8). Either individuals fed more efficiently or the forage was more nutritious in this season. The amount of time spent feeding did not immediately drop at the beginning of the monsoon because, presumably,

Table 12: Number of sightings of different types of activity of adult females and juveniles

Month	Drinking	Feeding	Grooming	Lying	Moving	Standing	Aggression	Total
May	6 (0.4)	1,210 (84.1)	0	184 (12.8)	–	39 (2.9)	0	1,439
June	12 (0.5)	1,693 (65.4)	19 (0.7)	602 (23.3)	52 (2.1)	206 (8.0)	4 (0.2)	2,588
July	0	1,546 (57.7)	9 (0.3)	660 (24.6)	187 (6.9)	273 (10.2)	4 (0.2)	2,679
August	0	1,897 (61.5)	28 (0.9)	415 (13.5)	455 (14.8)	280 (9.1)	8 (0.3)	3,083
September	0	963 (44.1)	29 (1.3)	400 (18.3)	491 (22.5)	293 (13.4)	6 (0.3)	2,182
October	2 (0.0)	4,181 (66.9)	36 (0.6)	824 (13.2)	582 (9.3)	613 (9.8)	8 (0.1)	6,246
November	19 (0.4)	3,069 (70.5)	10 (0.2)	632 (14.5)	95 (2.1)	525 (12.1)	2 (0.0)	4,352
December	16 (0.3)	5,072 (78.3)	4 (0.0)	925 (14.3)	60 (0.9)	402 (6.2)	2 (0.0)	6,481
January	0	2,779 (70.0)	8 (0.2)	772 (19.5)	42 (1.1)	367 (9.2)	0	3,968
February	1 (0.0)	6,579 (81.4)	24 (0.3)	947 (11.7)	75 (0.9)	442 (5.5)	10 (0.1)	8,078
March	0	3,326 (69.7)	19 (0.4)	1,026 (21.5)	49 (1.0)	352 (7.4)	0	4,772
April	4 (0.1)	3,028 (68.5)	24 (0.5)	864 (19.6)	102 (2.3)	395 (8.9)	2 (0.0)	4,419
TOTALS	60 (0.1)	35,343 (70.2)	210 (0.4)	8,251 (16.4)	2,188 (4.4)	4,187 (8.3)	46 (0.1)	50,287

NOTE: Brackets indicate percentages.

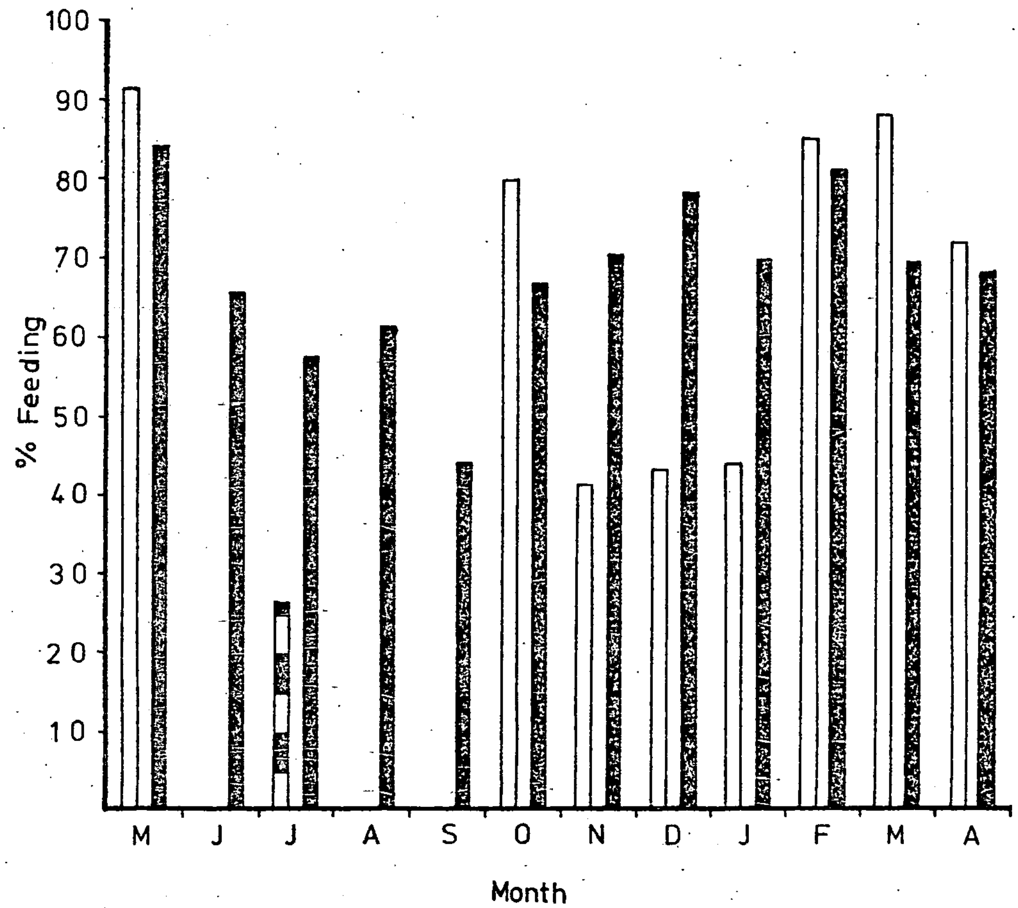


FIG. 8 Proportion of tahr feeding during daylight hours at different times of year, May 1976 - April 1977.

adult females, subadults, yearlings, young (>1month)

young (<1month)

adult males

it required several months to build up fat reserves, depleted as a result of the previous winter. The slight rise in feeding activity in August (Fig. 8) might be attributed to females requiring more nutrition after parturition in June-July. Least time (44%) was spent feeding in September. Over the year adult females and juveniles spent, on average, 70% of daytime feeding (Table 12).

No seasonal trends in lying or standing activity are apparent (Table 12) but much more movement was recorded between July and October than at other times of the year. As movement was correlated with foraging behaviour, this might suggest that tahr were more selective in their feeding habits during the monsoon, when food supply was abundant. Tahr probably drank each day in Area 1, except in the monsoon when the lack of sightings of this activity (Table 12) suggests that sufficient moisture was taken up with the fodder. On 18 November twelve tahr were watched at 1430 hrs as they hesitantly came down off the adjacent cliffs onto the main grazing grounds in order to drink from a stream. They were aware of the observer, over 500m away, and emitted alarm calls occasionally. After drinking for five minutes they retreated onto the cliffs. This particular observation indicates that the urge to drink overcame their fear of the observer. It is not known for how long tahr can exist without water. Social interactions, such as grooming and aggressive behaviour, used up little (less than 1%) daytime.

The daily activity of tahr followed a general pattern whereby a large amount of time was spent feeding in the early morning and late afternoon. Periods of rest tended to be restricted to late morning and early afternoon when individuals often rested for an hour without interruption; the longest recorded period was 90 minutes. This pattern varied seasonally with changes in daylength. Monthly patterns of feeding and lying are shown in Figure 9 for adult females and juveniles, based

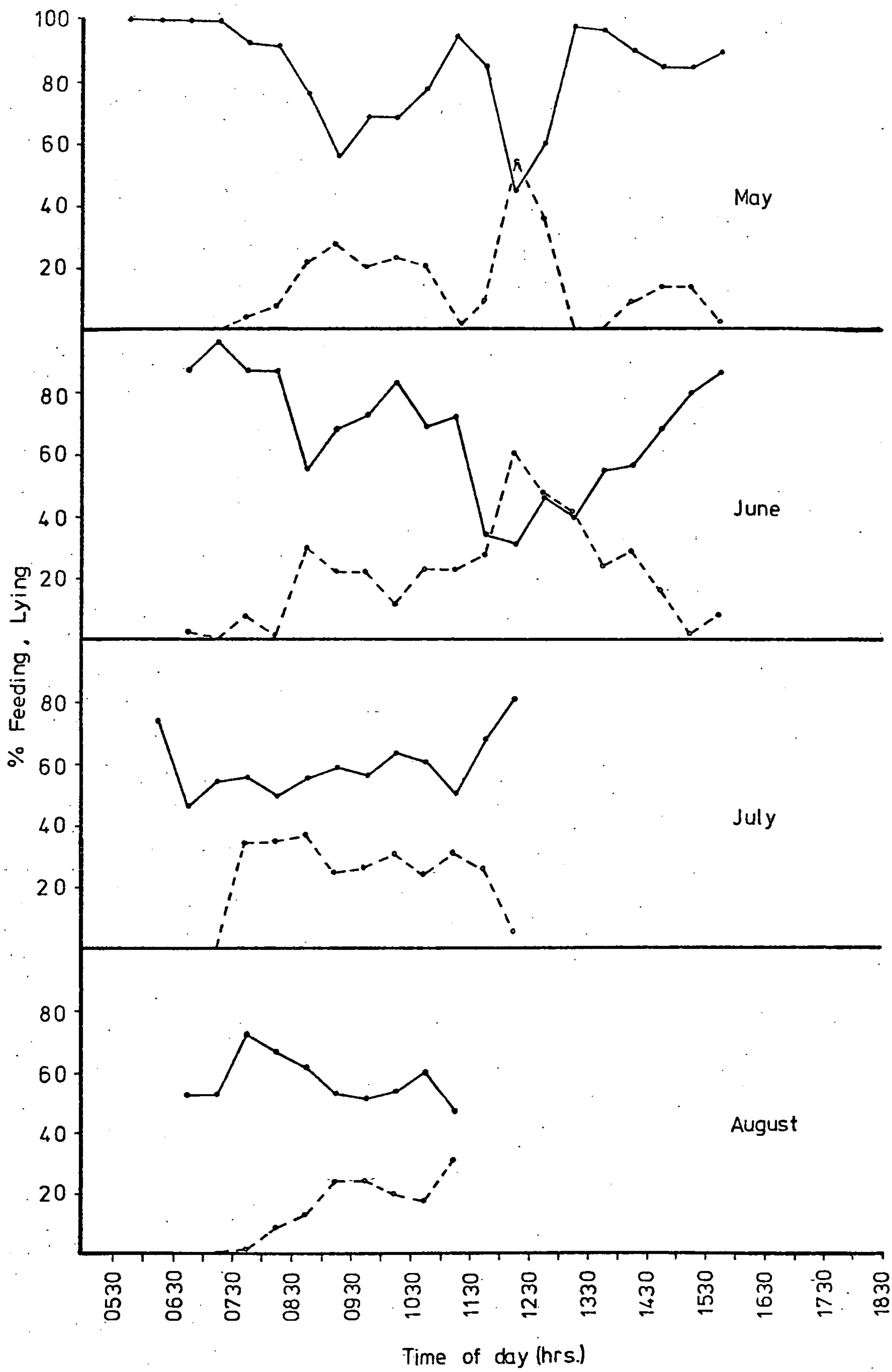
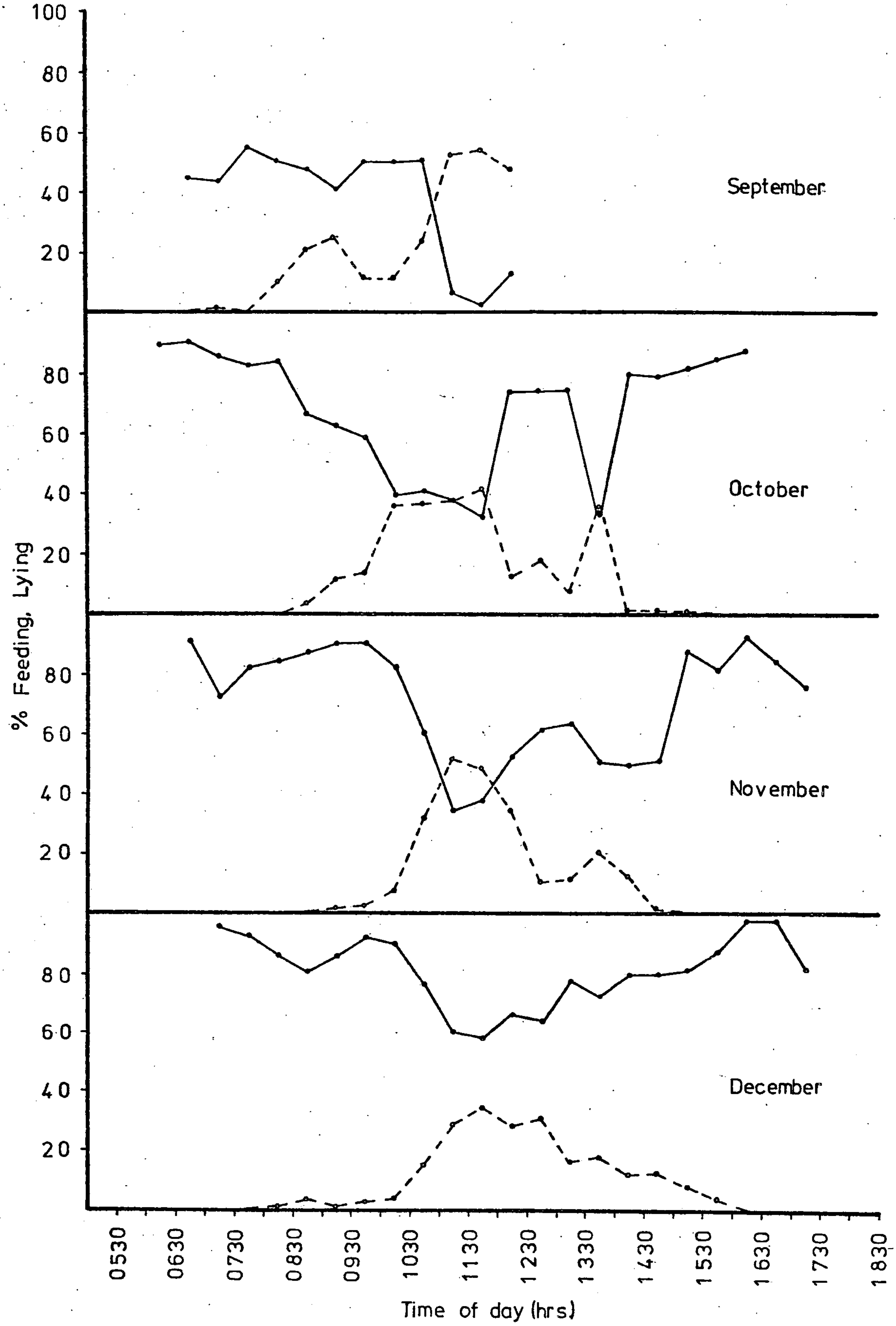


FIG.9 Proportion of tahr feeding and lying at differerent times of day in each month, May 1976 - April 1977.

feeding

lying



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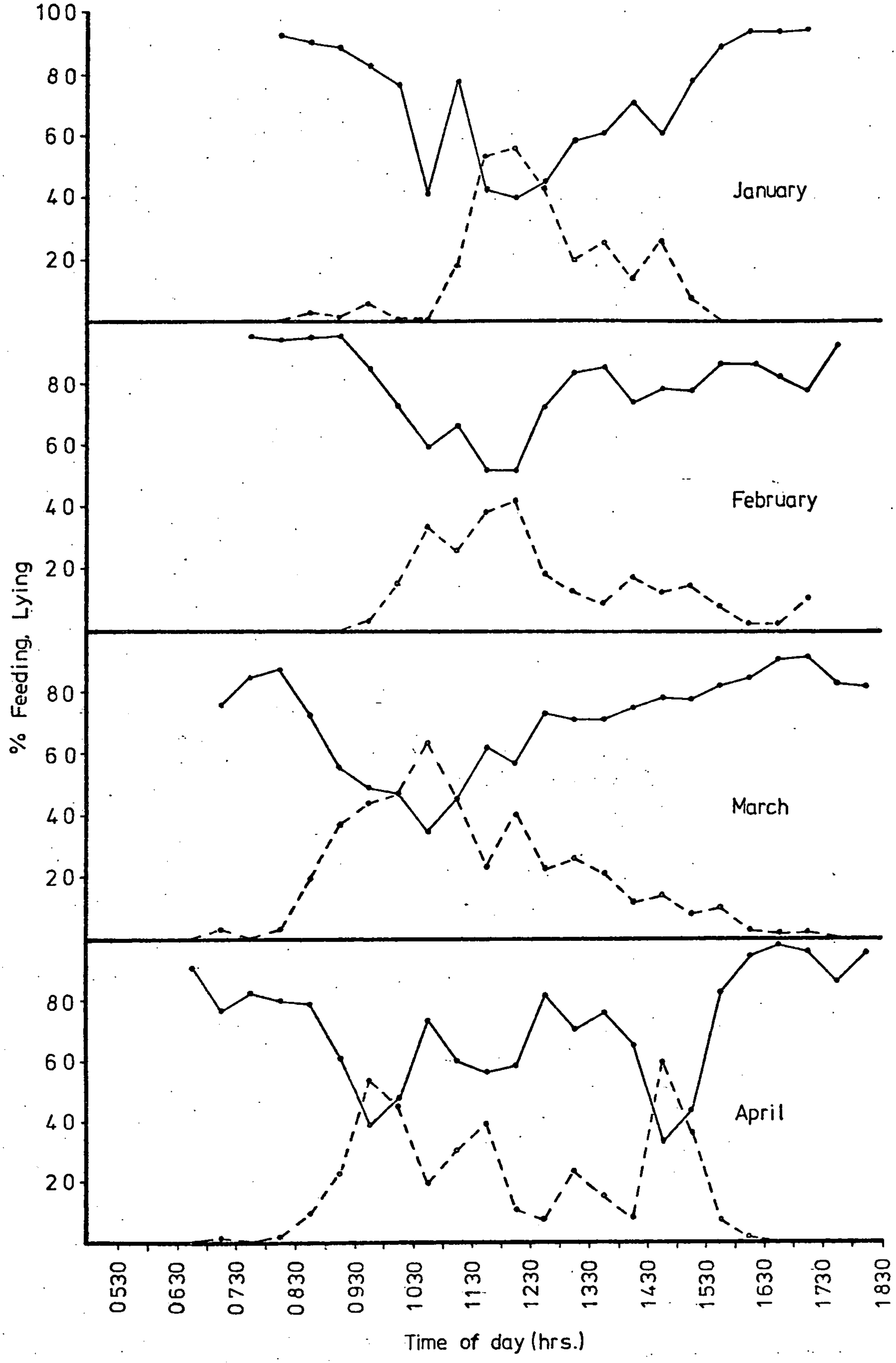
Time of day (hrs)

FIG.9 (Cont.)



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Time of day (hrs.)

FIG.9 (Cont.)

on data in Appendix V. The pattern of diurnal activity was tested for seasonal differences using X^2. The test was applied to sightings of feeding and non-feeding individuals made between 0800 hrs. and 1600 hrs. for each month, except July-September, when data were limited. A series of 2 x 9 contingency tables were constructed in order to compare the ratios of feeding to non-feeding sightings for the same half-hour intervals in different months. Details appear in Appendix III. The values of X^2, with eight degrees of freedom (Table 13), were corrected by a factor of one sixth to compensate for an otherwise exaggerated sample size. As the number of animals feeding was recorded every five minutes, the total number of feeding sightings for each half-hour period was theoretically six times greater than the actual sample size because the same animals were observed repeatedly. In practice sample size often varied during each half-hour period, since animals disappeared from sight and then reappeared. However, division of X^2 values by a factor of six provides a conservative estimate (T. Gleaves pers. comm.). From X^2 values in Table 13 it is concluded that the pattern of diurnal activity was significantly different ($P < 0.05$) for almost every half-hour interval between 0830 hrs and 1500 hrs, in the nine months for which data are available. The slightly low value of X^2 for 1400 hrs. is overridden by the other significant values of X^2. Before 0830 hrs and after 1500 hrs. feeding activity was consistently high in each month.

Monthly changes in the pattern of diurnal activity are best illustrated by the curves for inactivity (i.e. lying) in Figure 9. In January animals were mainly inactive between 1100 hrs and 1530 hrs; inactivity was greatest at 1200-1230 hrs. In February inactivity was again most pronounced at midday but it extended over a greater part of the day, from 0930 hrs until approximately 1600 hrs. or beyond. From March through to September animals rested from as early as 0730 hrs.,

Table 13: Values of X^2, with eight degrees of freedom, for ratios of feeding to non-feeding sightings for the same half-hour intervals in different months

Hrs	0800	0830	0900	0930	1000	1030	1100	1130	1200	1230	1300	1330	1400	1430	1500	1530	1600
X2	36.1	234	466	493	444	245	237	127	140	115	162	160	73.1	169	108	6.2	54.0
X^{2*}	(6.0)	39.0	77.7	82.1	73.9	40.8	39.5	21.2	23.4	19.1	27.0	26.7	(12.2)	28.1	18.0	(1.0)	(9.0)

NOTE: i. Asterisk indicates that X^2 is corrected for sample size.

ii. Brackets indicate that X^2 is not significant (i.e. $P > 0.05$).

with peaks of inactivity between 0930 hrs and 1500 hrs. The pattern of inactivity in October was similiar to that in April, with peak periods of resting before and after midday. November and December were similar to January and February as animals rested mainly between 1000 hrs and 1600 hrs. Inactivity was greatest at 1100-1200 hrs in November and December, slightly earlier than in the two subsequent months.

In Figure 10 data for each month has been amalgamated into four periods in order to summarize seasonal changes in the pattern of daily activity. It is evident that this pattern is governed by daylength. From October until March, when daylength was shortest, the proportion of animals resting exceeded 10% for about 6½ hours of the day (0900-1530 hrs); moreover, inactivity was greatest around midday. In the other months, from April until September, days were longer and the proportion of animals resting exceeded 10% for about 8½ hours of the day (0700-1530 hrs). As animals could not be observed throughout the day during the monsoon, it is possible that inactivity extended beyond 1530 hrs between July and September. Rather than being concentrated around a single midday peak, inactivity tended to be dispersed amongst several subsidiary peaks in the spring and summer months.

In Figure 8 it is shown that adult females and juveniles spent, on average, a smaller proportion of daylight hours feeding in the summer than in the winter months. This does not necessarily mean that they spent less time feeding in summer than in winter because it ignores the effect of daylength. From the data presented in Figure 9, it is evident that changes in the pattern of diurnal activity compensated for seasonal changes in daylength. In the winter a reduced period of inactivity compensated for the shorter days. It is quite likely, therefore, that the amount of time actually spent feeding during daylight hours did not vary appreciably in different months but with

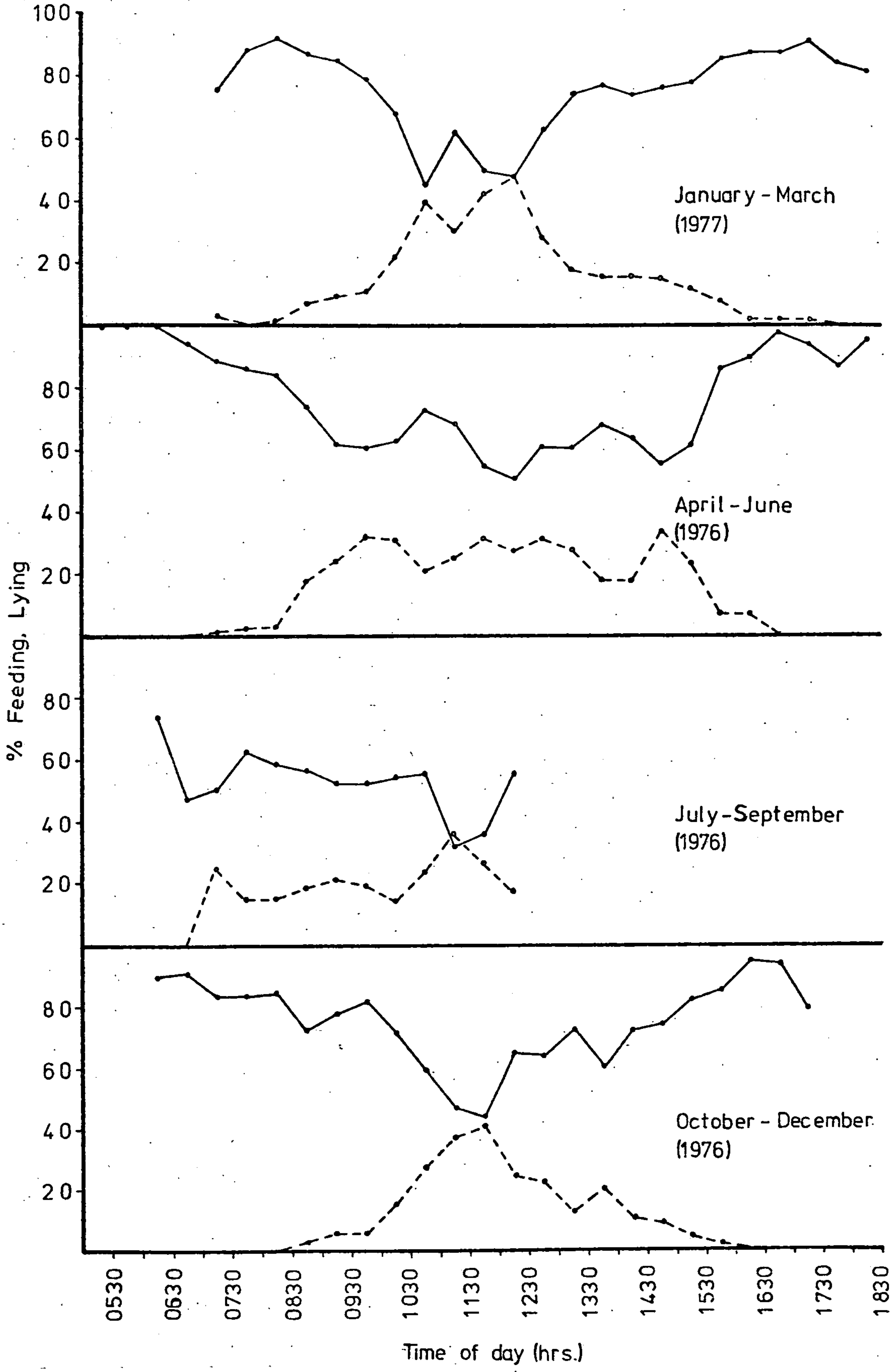


FIG.10 Proportion of tahr feeding and lying at different times of day in combined months.

feeding

lying

biased sampling in the monsoon this cannot be established with certainty.

In July the daily activity of young, less than one month old, was independently recorded, as shown in Table 14. The term feeding included grazing or browsing and suckling; the latter activity only amounted to 3(1%) of the 278 sightings. Young normally suckled for about one minute intervals during their first month of life; four minutes was the longest recorded period. They usually approached their mothers from the flanks, though sometimes dived beneath the fore- or hind-legs. Suckling commenced with a series of rapid thrusts by the young as it nuzzled its mother's teats. Once this action was violent enough to cause the mother to lose her balance; in this case the young was approaching one year old. While suckling, young commonly quivered their tails. Suckling was always seen to be terminated by the mother who either stepped aside or moved forward. By mid-July periods of suckling were not observed to last longer than 30 seconds. Throughout the remainder of their first year, young often tried to suckle but attempts were either futile or only lasted about five seconds before being thwarted by the mother. In their first month of life, young spent most of their time resting (35%). About equal amounts of time were spent moving (26%) and feeding (27%); the amount of the latter activity was less than half that recorded for adult females and juveniles (58%) in the same period (Fig. 8). Playing was common among young.

Table 14: Number of sightings of different types of activity of young in July

Feeding	Lying	Standing	Moving	Playing	Total
74(26.6)	97(34.9)	23(8.3)	72(25.9)	12(4.3)	278

NOTE: Brackets indicate percentages.

Data concerning the activity of adult males in Appendix V are summarized in Table 15 for each month that visibility permitted their observation. As the number of sightings of individuals drinking (n=3) and grooming (N=5) was small, they are omitted from Table 15. Between November and January adult males spent about half the amount of time feeding as they did in other months (Fig. 8). At this time of year

Table 15: Number of sightings of different types of activity of adult males

Month	Feeding	Lying	Moving	Standing	Courting	Total
May	187(91.7)	3(1.5)	4(2.0)	10(4.9)	0	204
Oct	40(80.0)	1(2.0)	1(2.0)	8(16.0)	0	50
Nov	198(41.6)	95(20.0)	18(3.8)	144(30.3)	21(4.4)	476
Dec	514(43.5)	152(12.9)	10(0.8)	446(37.8)	59(5.0)	1,181
Jan	411(44.2)	216(23.3)	13(1.4)	249(26.8)	40(4.3)	929
Feb	249(85.3)	8(2.7)	3(1.0)	32(11.0)	0	292
Mar	544(88.5)	51(8.3)	1(0.2)	19(3.1)	0	615
Apr	393(72.6)	76(14.0)	17(3.1)	55(10.2)	0	541
TOTALS	2,536(59.1)	602(14.0)	67(1.6)	963(22.5)	120(2.8)	4,288

NOTE: Brackets indicate percentages

considerably more time was spent standing and lying (Table 15). Such seasonal changes are correlated with the rut when, instead of feeding, much more time was spent standing in close proximity to females or lying down to rest. This standing behaviour was a preliminary to courtship. The amount of time spent moving did not change markedly during the year. Following the end of the rut in mid-February, adult males spent about as much or more time feeding that adult females and juveniles (Fig. 8), probably to replenish fat reserves which had become exhausted.

Two attempts were made to observe tahr at night, aided by a full moon. Partial success was achieved. On the night of 4 November an adult male was watched from 2030 hrs. until 2155 hrs.; thereafter further observation was precluded by a low mist. The total amount of time spent feeding was 32 minutes (38%) and the longest feeding interval lasted 15 minutes.

5.2 Aggressive Behaviour

Although tahr have been noted for their docile nature (Anderson and Henderson 1961), they do interact aggressively. Such interactions constituted less than 1% of activity sightings (Table 12). Butting was observed most often between juveniles, occasionally between Class II adult males and never between Class III adult males.

The playful activity of young animals under one month old included butting, chasing and scrambling under or over each other. Sometimes an individual placed its neck over an opponent's after a head-to-tail confrontation in which individuals circled each other. Butts were normally directed towards the head and shoulders but sometimes an opponent received blows in its flanks, rump or groin. In their first month of life, young were seen in play-groups of two to six.

Yearlings were observed fighting for periods lasting up to three minutes. Horns were sometimes interlocked in a clash and individuals circled each other. Once a yearling delivered a butt from a broadside position which caused the opponent, a yearling, to fall a vertical distance of two metres. During head-to-tail confrontations opponents were occasionally propelled into the air with a hook delivered to the belly region. Yearlings fought with each other, adult females and subadults. Sometimes they were chased over short distances by adult females and adult males.

Class II adult males were normally seen fighting with subadults rather than each other. In the rut Class III adult males occasionally chased each other, or Class II adult males, for short distances of about 10m in a manner described by Schaller (1973) as a hunch . Class III adult males were never observed butting each other; fights of the kind described by Roberts (1971) were never witnessed. There were seldom any aggressive interactions between adult males and yearlings or young, which tended to maintain a discrete distance from older males or took fright if approached. Once a yearling was chased by a Class III adult male in a low-stretch with its tongue flicking.

Adult females interacted aggressively during courtship. On one occasion a Class III adult male was seen to repeatedly jerk its head down towards a female which it was courting. Sometimes these jerks were followed by a low-stretch. Each of the male's threats was reciprocated by the female which jerked its head downwards in a similar manner. Another time a nine year old male was watched standing next to a six year old female which was lying down. Every time that the male lunged towards its mate, with a downward jerk of the head and its tongue flicking, she responded with a head-jerk which was accompanied by a shrill whistle. In doing so, her horns brushed the head of the male but no forceful butt was ever delivered.

5.3 Courtship Behaviour

The rut consists of a period in which males show interest in and display to anoestrus females, sometimes called the pre-rut, and a time when mating actually takes place (Schaller 1977). Only intensive observations may distinguish between the two periods. Rut is used here in its general context to include the whole period in which males and females were together for the purposes of reproduction.

From direct observations it is thought that the rut commenced late in October and lasted until about 19 February. On 27 October an adult male was seen for the first time, since the previous spring, amidst a group of about 47 adult females and juveniles. Once this male approached a female in a low-stretch position and sniffed her perineum. On 17 November two adult males were seen about 200m away from a maternal group of 39 individuals. Within two hours the adult males had joined this group and over the subsequent seven hours they courted females on six occasions. The last occasion on which an adult male was seen pursuing a female was 19 February, although on 21 February a Class II adult male was seen engaged in reciprocal grooming with a female. The much higher incidence of mixed groups between November and February (Table 6) and the reduced time spent feeding by adult males between November and January (Fig. 7), as compared with other months of the year, are also indicative of the date of the rut. The increase in the feeding activity of adult males recorded in February might appear to have been premature if the rut did not finish until the second half of that month. This apparent anomaly is explained by the fact that feeding activity data was obtained on 24, 25 and 29 February rather than earlier in the month, when rutting behaviour was still evident.

The date and number of sightings of adult males seen courting is shown in Table 16. No data were obtained between 17 January and 18 February, due to my being absent from the study area. Most copulation probably occurred between late November and mid January, in view of the higher amounts of courting activity recorded in this period. With a six and a half month gestation period (Caughley 1971a) and a breeding season of about seven weeks, or possibly more, parturition would be expected to occur between mid-June and the end of July (Section 5.4).

A large undulating slope was the main rutting ground for those members of the Langtang population which ranged in Area 1. After the end of the monsoon, one to three adult males were often seen near the

Table 16: Date and number of sightings of adult males courting females during the rut

November	Court. Males	Total Males	December	Court. Males	Total Males	January	Court. Males	Total Males
6	0	7	2	0	6			
17	4 (2.9)	138	3	0	1	7	1 (2.6)	39
			8	9 (7.3)	124			
18	0	27	9	6 (3.0)	199	8	3 (1.6)	187
25	0	17	10	1 (4.8)	21	11	1 (1.0)	103
26	0	34	11	2 (4.3)	47	12	13 (5.6)	232
29	6 (4.1)	149	14	0	24	13	20 (7.1)	280
30	11 (10.6)	104	15	0	14	15	1 (2.7)	37
			20	23 (6.1)	380	16	0	37
			22	13 (4.1)	314	17	1 (7.1)	14
			30	5 (9.1)	55			
TOTALS	21 (4.4)	476	TOTALS	59 (5.0)	1,185	TOTALS	40 (4.3)	929

NOTES: i. The proportion of daytime spent courting by adult males is given in brackets as a percentage.

ii. Table 16 is a breakdown of column six in Table 15.

top of this slope but they remained aloof from maternal groups, which ranged below, until late October when mixed groups were first seen. The greatest number of adult males seen on the rutting ground within a mixed group (N=67) was 12 on 30 December. Fewer Class II adult males were seen in mixed groups at the beginning than at the end of the rut (Table 9) and none were seen courting females prior to 8 December. This concurs with the suggestion that Class III adult males were potentially more aggressive at the beginning of the rut (Section 4.5) and, therefore, it was not in the interests of subordinates to court at this time. Females were rarely courted by subadult males and usually ran off if approached by them.

In 137 hours of observation between November and January no copulations were ever witnessed. Adult males normally approached females from behind, or in front, with their neck extended in a low-stretch position; short chases over about 10m often ensued. Low-stretches were accompanied by tongue-flicking, head-jerking, teeth-baring and lip-curling. Only once was an adult male observed directing a front-kick towards a female. On this occasion the kick was delivered to the female's side while standing in a low-stretch position. Females paid little attention to the sexual displays of adult males and either continued with whatever they had been doing or moved away. Occasionally females behaved aggressively towards adult males (Section 5.2). The following account of courtship is taken from field notes for 29 November:-

> At 0900 hrs a Class III adult male was seen feeding alone at 50-100m from the rest of the group (N=19). At 1020 hrs it approached a female from behind in a low-stretch and then maintained this display from a broadside position. This was ignored by the female which continued to feed. After a ten minute interlude of standing, then feeding, the male approached from in front with a series of low-stretches. The female was now lying down and merely averted its gaze by turning its head aside. After a final low-stretch, in which the muzzle was raised and the neck arched backwards in a head-up display, the male lay down beside the female (1055 hrs). Within five minutes the female got up and wandered off to resume feeding.

A few observations suggest that adult males paired up with females while breeding. Such pairs were never remote, however, from other individuals. On 20 and 30 December a Class III adult male and a female were seen together, somewhat detached from the rest of their group. On the latter occasion the male stood beside the female which was lying down. It repeatedly jerked its head, tongue-flicking, which caused the female to butt in gentle defiance. This pair were about 50m from the rest of the group (N=67) and were photographed (Plate Va). On 13 January a group of five tahr, comprising two Class III males, two females and a young, were seen on a large ledge which backed onto a cave in Area 4. Each adult male lay beside a female. One adult male was seen to stand up and repeatedly jerk its head towards its mate.

5.4 Parturition

In 1976 new-born young were first observed on 5 July. Tahr were previously observed on 23 June and so the young must have been born in the interim. These young were probably at least a week old when first observed because their movements were well-coordinated and all four individuals concerned were playing with each other.

In 1977 a new-born young was sighted about two and a half weeks earlier on 17 June. It was first noticed at 0655 hrs as it ran out from some nearby cliffs to suckle from its mother which had been standing about 100m below three other females, a yearling and two young of the previous year. The new-born young suckled for abour two minutes before its mother stepped aside and began walking uphill. The offspring followed, often stopping with apparent curiosity as it nosed rocks and vegetation. It did not stop to feed but may have taken an occasional nibble during its exploratory activity. The mother then began to head

PLATE Va A breeding pair at the foot of the main rutting grounds in Area 1, about 600m above the Langtang Khola (background). A Class III adult male stands beside an adult female.

PLATE Vb A Class II adult male.

downslope and its offspring followed, running,and once jumping about 1.5m off a small precipice. By 0705 hrs the new-born young disappeared from sight; possibly it entered a cave. This individual was probably only a few days old, judging by its exploratory behaviour and the fact that no play-group had yet been formed.

These limited observations indicate that parturition occurred in the second half of June. No births were ever witnessed.

5.5 Discussion

The daily pattern of vertical migration by tahr is the reverse of Soay sheep, Ovis aries, which run downhill to low-lying grass swards at daybreak and return slowly uphill in the afternoon (Grubb and Jewell 1974). In the Scottish Borders feral goats may leave the high ground and take refuge in rocky terrain lower down when disturbed (McDougall 1974), whereas in Snowdonia goats return to higher, broken ground if disturbed. In the case of the present study the cliffs at lower altitudes, to which tahr retreated for the night, provided good protection in the event of bad weather or predators. During daytime it was necessary for them to move uphill to reach the better pastures.

In New Zealand tahr do not undergo any great changes in altitude on a daily basis but, with reference to adult males, Anderson and Henderson (1961) state that, "They are loathe to descend even during prolonged periods of snow and storm conditions, prefering to hole up in their secluded bedding spots". Douglas (1967) reports that, "During favourable winter weather herds composed of all male and female age classes travel up in early morning from snow-free feeding grounds or bluff systems and remain most of the day ruminating or sleeping on the snow or rock ledges, browsing only occasionally.

Mass movement occurred at approximately mid-afternoon, when herds descended to feed...The descent began later in spring and early summer, and also, as feed became available with snow melt, the animals tended to retain altitude. In adverse weather animals drop to lower altitudes ... and camp on cliff ledges .... or stay in the scrub belt." He also noted the rapidity with which two adult males descended some 450-600m - about four minutes.

Periodicity in grazing is shown by Soay sheep which nearly always devote the early morning and late afternoon to feeding. Lying is more restricted around midday from September through to December (Grubb and Jewell 1974). Hoefs (1974) found that the number of feeding periods is proportional to daylength in captive Dall sheep, _Ovis dalli dalli_. In winter there is a single midday siesta but as daylength increases there are more resting periods.

Schaller (1977) recorded the daily activity of Himalayan and Nilgiri tahr, markhor (_Capra falconeri_) and bharal (_Pseudois nayaur_) but he was " ... unable to explain why markhor and Himalayan tahr have one major diurnal rest period and bharal and Nilgiri tahr have two." The reason for such differences becomes clear on considering the time of year when these studies were made. The markhor was studied in December and January when days were shortest. Activity was less than 50% between 1100 hrs and 1300 hrs; in other words, resting was concentrated around midday. The Himalayan tahr, studied in February and March, had a similar pattern except that the midday trough in activity began over an hour earlier. This earlier beginning of the siesta period is explained by the longer days. Schaller's graph of daily activity of Himalayan tahr is remarkably similar to that for March in Figure 9. Both graphs show peak inactivity at 1030-1100 hrs. Bharal were studied in November and, again, the pattern of daily activity closely resembles that of Himalayan tahr for the same month, November, with two peaks of inactivity either side of midday (Fig. 9). Schaller (1977) also studied Bharal in March when, due to the longer days, the two main periods of inactivity commenced earlier in the day than in November. Nilgiri tahr were studied mainly in October; there were two periods at 0800-1030 hrs and 1430-1530 hrs when activity was less than 40% (Schaller 1970). It is concluded, therefore, that the daily activity patterns of these caprinid species are in fact similar; apparent differences are resolved if the seasonal parameter of daylength is taken into account.

Apart from daylength, the pattern of daily activity may also be influenced by climatic, social and other factors. Different groups were often observed resting at different times on the same day. Although members of a group were normally active in the early morning and late afternoon, they seldom all rested simultaneously. Schaller (1977) reports that the average amount of daytime spent feeding by Himalayan tahr, markhor and two bharal populations is 72-76%, which agrees well with the average of 70% for adult females and juveniles in the present study. Nilgiri tahr only spent 55% of daylight hours feeding but, as Schaller (1977) points out, this species was studied shortly after the monsoon when the food supply was abundant. In the present study feeding activity was lowest (44%) at the end of the monsoon, in September. In New Zealand feeding activity occupies over 60% of daylight hours in summer but only 25% or less in winter in deep snow conditions (Anon 1977a). This transition is completely the reverse of the situation in the present study, when adult females and juveniles spent a greater proportion of daytime feeding in winter than in summer. However, tahr in Langtang never experienced deep snow in the winter of 1976-77, which may account for such a difference. Adult males, on the other hand, spent a smaller proportion of daytime feeding during the rut than at other times of the year, which must be a behavioural adaptation to facilitate courtship. In Soay ewes feeding activity was about 70% of daylight hours in mid-summer and over 90% in winter. During spring there was a marked decrease in the proportion of daytime spent feeding by ewes. "This change paralleled the resurgence in growth of the pastures but was also occurring as the hours of daylight were increasing." (Grubb and Jewell 1974). During the autumn, however, feeding activity increased again. Soay rams spent a similar amount of daytime feeding, compared with ewes, except during the rut. At the peak of mating activity rams fed for only a fifth of daylight hours (Grubb and Jewell 1974).

It is not known to what extent tahr remain active at night, though one observation suggests that feeding may continue for several hours after dusk. Schaller (1977) notes that bharal and markhor often feed into the night. Stone sheep (Geist 1971) and Dall sheep (Hoefs 1974) regularly graze for about an hour after dusk, whereas Soay sheep (Grubb and Jewell 1974) graze little after dark. It is likely that grazing at night is influenced by daylength and the quality of the pasture. Observations have shown that in winter or on poor pasture domestic sheep graze at night, mainly in the late hours up to midnight (cited in Grubb and Jewell 1974).

Caprinid societies are all based on a linear hierarchy. Between strangers an individual's rank is assessed by its physical characters, such as body and horn size. Such rank symbols must, therefore, be graded in size for such a hierarchy to function. Horn length seems to be the main criterion of status among all Caprini except in tahr, which does not grow massive horns during its life (Schaller 1977). Between strangers the memory of past encounters may also be important in determining an individual's status. Aggression may be direct, involving bodily contact, or indirect, in which it is limited to intimidation by using rank symbols.

Schaller (1973) quantified the amount of overt aggression shown by various age and sex categories. On the basis of the number of sightings of jerks, lunges, jumps, butts, clashes and head-to-tails he concluded that most aggression was exhibited by young and yearlings. Adult females were only aggressive in courtship and Class I, II and III males asserted themselves infrequently. In 106 animal-hours of observation no butts were recorded for Class II or III adult males. Similar behaviour was noted in the present study.

In a description of the head-to-tail confrontation for Himalayan tahr, Schaller (1973) states that "... the animals did not shove with their bodies." whereas he observed neck-pushing in Nilgiri tahr (Schaller 1970). In the present study neck-pushing, when an individual placed its beck over the opponent's, was witnessed during head-to-tail encounters. This observation concurs with Geist (1971) who, in the absence of any records of tahr fighting in serious combat, concluded that, "The males will push each other with shoulders and hips; one may attempt to put his neck over the opponent's and wrestle him to the ground." At a later date Schaller (1977) saw a neck-fight between two young at the New York Zoological Park.

Young were twice seen to rear up on their hindlegs in front of another individual by Schaller (1973) who stated that such jumps probably" ... represent an intention movement to clash with a downward thrust of the horns." Although jumping was observed among young,while playing, older individuals were never seen to "... rear up on their hindlegs in unison and lunge downwards to clash their horns forcefully in the manner of Nilgiri tahr, ibex, markhor and other goats..." as anticipated by Schaller (1973). He later reports, "Interestingly, Himalayan tahr have as yet not been observed to rear on their hindlegs and lunge down to clash in the manner of Nilgiri tahr and Capra."

(Schaller 1977). This conclusion is endorsed by the present study.

Intraspecific fighting was never seen to cause bodily harm, let alone a fatality, and rarely did an opponent fall as a result of combat. Geist (1971) postulated that tahr engage in damaging, bloody fights of the kind observed by Roberts (1971) when an adult male unbalanced its opponent and then ripped it in the belly. Such incidents appear to be rare events in view of the extensive work done in New Zealand by Caughley and Tustin (cited in Schaller 1977). Tahr are reported to be quite aggressive in captivity. On Woburn Estate in England they killed deer by disembowelling them (Anderson and Henderson 1961).

Most forms of direct aggression are widespread among the Caprinae but indirect forms are sometimes species specific (Schaller 1977). One form of behaviour not previously recorded in the tahr is the shake. On several occasions during the rut adult males were seen vigorously shaking their head and shoulders while in a low-stretch position.

According to Anderson and Henderson (1961) and Christie and Andrews (1964), males are monogamous. Schaller (1977) found no evidence in either Nepal or New Zealand for such behaviour. In this study pairing undoubtedly occurred because on several occasions an adult male was seen attending a female, never leaving her side. Similar behaviour has been noted in New Zealand, "The bull will follow the nanny for several days and stand by her in this way, often for hours on end, head and neck raised in nearly motionless poses." (Anon 1977a). It may be that males are promiscuous rather than monogamous or polygamous, as in the case of feral goats in New Zealand (Rudge 1969).

The surprising lack of copulation over a considerable period of observation indicates that the period of mating is very short in breeding pairs. While observing single rams guarding an oestrus female or a breeding pair, Geist (1961) noted how rarely the rams courted and mounted. It is possible that pairs moved off the main rutting ground in Area 1 and onto the cliffs towards the height of courtship. In mountain sheep "... it is more common to see large rams with a ewe standing dispersed in the cliffs." (Geist 1971). Another possibility is that most mating may have taken place at night. Several caprinids conduct at least some of their courtship at night, although the importance of sexual displays would seem to be lost (Schaller 1977). Anderson and Henderson (1961) did not observe tahr mating; in view of the little amount of activity displayed by adult males during the day when paired with females, they suggest that copulation usually happens at night. The only complete account of courtship is given by Schaller (1973) who saw a Class III adult male mount a female late in March after the end of the main rut. He remarks on the gentleness of courtship, "The males did not press their attention on the female, but limited themselves to displaying and lingering nearby."

Parturition coincided with the beginning of the monsoon when an abundant food supply was assured to both neonate and lactating females. Parturition may have lasted from mid-June until the end of July but precise data are lacking. It is worth noting that in New Zealand births are spread over a period of about 2½ months (Caughley 1971a). It is likely that females retired to inaccessible sites, affording good cover, in order to give birth as in mountain sheep (Geist 1971) and feral goats (Rudge 1970). Anderson and Henderson (1961) noted that pregnant female tahr moved into scrub cover just before parturition; regrouping occurred soon after the young were dropped. A female's withdrawal to a secluded site affords the neonate with better protection from predators. The choice of cliffs may also provide shelter from the wind, thereby minimizing heat loss post-partum. A period of seclusion is probably necessary to ensure that mother and neonate can learn to recognize each other (Schaller 1977). Failure to establish an exclusive bond between mother and neonate could result in an excessive amount of butting by strange females which would affect the newborn's chance of survival (Geist 1971).

In a review of mother-infant relationships in ungulates, Lent (1974) discusses the concept of "followers" and "hiders". Follower type species, which include equids, most large bovids and sheep, maintain close spatial relationships between mother and infant after the post-partum period. In hiders, such as many deer, gazelle and antelope species, the mother and infant undergo a phase, lasting several weeks or months, during which they are out of contact for long periods of time each day. Infants of hider species tend to select their own hiding sites. Mothers of most of these species do not approach their infant in its hiding place but await its emergence at some distance away. The phase of hiding is either short or absent in the genus Capra; for instance, in ibex and feral goats it lasts two to three and four days, respectively. During this phase, in feral goats, the mother is absent for periods of at least 1½ hours and sometimes as long as eight hours while foraging up to 500m away (Rudge 1970). Similar behaviour by tahr was observed on the occasion when an infant emerged from some cliffs to join its mother for about 10 minutes and then suddenly disappeared, presumably to its hiding place. Schaller (1977) confuses the issue somewhat by saying that goats are considered to be followers; however, he also states that many have a short hiding phase which places them on a continuum between true followers and true hiders. By the end of the first week all Caprini infants become closely attached to their mothers and follow them (Schaller 1977).

Infants nurse often during the first few days of life but as they grow older periods of suckling become shorter and less frequent. Grass supplements milk at an early age, within the first week in the case of wild goats (Schaller 1977). Limited observations suggest that this was also true of tahr and that infants were weaned within two or three months.

6. FEEDING ECOLOGY

6.1 Analysis of Diet

A limited amount of information concerning the diet of tahr was obtained by direct observation. Plants which tahr were actually seen to eat are listed in Table 17. Direct observations suggest that tahr grazed to a greater extent than they browsed, Graminae and Cyperaceae being the major dietary constituents. Mosses were also eaten. For instance, on 19 August a female and her young were disturbed when feeding in a narrow ravine. Subsequent inspection showed teeth marks where mosses had been scraped away from the rock surface. On many other occasions tahr fed from rock surfaces which appeared to be devoid of vegetation and free from moisture. Salts were probably derived in this manner. This was borne out in the faeces because 21% of samples (N=61) contained grit. Some of these particles might have been ingested while eating roots. However, tahr were only observed digging up roots between late October and mid March, whereas the incidence of grit in the faeces was not restricted to any one season.

Table 17: List of species and groups of plants which tahr were observed eating

Berberis concinna	*Juniperus wallichiana*
Bryophta	*Ligularia amplexicaulis*
Caragana nepalensis	*Potentilla pedunculata*
Cotoneaster microphylla	*Primula aureata*
Cyperaceae	*Rheum moorcraftianum*
Graminae	*Rhododendron lepidotum*
Iris decora	

A reference collection of plants which were common in Area 1 is given in Appendix VI. It includes those species which might have been eaten by tahr on account of their abundance. Some examples of photomicrographs of plant fragments prepared from this reference collection are shown in Plates VI-VIII. Ease of identification of plant fragments in the faeces varied between species. In general grasses, sedges, dicotyledons, ferns and mosses were easily distinguished from each other. Of the grasses Danthonia schneideri (Plate VIb), Festuca ovina (Plate VIa), Festuca gigantea and Poa pagophila were confidently identified but determination of the presence or absence of other grasses listed in Appendix VI was less certain. Sedges (Carex and Kobresia spp.) all looked alike (Plate VIc) and individual species could not be distinguished. Only two species of dicotyledons, Geranium collinum (Plate VIIb) and Rhododendron lepidotum (Plate VIIa), were confidently identified in the faeces. One species of fern, Dryopteris sp. (Plate VIIc), and at least two unknown species of moss (Plate VIIIc), were recorded in the faeces. Also present were two distinctive types of fragments, X (Plate VIII a) and Y (Plate VIIIb), which did not resemble anything in the plant reference collection. X, which looks like a stellate hair, and Y are probably both dicotyledons. In view of the limited extent to which plant fragments were confidently identified to species level, the following broader categories were recognized:- grasses, sedges, dicotyledons, mosses, ferns and unknown species X and Y.

The number of different types of fragment identified in a single drop of faecal material are shown in Table 18 for different samples. Data for January are absent because no faeces were collected that month. The mean frequency of occurrence is 54% for grasses and sedges and 27% for dicotyledons. The latter figure would be higher by 11% of the two unknown species, X and Y, proved to be dicotyledons. The incidence of mosses and ferns are on average below 5%, although they exceed 10% at certain times of the year. As the various categories of

Table 18: Number and percent composition of plant fragments in faeces

Sample No.	Date	Grass	Sedge	Dicot	Species X	Species Y	Fern	Moss	Total
1	29. 5.76	49 (43.4)	48 (42.5)	7 (6.2)	0	9 (8.0)	0	0	113
2	"	44 (40.7)	39 (36.1)	23 (21.3)	0	1 (0.9)	0	1 (0.9)	108
3	2. 6.76	32 (26.2)	38 (31.2)	15 (12.3)	0	36 (29.5)	0	1 (0.8)	122
4	15. 6.76	27 (24.8)	46 (42.2)	14 (12.8)	0	22 (20.2)	0	0	109
5	"	37 (33.6)	32 (29.1)	19 (17.3)	0	22 (20.0)	0	0	110
6	"	24 (21.1)	34 (29.8)	21 (18.4)	0	34 (29.8)	1 (0.9)	0	114
7	23. 6.76	24 (21.8)	25 (22.7)	8 (7.3)	2 (1.8)	51 (46.4)	0	0	110
8	"	19 (18.5)	52 (50.5)	14 (13.6)	0	18 (17.5)	0	0	103
	Mean (Mean %)	32.0 ± 8.8 (28.8 ± 7.9)	39.3 ± 7.5 (35.4 ± 6.8)	15.1 ± 4.8 (13.6 ± 4.3)	0.3 ± 0.6 (0.3 ± 0.5)	24.1 ± 13.3 (21.7 ± 12.0)	0.1 ± 0.3 (0.1 ± 0.3)	0.3 ± 0.4 (0.3 ± 0.4)	111.1
9	19. 7.76	25 (23.4)	31 (29.0)	40 (37.4)	0	11 (10.3)	0	0	107
10	"	24 (19.8)	14 (11.6)	40 (33.1)	0	43 (35.5)	0	0	121
11	26. 7.76	27 (25.7)	17 (16.2)	29 (27.6)	0	31 (29.5)	1 (1.0)	0	105
12	"	20 (17.0)	26 (22.0)	29 (24.6)	1 (0.9)	42 (35.6)	0	0	118
13	19. 8.76	13 (11.4)	48 (42.1)	41 (36.0)	8 (7.0)	1 (0.9)	3 (2.6)	0	114
14	"	29 (28.7)	37 (36.6)	30 (29.7)	3 (3.0)	0	2 (2.0)	0	101
15	28. 8.76	55 (58.5)	10 (10.6)	25 (26.6)	3 (3.2)	1 (1.1)	0	0	94
16	"	44 (41.5)	27 (25.5)	17 (16.0)	13 (12.3)	2 (1.9)	1 (0.9)	2 (1.9)	106
17	8. 9.76	35 (33.0)	29 (27.4)	34 (32.1)	3 (2.8)	0	2 (1.9)	3 (2.8)	106
18	"	44 (39.3)	23 (20.5)	19 (17.0)	20 (17.9)	5 (4.5)	0	1 (0.9)	112
19	"	36 (26.7)	32 (23.7)	27 (20.0)	29 (21.5)	2 (1.5)	5 (3.7)	4 (3.0)	135
	Mean (Mean %)	32.0 ± 8.2 28.9 ± 7.4)	26.7 ± 7.2 (24.1 ± 6.5)	30.1 ± 5.5 (27.2 ± 4.9)	7.3 ± 6.4 (6.6 ± 5.8)	12.5 ± 11.6 (11.3 ± 10.5)	1.3 ± 1.1 (1.2 ± 1.0)	0.9 ± 1.0 (0.8 ± 0.9)	110.8

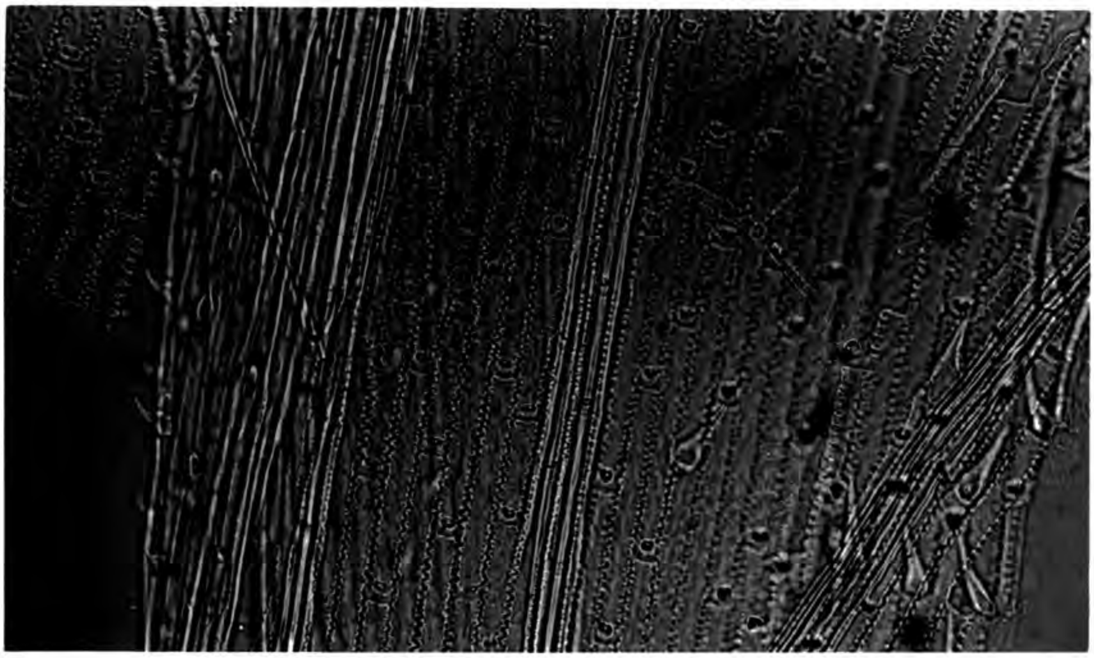
20	11.10.76	39 (40.2)	13 (13.4)	35 (36.1)	4 (4.1)	1 (1.0)	0	5 (5.2)	97
21	"	67 (57.8)	8 (6.9)	32 (27.6)	3 (2.6)	1 (0.9)	3 (2.6)	2 (1.7)	116
22	"	52 (44.8)	2 (1.7)	44 (37.9)	10 (8.6)	3 (2.6)	4 (3.5)	1 (0.9)	116
23	18.11.76	36 (29.3)	7 (5.7)	72 (58.5)	0	1 (0.8)	3 (2.4)	4 (3.3)	123
24	"	33 (30.8)	3 (2.8)	56 (52.3)	0	0	10 (9.4)	5 (4.7)	107
25	11.12.76	33 (28.5)	4 (3.5)	26 (22.4)	9 (7.8)	0	19 (16.4)	25 (21.5)	116
26	"	37 (30.8)	3 (2.5)	38 (31.7)	0	0	13 (10.8)	29 (24.2)	120
27	"	42 (34.4)	3 (2.5)	44 (36.1)	0	1 (0.8)	26 (21.3)	6 (4.9)	122
28	"	36 (31.0)	11 (9.5)	27 (23.3)	0	0	15 (12.9)	27 (23.3)	116
29	30.12.76	69 (63.3)	11 (10.1)	18 (16.5)	0	0	1 (0.9)	10 (9.2)	109
30	"	35 (27.8)	13 (10.3)	54 (42.9)	0	0	9 (7.1)	15 (11.9)	126
	Mean (Mean %)	43.5 ± 8.9 (37.7 ± 7.7)	7.1 ± 2.9 (6.2 ± 2.5)	40.5 ± 10.5 (35.2 ± 9.1)	2.4 ± 2.6 (2.1 ± 2.2)	0.6 ± 0.6 (0.6 ± 0.5)	9.4 ± 5.5 (8.2 ± 4.8)	11.7 ± 7.1 (10.2 ± 6.1)	115.3
31	21. 2.77	37 (33.0)	37 (33.0)	28 (25.0)	0	0	7 (6.3)	3 (2.7)	112
32	"	37 (34.3)	32 (29.6)	37 (34.3)	0	0	2 (1.9)	0	108
33	5. 3.77	28 (26.2)	31 (29.0)	36 (33.6)	0	0	7 (6.5)	5 (4.7)	107
34	"	26 (23.9)	18 (16.5)	52 (47.7)	0	0	4 (3.7)	9 (8.3)	109
35	"	30 (27.0)	26 (23.4)	44 (39.6)	0	0	5 (4.5)	6 (5.4)	111
36	"	79 (74.9)	10 (9.4)	10 (9.4)	1 (0.9)	0	0	6 (5.7)	106
37	"	72 (69.9)	6 (5.8)	17 (16.5)	0	0	0	8 (7.8)	103
	Mean (Mean %)	44.1 ± 20.3 (40.1 ± 18.8)	22.9 ± 10.9 (21.2 ± 10.1)	32.0 ± 13.7 (29.6 ± 12.7)	0.1 ± 0.3 (0.1 ± 0.3)	0 (0)	3.6 ± 2.8 (3.3 ± 2.6)	5.3 ± 2.8 (4.9 ± 2.6)	108.0
	Overall Mean (Overall Mean %)	37.7 ± 5.0 (33.8 ± 4.5)	22.9 ± 4.8 (20.5 ± 4.3)	30.3 ± 4.8 (27.2 ± 4.3)	3.0 ± 2.0 (2.6 ± 1.8)	9.1 ± 5.0 (8.2 ± 4.5)	3.9 ± 2.0 (3.5 ± 1.8)	4.8 ± 2.4 (4.3 ± 2.1)	111.7

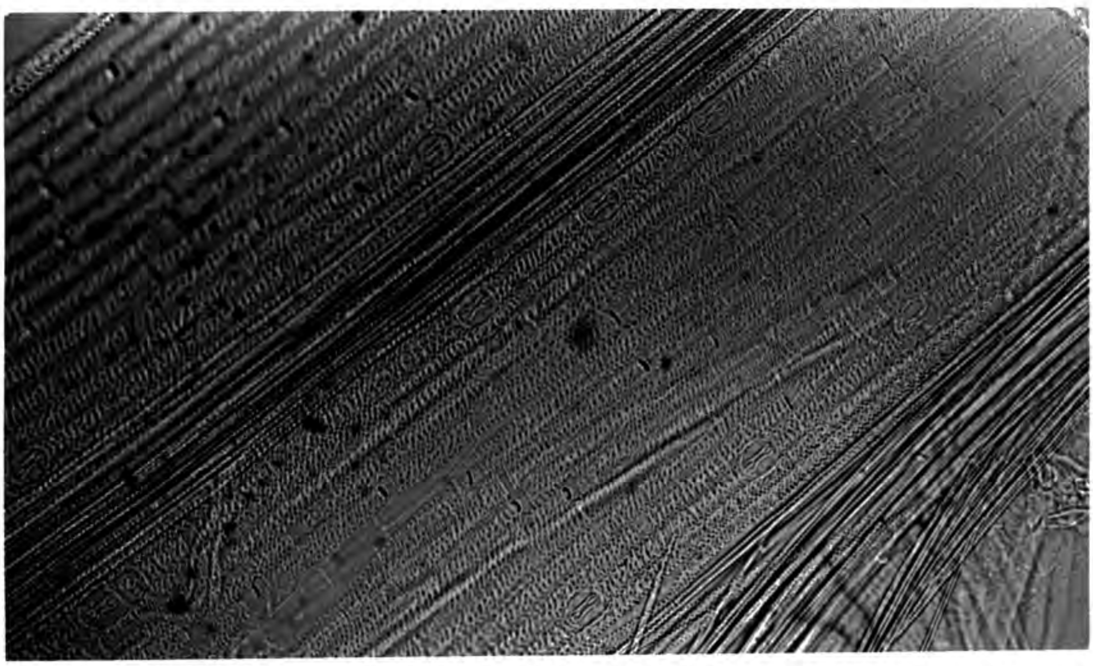
NOTES: i. Brackets indicate percentages.
ii. Mean values are given with 95% confidence limits (± 2 S E). Standard errors are corrected for small sample size, where N is less than 30, using Student's t-distribution.

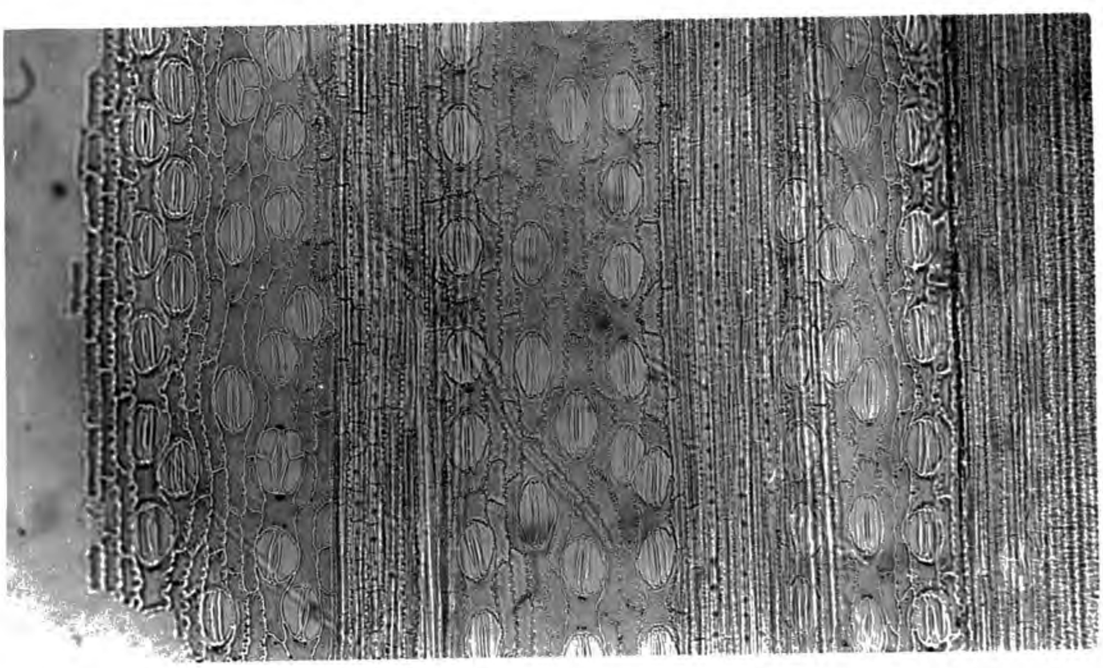
PLATE VIa Festuca ovina (x 160)

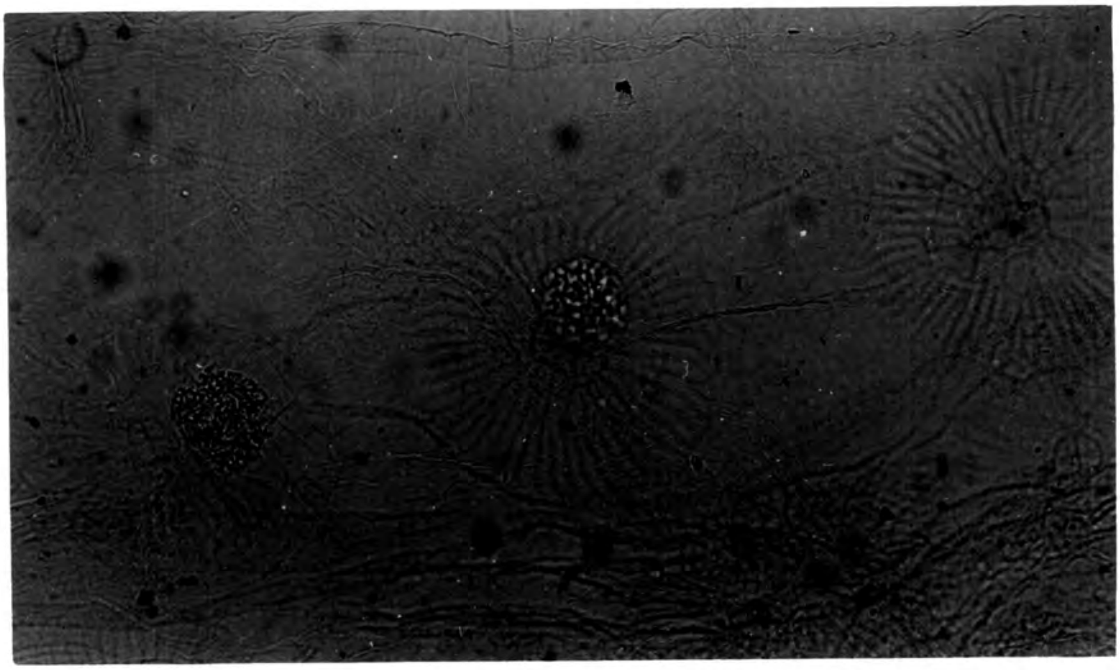
PLATE VIb Danthonia schneideri (x 160)

PLATE VIc Kobresia sp. (x 160)









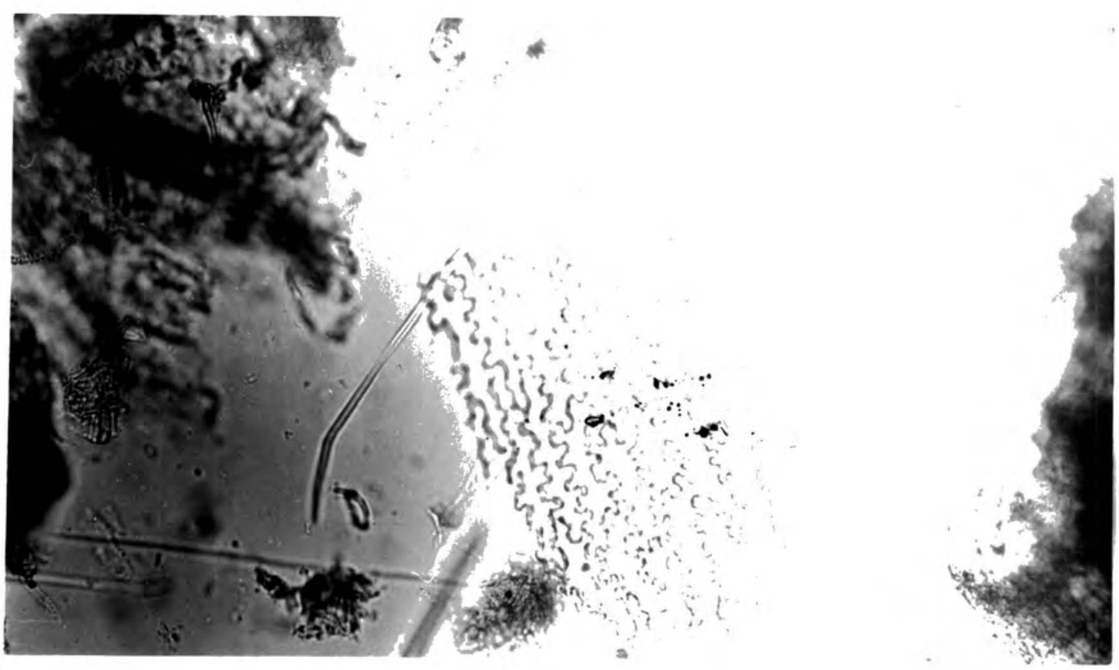


PLATE VIIa Rhododendron lepidotum (x 160)

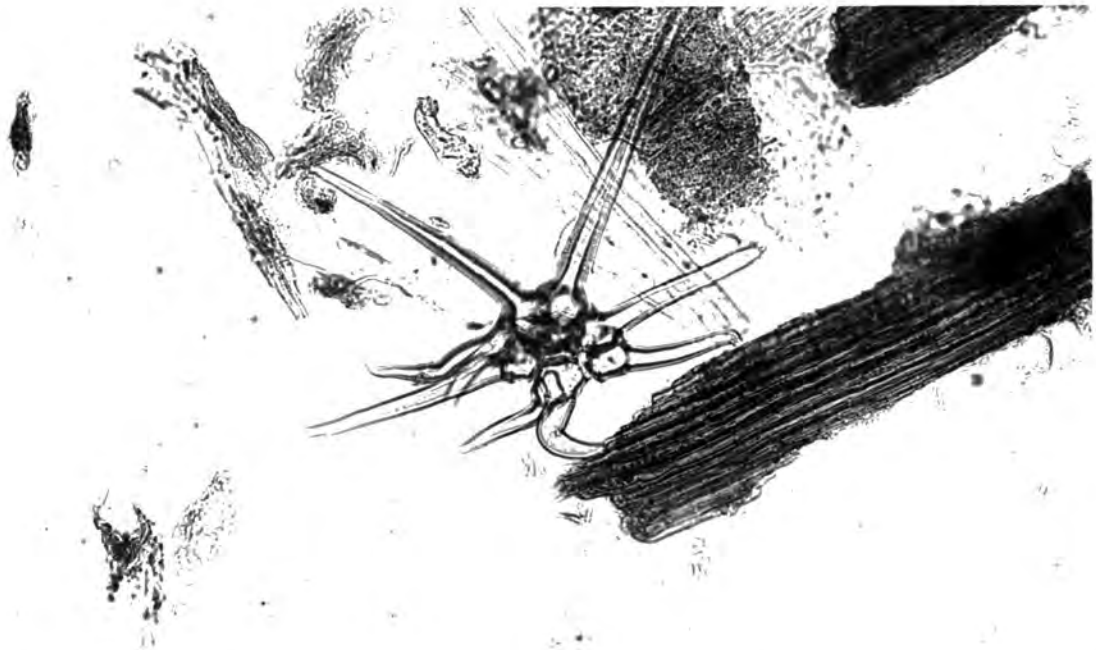
PLATE VIIb Geranium collinum (x 160)

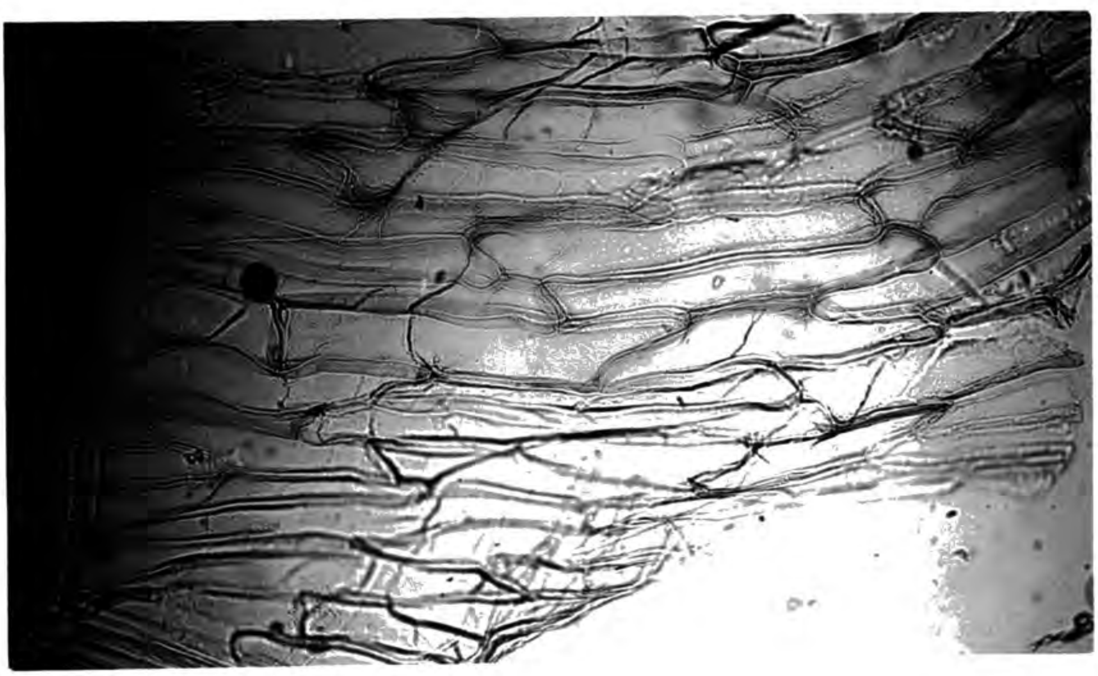
PLATE VIIc Dryopteris sp. (x 160)

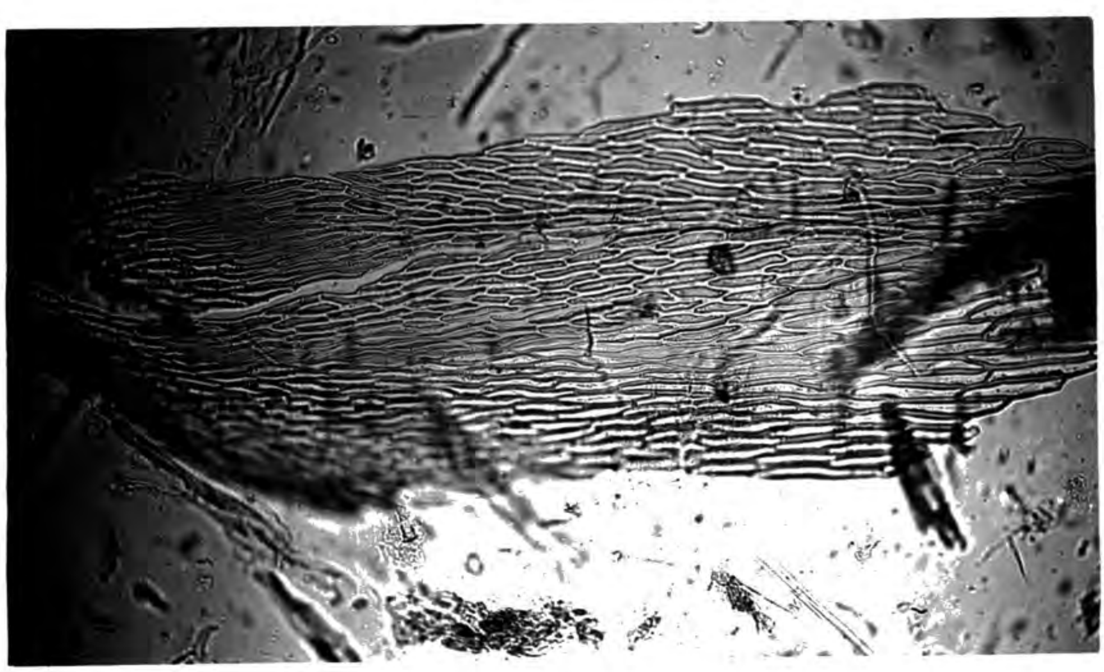
PLATE VIIIa Species X (x 160)

PLATE VIIIb Species Y (x 160)

PLATE VIIIc Moss (x 160)







plant fragments in the faeces were approximately the same size, frequency of occurrence equates to percent composition except in the case of mosses which tended to be smaller and, therefore, over-estimated.

Examination of the data in Table 18 reveals large differences between faecal samples taken in the same month. As samples within the same month probably represent different individuals, such variation may reflect differences in feeding between animals. Heterogeneity between samples of the same month was tested using X^2. Expected numbers of fragments for each plant category were computed from the data in Table 18. Any category in which the expected number of fragments was less than five was omitted for the purpose of computing X^2. Values of X^2 are shown for each month in Table 19. In every case, except November and February, there are significant differences between samples of the same month at the 1% level of probability. It is concluded, therefore, that animals fed differently from each other in most months of the year.

Table 19: Values of X^2 based on the number of various types of plant fragments counted in faecal samples of the same month

Month	M	J	J	A	S	O	N	D	F	M	Total
d.f.	3	15	9	9	6	6	4	20	3	12	87
X^2	16.0	52.0	32.5	73.2	25.1	20.5	6.7	112.1	4.4	123.7	466.0
P	< .01	< .001	< .001	< .001	< .001	< .01	> .10	< .001	> .20	< .001	< .001

The data in Table 18 show definite fluctuations in the case of some categories of plant fragments. For example, the proportion of sedges in the faeces was distinctly low between October and December, being least in November. This was correlated with a high incidence of dicotyledons in the same period. Also mosses, ferns and species X and Y were only present in the faeces at certain times of the year. Due to the inherently significant differences between samples of the same month

(Table 19), it was necessary to use a Monte Carlo test to determine whether or not samples vary significantly between different months.

The Monte Carlo significance test procedure consists of comparing the observed data with random samples which are generated in accordance with the hypothesis being tested (Hope 1968). In this case the Null hypothesis is that there is no seasonal variation in the composition of the faeces. Table 20 shows the observed and expected numbers of different types of plant fragment for each month, from which the value of X^2 is computed (X^2 = 1983.7, d.f. = 54, $P < 0.001$). This apparently significant value of X^2 is misleading on account of the large differences between samples of the same month (Table 19). According to the Null hypothesis, the animals sampled in each month should be typical of the samples taken over the whole year. Thus, the X^2 value from Table 18 should be typical of those obtained by randomly shuffling the samples between different months. For example, May might be represented by sample Nos. 15 and 27 rather than 1 and 2 as the result of a random shuffle. Table 18 was randomly shuffled 999 times in this way and values of X^2 were computed each time. The results of this procedure are displayed in Figure 11, which shows that Table 18 is atypical and so the Null hypothesis can be rejected at the 0.1% level of probability. The observed value of X^2 (1983.7) lies well outside the distribution of 999 values of X^2, computed by random shuffling, and is much larger than the highest of these values (X^2 max = 1257.5). It is concluded that the composition of faecal samples varied significantly between months, such variation being over and above any differences caused by animals feeding differently within the same month.

In view of the small number of samples taken each month, the data in Table 18 were amalgamated into four seasons: spring (April-June), summer (July-September), autumn (October-December) and winter

Table 20: Observed and expected numbers of plant fragments in faeces

Month		GRASS	SEDGE	DICOT	SPECIES X	SPECIES Y	FERN	MOSS
MAY	OBS	93	87	30	10	0	1	0
	EXP	74.7	45.2	60.0	18.1	7.6	9.5	5.8
JUNE	OBS	163	227	91	183	1	1	2
	EXP	225.7	136.8	181.4	54.6	23.1	28.8	17.6
JULY	OBS	96	88	138	127	1	0	1
	EXP	152.4	92.3	122.5	36.9	15.6	19.4	11.9
AUG	OBS	141	122	113	4	6	2	27
	EXP	140.2	85.0	112.7	33.9	14.4	17.9	10.9
SEPT	OBS	115	84	80	7	7	8	52
	EXP	119.3	72.3	95.9	28.9	12.2	15.2	9.3
OCT	OBS	158	23	111	5	7	8	17
	EXP	111.2	67.4	89.3	26.9	11.4	14.2	8.7
NOV	OBS	69	10	128	1	13	9	0
	EXP	77.7	47.1	62.5	18.8	8.0	9.9	6.1
DEC	OBS	252	45	207	1	83	112	9
	EXP	239.5	145.2	192.5	58.0	24.5	30.5	18.7
FEB	OBS	74	69	65	0	9	3	0
	EXP	74.3	45.0	59.7	18.0	7.6	9.5	5.8
MAR	OBS	235	91	159	0	16	34	1
	EXP	181.1	109.7	145.5	43.8	18.5	23.1	14.1

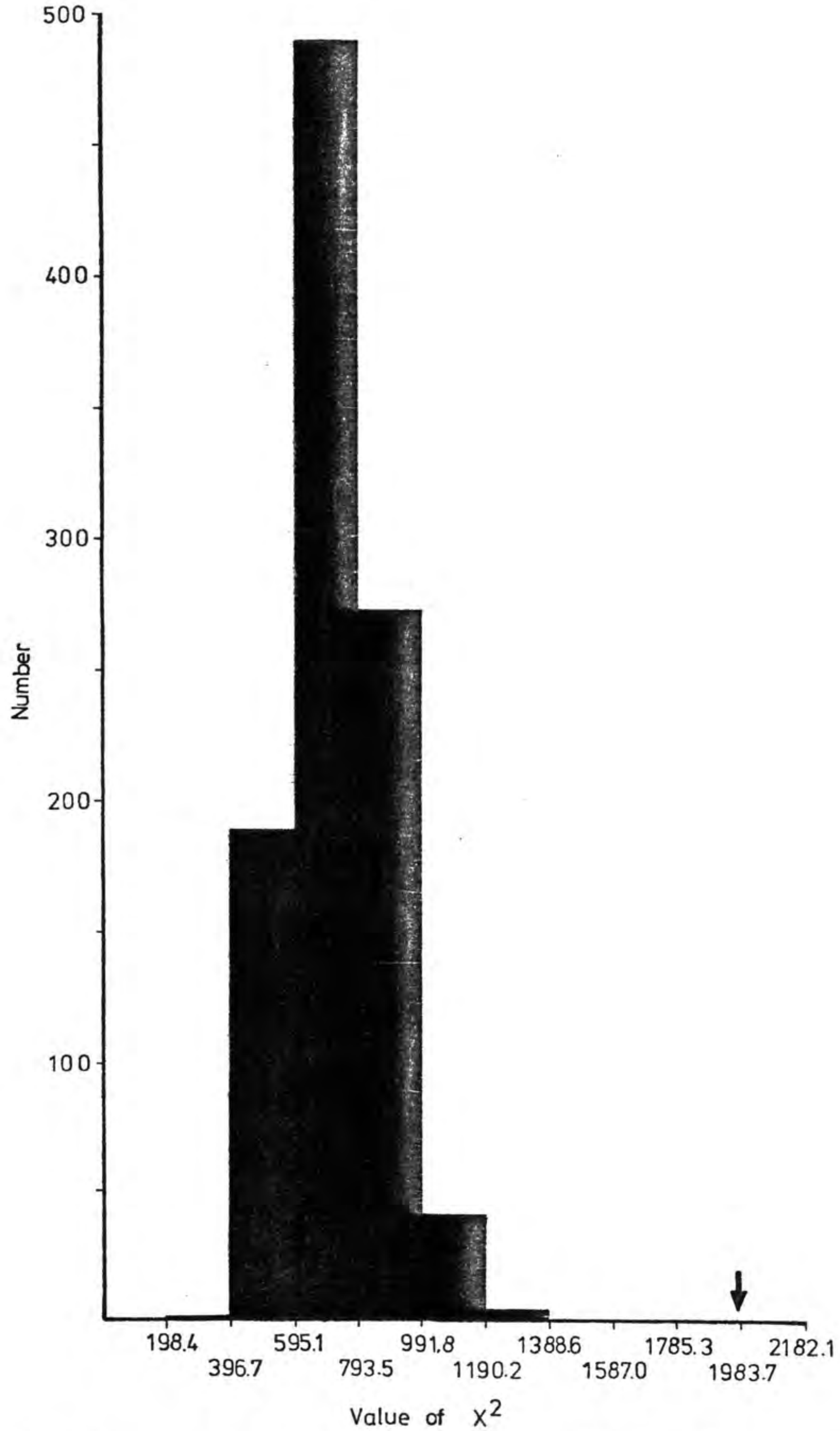


FIG.11 Frequency distribution of observed (N=1) and computed (N=999) values of X^2.

computed values of X^2

observed value of X^2

(January-March). Seasonal changes in the mean percent composition of plant fragments in the faeces are shown, with 95% confidence limits, in Figure 12. In general, the proportion of grasses within the faeces did not change significantly, at the 5% level, during the year although it appears to have increased in the autumn and winter. The incidence of sedges was significantly lower in the autumn than in other seasons.

During this period the incidence of dicotyledous, ferns and mosses was highest. The levels of species X and Y in the faeces were highest in the summer and spring seasons, respectively.

These results indicate that the composition of the faeces was governed by the seasonal availability of the different food plants; they also suggest that tahr foraged selectively. During and after the monsoon increasing amounts of grasses and dicotyledons were eaten, reaching peaks in October and November respectively, perhaps at a time when they were most readily available. The lower incidence of sedges in the faeces during this same period implies that they were less palatable. The sharp incline in the level of sedges in the winter suggests that tahr resorted to this type of food when grasses and dicotyledons were less readily available. Ferns were also eaten in preference to sedges in December. The highest levels of species X and Y in the summer and spring, presumably, corresponded to the seasons when they were most abundant. In December it appears that tahr supplemented their diet with quantities of moss. The decline in the level of mosses immediately after December, rather than in the spring when other food plants became available, can only be explained if this food resource quickly became depleted.

6.2 Discussion

Seasonal fluctuations in the composition of the diet of tahr were significant despite considerable individual variation. The

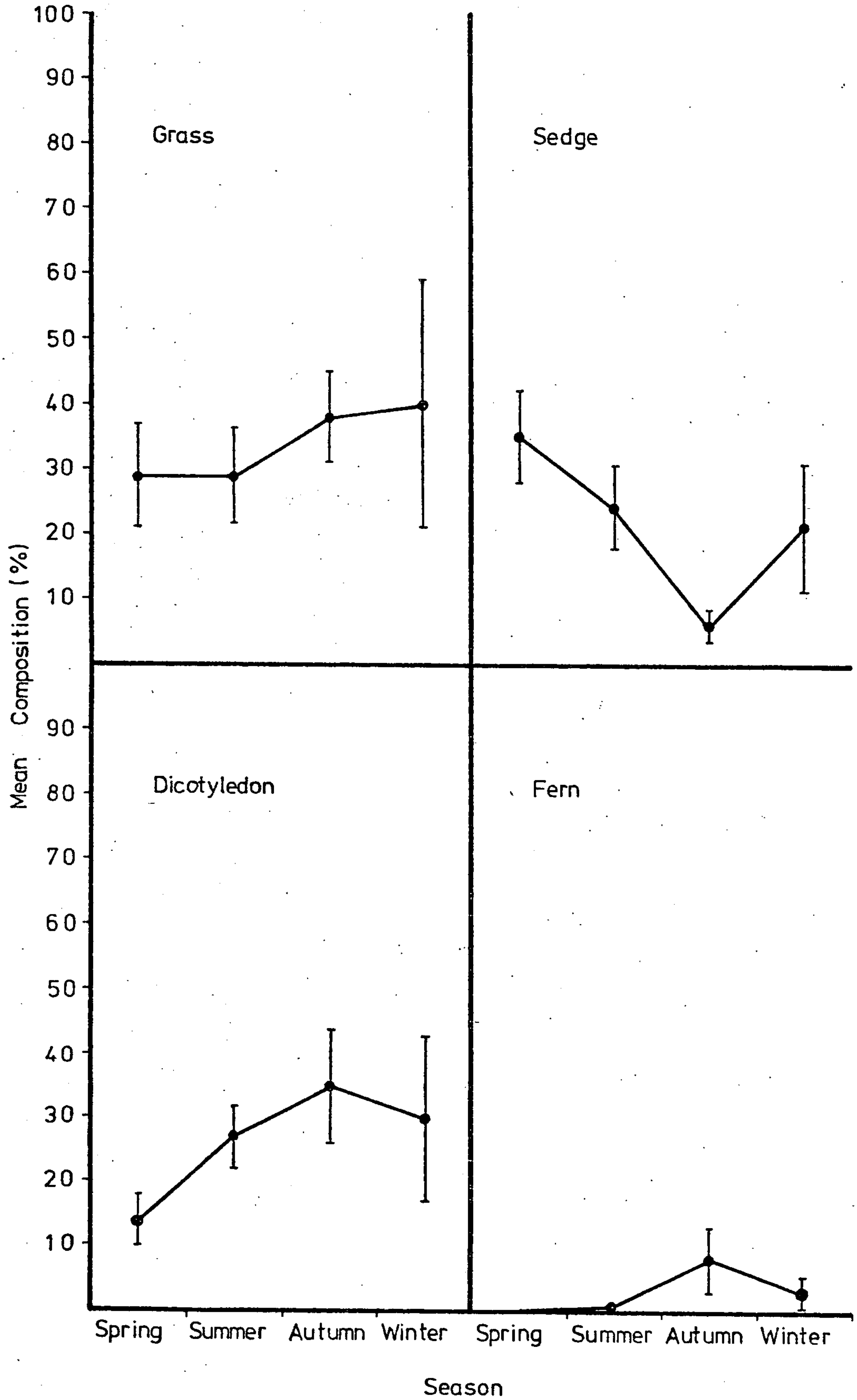


FIG.12 Mean percent composition of plant fragments in faeces, with 95% confidence limits, at different times of year.

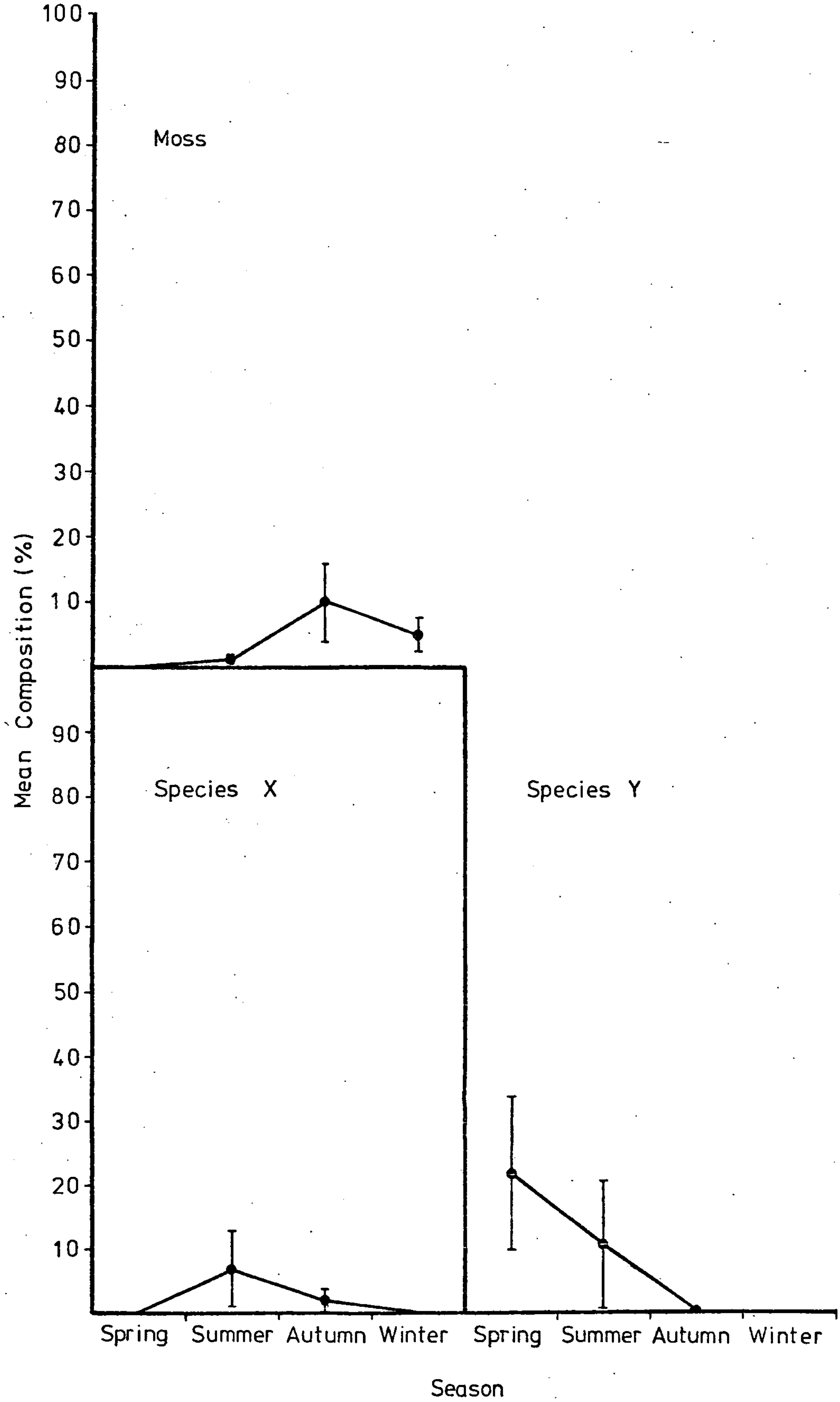

100
90
80
70
60
50
40
30
20
10
Moss
Mean Composition (%)
90
80
70
60
50
40
30
20
10
Species X
Species Y
Spring
Summer
Autumn
Winter
Spring
Summer
Autumn
Winter
Season

FIG.12 (Cont.)

frequency of a particular type of plant in the faeces is a reflection of its local abundance and palatability at the time of consumption. It appears that grasses, sedges and dicotyledons were the major constituents of the diet over the year, except in the autumn when the incidence of sedges in the faeces declined significantly. Ferns, mosses and two unknown species were important minor constituents for limited periods of the year.

The diets of two ecologically distinct groups of Soay sheep were found to be similar and to vary seasonally (Milner and Gwynne 1974). These authors note that the Cyperaceae were grazed during a short-lived main growth period in the spring and provided green herbage at the time of greatest scarcity of grazing in the winter. Bryophytes were also important constituents of the diet between late-winter and spring. Similar seasonal trends were detected in the present study.

As the availability of food plants in the field was not quantitatively estimated, it is not possible to make any concrete deductions about selective feeding. However, it seems that grasses and dicotyledons were preferred to sedges in the autumn, judging by the low incidence of the latter in the faeces at this time of year. As sedges often grew together with grasses in large tussocks, it is likely that tahr fed selectively on the grasses during this season. In the monsoon tahr spent a greater proportion of daylight hours moving and a correspondingly smaller proportion of daytime feeding than at other times of the year (Section 5.1). The greater amount of movement recorded in the summer months probably reflects more time spent searching for favourite food plants. Bouts of feeding activity were noticeably less intense in this season as animals perpetually wandered from one plant community to the next, whereas in winter animals often spent much longer periods of time feeding from the same patch.

Food was in short supply in parts of Area 1 in the winter. By mid-November the vegetation was very dry, except for a few genera such as Caragana, Festuca, Mechanopsis and Primula which appeared to have put on new growth and remained green. By the end of winter the main grazing grounds showed signs of being overgrazed with large patches of bare earth where the pasture had been grazed to its roots. Some quadrat samples taken on 8 April 1977 indicated a standing crop of about 0.2gm^{-2} (dry weight). It was about five times greater in nearby gullies where tussock grasses and sedges were abundant. Such plants may have been unpalatable, as there were no signs of them being grazed. It appears that tahr supplemented their diet with ferns and mosses and resorted to digging for roots in the winter. The extent to which food became limited during the winter also depended on the depth and duration of the snow cover but in Area 1 this was negligible.

Goats and sheep prefer grass when it is available, although both may consume a wide variety of forbs and leaves from trees and shrubs. Goats show adaptations to browsing by rearing up on their hindlegs and even jumping into trees; such behaviour is not often practised by Sheep (Schaller 1977). Tahr frequently stood up on their hindlegs in order to reach grasses and mosses growing in otherwise innaccessible rocky places. In eastern Nepal the diet consisted of 75% grasses, 7% twigs and leaves, 6% bamboo and 4% forbs in late February; tahr also appeared to lick crustose lichens off rocks (Schaller 1973). Markhor are known to lick soil for salt and bharal were once seen licking a white substance which seeped from cracks in rocks (Schaller 1977). It is likely, therefore, that tahr also obtain salts by licking rocks. In New Zealand snow grass (Chionochloa sp.) is a principal food of tahr (Caughley 1970a).

7. CONSERVATION AND MANAGEMENT

In the upper Langtang Valley some of the more accessible tahr habitat was periodically grazed by livestock. If food was limited then the difference in size between the Langtang and Yala populations might be attributed to competition between tahr and domestic animals. The lower density of tahr in Areas 5-6, as compared with Areas 1-4 (Section 4.2), might be similarly explained, since the former areas were grazed by livestock, whereas the latter were inaccessible to domestic animals.

Although the diet of the various types of livestock was not analysed, it was probably similar to that of tahr which ate a wide range of food plants. When livestock grazed the alpine pastures during the monsoon they must have consumed a considerable amount of food which would otherwise have been available to tahr.

Grazing pressure can be estimated by considering the time spent by wild and domestic animals within a given area. Data concerning the numbers and pattern of movement of livestock in the upper Langtang Valley are taken from Robinson (cited in DUHE 1976a). The seasonal distribution of livestock is shown in relation to the ranges of the Langtang and Yala tahr populations in Figure 2. In Area K, which encompasses Areas 5-6, and Area Y, which includes Area 7, the ranges of tahr and livestock overlapped. In 1976, between 16 June and 20 October, some 661 cattle and 1703-1918 sheep and goats were present in the upper Langtang Valley. The number of cattle had changed little since 1974, when Bonnemaire and Teissier (1976) recorded 662. During the winter months most livestock were taken down to lower altitudes but about 200 yaks, naks and chauries remained in the upper Langtang Valley (Robinson, pers. comm.). According to Field and Pandey (1969) an adult yak, or chauri[1], and a sheep annually require 6-8 tonnes and 1.7 tonnes fodder (fresh weight), respectively. An adult tahr is about half the weight of an adult yak or chauri and twice that of a sheep, so it will be assumed that it annually requires 3.5 tonnes of fodder (fresh weight) in the absence of other data. The amount of fodder consumed by an animal also depends on its age and sex but data of this nature are incomplete. For present purposes, therefore, it was assumed that all domestic and wild animals were adults and that there were no differences in feeding requirements between the sexes. The estimated numbers of tahr and livestock in Areas 1-4, K and Y (Fig. 2) are given in Table 21, together with a crude estimate of the total amount of fodder required annually in the three regions. Estimates of fodder requirements are exaggerated because a large proportion of domestic and wild animals were immature and so required less fodder than adults.

Data in Table 21 show that Areas 1-4 supported a greater biomass of ungulates than either Area K or Area Y. This is explained by the fact that much more of Areas 1-4 than Areas K or Y is at a lower altitude, where the growing season is longer and growth rates are higher. Area Y encompasses a higher range of altitudes than Area K and the two habitats are also very different in aspect and topography. Much of Area K faces east and the terrain is rugged, whereas a large part of Area Y is plateau and the rest consists of south-facing cliffs. The Yala plateau, in Area Y, is reputed to be one of the finest alpine pastures in Nepal. Such differences probably account for the greater ungulate biomass supported by Area Y as compared with Area K.

In Area 1 there were signs of overgrazing by tahr (Section 6.2).

1 Chauri is the Nepali term for the hybrid resulting from a cross between a yak (*Bos taurus*) and a cow (*Bos indicus*).

Table 21: Estimated annual fodder requirements of tahr and livestock in various areas

	Estimated No.	Corrected Estimate	No. Days	Area km^2	Annual fodder requirement tonnes km^{-2}	
AREAS 1-4 (Lower and Upper Subalpine, Lower Alpine Zones)						
Tahr (all year)	84.6	129.4	365	3.33		136.0
Livestock (all year)	0	0	0	3.33		0
TOTAL						136.0
AREA K including Areas 5-6 (Upper Subalpine and Lower Alpine Zones)						
Tahr (all year)	27.8	44.5	365	5.37		29.0
Sheep (summer)	103	103	56	5.37	5.0	28.0
Cattle (summer)	81	93.3	56	5.37	18.7	
Cattle (winter)	5	5	239	5.37	4.3	
TOTAL						57.0
AREA Y including Area 7 (Upper Subalpine, Lower Alpine, Upper Alpine Zones)						
Tahr (all year)	40	40	365	12.12		11.6
Sheep Gp IV (summer)	33	33	61	12.12	0.8	78.0
Sheep Gp V (summer)	150	150	98	12.12	5.6	
Sheep Herd 1 (summer)	300	300	68	12.12	7.8	
Cattle Gp IV (summer)	130	149.7	61	12.12	14.5	
Cattle Gp V (summer)	115	132.4	98	12.12	20.5	
Cattle Gp VI (summer)	30	34.5	49	12.12	2.7	
Cattle (winter)	69	69	239	12.12	26.1	
TOTAL						89.6

NOTES:

i. Robinson's estimate of 661 cattle in the upper Langtang Valley included 100 animals which were not censused in the summer (cited in DUHE 1976a). Summer estimates of numbers of cattle are, therefore, corrected by a factor of 761/661.

ii. Annual fodder requirements are based on estimates of 7, 3.5, and 1.7 tonnes (fresh weight) for cattle, tahr and sheep respectively.

iii. Data for livestock are taken from Robinson (cited in DUHE 1976a).

iv. Data for tahr are taken from Section 4.2.

According to locals the quality of the Yala pastures is deteriorating and erosion, due to over-use, is apparent in places. Every few years locals burn the scrub within Areas K and Y in an attempt to improve grazing. Such practices may be detrimental to the quality of the pastures in the long-term, particularly since burnt scrub regenerates within a few years. Although precise data are lacking, it appears that the pastures throughout the upper Langtang Valley are grazed to their maximum capacity by both wild and domestic ungulates. Food must, therefore, be limiting any increase in the ungulate population.

It may be deduced from Table 21 that the number of tahr in Areas K and Y would increase by about 40 and 270, respectively, if livestock were removed. Conversely, an increase in the livestock population would result in a decrease in the tahr population. The extent of such a decline depends on the degree to which tahr compete with livestock for fodder. Since certain tahr habitat will always remain inaccessible to less agile domestic animals and because the Langtang people do not hunt, the Langtang and Yala populations are unlikely to become endangered. Numbers may decrease further but, provided the Langtang and Yala populations remain large enough to be viable breeding units, then active conservation measures are not deemed necessary.

A major reason for promoting an increase in the tahr populations, particularly the Yala one, would be to provide tourists with a better opportunity of observing these wild animals. In the case of the Langtang National Park, however, attention should first be directed towards the Park's local residents who presently live at subsistance level. To recommend the removal of livestock from Yala (Area Y) in order to promote an increase in the tahr population, would severely damage the local economy. Moreover, it would not be in the long-term interests of the Park, as such a policy would merely increase the present antagonism shown by local residents towards the Park.

A system of zonation has already been proposed for the Langtang National Park (DUHE 1977b), based on the classification adopted by Dasmann (1973), as a means of compromising between the conflicting interests of the Park's wild life, resident locals and visitors. For instance, in view of the intense pastoral and agricultural activities in the upper Langtang Valley, a large proportion of this area has been proposed suitable for designation as a "Cultivated Landscape" (Fig. 2), to enable such land use activities to continue. However, east of the terminal moraine at Nubmathang (Fig. 2) it has been proposed that the valley should be designated a "Wilderness Area" (Fig. 2) in order to maintain an element of the wild for the nature lover (DUHE 1977b). At present this region is used by about 30 cattle and 300 sheep, belonging to Park residents, for 49 days each monsoon (DUHE 1976a) and by about 6 tahr (Section 4.2). If the livestock were removed from this region, the numbers of tahr would theoretically be expected to increase by about 30 animals. The livestock would need to be accommodated elsewhere in the upper Langtang Valley once other management proposals had been implemented, such as the removal of 1300-1500 sheep, which originate from outside the Park (DUHE 1976b). An increase in the number of tahr in this uppermost section of the Langtang Valley would be welcomed by visitors, who at present rarely see these animals, and need not be detrimental to local grazing rights provided that other management policies could be concurrently implemented.

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APPENDIX I

All sightings of groups are listed in the tables below, together with the sex and age of individuals if they were classified. Groups which were known to be larger than indicated, due to individuals being out of sight, are marked with an asterisk. Adult male, maternal and mixed groups are marked M, F and M-F, respectively. Adult males of unknown age category are entered into the III-II column. The columns F-S, Yl and Yo are assigned to adult females-subadults, yearlings and young respectively. Sometimes no distinction was made between young and adult females-subadults, in which case the F-S-Yo column is entered. Prior to parturition in 1976, the previous year's young were not consistently distinguished from yearlings and so all individuals, apart from adult males, are entered into the F-S-Yl-Yo column for this period. Individuals which were not aged or sexed appear in the unclassified (U) column. The data appear in separate tables for the Langtang and Yala populations.

Langtang Population

Date	Area	Group size	Group type	Adult male III	Adult male II	Adult male III-II	F-S	Yl	Yo	F-S-Yl	F-S-Yl-Yo	U
20.4.76	1	4	F								4	
21.	1	8	F								8	
30.	1	6	F								6	
30.	1	8	F								8	
17.	6	21	?									21
18.	6	21	?									21
20.	6	11	?									11
23.	6	6	F								6	
23.	6	18	M			17					1	
24.	6	17	?									17
24.	6	3	F								3	
TOTALS		123	1M 6F			17					36	70

Date	Area	Group size	Group type	Adult male III	Adult male II	Adult male III-II	F-S	Yl	Yo	F-S-Yl	F-S-Yl-Yo	U
2.5.76	1	3	F								3	
2.	1	16	F								16	
2.	1	5	F								5	
3.	1	*12	?								12	
4.	1	32	F								32	
16.	1	2	F								2	
28.	1	22	F								22	
28.	1	3	M	3								
29.	1	56	M-F									56
31.	1	40	F								40	
31.	1	1	F								1	
3.	6	8	?									8
4.	6	20	?									20
6.	6	16	?									16
11.	6	15	?		6						8	1
11.	6	18	M	11	7							
21.	6	24	M-F		1						22	1
21.	6	2	M		2							
21.	6	17	M	11	6							
22.	6	20	M-F		1						9	10
26.	6	19	?									19
TOTALS		339 *12	4M 8F 3M-F	25	23						172	131

Date	Area	Group size	Group type	Adult male III	Adult male II	Adult male III-II	F-S	Yl	Yo	F-S-Yl	F-S-Yl-Yo	U
1.6.76	1	45	M-F	2							42	1
2.	1	2	F								2	
2.	1	2	F								2	
2.	1	1	F								1	
7.	1	30	M-F		2						13	15
15.	1	40	M-F		1						39	
15.	1	7	F								7	
16.	1	1	F								1	
16.	1	23	M-F			7					16	
16.	1	*21	?								21	
19.	1	*31	M-F								12	19
19.	1	9	F								9	
21.	1	48	?									48
22.	1	1	?									1
22.	1	11	?									11
23.	1	20	F								20	
16.	2	22	F								22	
16.	3	* 4	?									4
18.	3	* 3	F								3	
18.	3	7	?									7
19.	3	1	?									1
21.	3	6	?								5	1
22.	3	17	?								12	5
8.	6	26	M-F		5						21	
8.	6	10	M	10								
8.	6	1	F								1	
10.	6	7	F								7	
10.	6	33	M-F	10	8						15	
TOTALS		370 *59	1M 11F 7M-F	22	16	7					271	113

Date	Area	Group size	Group type	Adult male III	Adult male II	Adult male III-II	F-S	Yl	Yo	F-S-Yl	F-S-Yl-Yo	U
3.7.76	1	1	F							1		
10.	1	18	?									18
10.	1	26	F				14	2	10			
12.	1	*23	F				14	0	9			
12.	1	35	F						1	34		
13.	1	*32	F						0	32		
17.	1	2	F				1		1			
19.	1	4	F				4					
20.	1	10	F				10					
21.	1	7	F				3	3	1			
21.	1	*28	F				16	1	11			
22.	1	33	F				18	1	14			
22.	1	1	F				1					
23.	1	* 8	?				7		1			
31.	1	2	?									2
3.	2	16	?									16
5.	3	8	F				4		4			
20.	3	10	F				5	5				
21.	3	12	F				10	2				
27.	3	30	F				17	1	12			
TOTALS		215 *91	16F				124	15	64	67		36
2.8.76	1	*17	?				11		6			
2.	1	8	F				4		3		1	
3.	1	32	F				17	8	7			
3.	1	1	F				1					
4.	1	1	F				1					
14.	1	50	F						9	41		
15.	1	2	F				1		1			
15.	1	*13	?								13	
19.	1	2	F				1		1			
19.	1	64	F				30	22	12			
21.	1	44	F						9	33	2	
26.	1	24	F						10	14		
27.	1	52	F						10	38	4	
28.	1	36	F						9	27		
3.	2	1	F				1					
14.	2	33	F				20	3	8		2	
15.	2	*12	F							12		
15.	2	*29	F						10	19		
26.	2	1	F				1					
2.	3	9	F				5		4			
20.	3	10	F				6		4			
20.	3	7	F				4		3			
20.	3	* 4	?				4					
21.	3	* 2	?									2
TOTALS		377 *77	20F				107	33	106	184	22	2

Date	Area	Group size	Group type	Adult male III	Adult male II	Adult male III-II	F-S	Yl	Yo	F-S-Yl	F-S-Yl-Yo	U
6.9.76	1	6	F							6		
6.	1	13	F						5	8		
6.	1	14	F				6	4	4			
7.	1	13	F								13	
7.	1	24	F				10	7	7			
8.	1	21	?									21
28.	1	3	F					3				
29.	1	3	F				1	2				
30.	1	27	F				10	8	9			
30.	1	9	F				4	1	4			
30.	1	2	M			2						
6.	2	5	F				2	2	1			
7.	2	1	F					1				
29.	2	*21	F						9	12		
29.	2	16	F				7	3	6			
30.	2	9	F				4	1	4			
30.	2	8	F				3	2	2		1	
28.	3	*22	F								22	
30.	3	* 9	?						2	7		
TOTALS		174 *52	1M 16F			2	47	34	53	33	36	21
1.10.76	1	2	F				1		1			
1.	1	26	F				11	4	9		2	
1.	1	2	M			2						
4.	1	3	M			3						
4.	1	36	F						10	16	10	
4.	1	4	F				2		2			
11.	1	66	M-F			1	42	11	12			
13.	1	61	F						17	44		
25.	1	1	M			1						
26.	1	2	F				1	1				
26.	1	*43	?									43
26.	1	*15	?									15
27.	1	*47	M-F		1		6	9	4			27
28.	1	* 7	?									7
28.	1	4	F									
28.	1	4	F				7	6	4		4	
28.	1	12	F									
28.	1	1	F									
28.	1	4	F				2	1	1			
25.	2	*27	F						5	20	2	
1.	3	* 6	?				1	1	1		3	
1.	3	*16	?									16
9.	3	11	F				4	2	5			
4.	5	7	F						2	5		
4.	6	1	M			1						
4.	6	1	M			1						
8.	6	1	M			1						
8.	6	18	F						8	10		
21.	6	6	?									6
TOTALS		273 *161	6M 15F 2M-F		1	10	77	35	81	95	21	114

Date	Area	Group size	Group type	Adult male III	Adult male II	Adult male III-II	F-S	Yl	Yo	F-S-Yl	F-S-Yl-Yo	U
6.11.76	1	1	M			1						
6.	1	*13	?						1	7		5
17.	1	41	M-F	2	1				11	27		
18.	1	1	M	1								
18.	1	12	M-F		1		7	3	1			
18.	1	14	M-F	1			1	12				
25.	1	1	M			1						
25.	1	1	F				1					
25.	1	*10	M-F	1					2	7		
26.	1	2	M	2								
26.	1	*10	M-F	1			4	2				3
26.	1	1	F					1				
29.	1	19	M-F	2							17	
30.	1	42	M-F	4	1				7	30		
29.	2	19	M-F	3	1		5	1	3			6
30.	2	14	M-F		1				4	9		
4.	3	8	F						2	6		
6.	3	* 3	?									3
29.	3	* 3	M-F		1		1		1			
30.	3	12	M-F	2					2	8		
4.	6	4	M-F			1					3	
5.	6	12	M-F	1	2		5	1	3			
TOTALS		204 *39	4M 3F 13M-F	20	8	3	24	20	37	94	20	17
3.12.76	1	56	M-F			6					50	
8.	1	*46	M-F	4							42	
9.	1	*41	M-F	6	2						33	
10.	1	4	M-F	1							3	
10.	1	* 2	M-F			1					1	
10.	1	1	M			1						
11.	1	51	M-F	5					11	35		
14.	1	*14	M-F	1							13	
20.	1	*52	M-F			10					42	
22.	1	*64	M-F	5	3				15	41		
30.	1	67	M-F	7	5				18	37		
3.	3	9	M-F	2							7	
9.	3	4	M-F	1			2		1			
10.	3	5	M-F	1							4	
20.	3	13	M-F	1	1		5	2	4			
2.	4	4	M-F	1							3	
8.	4	32	M-F	3	1						28	
2.	5	1	M	1								
14.	5	*15	?									15
14.	6	9	M-F	2	1						6	
15.	6	9	M-F		1		4	1	2			1
TOTALS		265 *234	2M 18M-F	41	14	18	11	3	51	113	232	16

Date	Area	Group size	Group type	Adult male III	Adult male II	Adult male III-II	F-S	Yl	Yo	F-S-Yl	F-S-Yl-Yo	U
8.1.77	1	23	M-F			4					19	
8.	1	58	M-F			8					50	
13.	1	* 4	?						1	3		
16.	1	*14	?									14
17.	1	13	M-F		2				3	8		
17.	1	*14	M-F	2							12	
7.	2	* 6	M-F	1	1						4	
7.	3	10	M-F	1					3	6		
16.	3	*19	M-F	1	1	1			7	9		
16.	3	*14	M-F			4			4	6		
7.	4	14	M-F	1	1						12	
11.	4	36	M-F	4	5				7	20		
12.	4	39	M-F	3	5				8	23		
12.	4	1	M	1								
13.	4	*18	M-F	2	2				2	12		
13.	4	7	M-F		1				1	5		
13.	4	5	M-F	2			2		1			
15.	4	7	M-F	1			4		2			
16.	4	2	M		2							
16.	4	14	M-F	2	1				4	7		
13.	5	28	M-F	5	3				9	11		
15.	6	6	M-F	1			3	1	1			
TOTALS		263 *89	2M 18M-F	27	24	17	9	1	53	110	97	14
18.2.77	1	*44	?									44
19.	1	77	?									77
21.	1	68	M-F		4				16	48		
21.	1	* 9	M-F		2				2	3		2
22.	1	*45	?									45
23.	1	*46	M-F	1			5	2	3			35
24.	1	*41	?									41
22.	2	17	M-F		1				6	10		
23.	2	21	M-F		3				4	14		
24.	2	27	M-F		3		15	5	4			
23.	3	15	M-F		2		5	1	4			3
24.	3	12	M-F		1		7	1	3			
22.	4	38	M-F	1	4		15	8	10			
23.	4	*16	?									16
24.	4	35	M-F	1	4				7	23		
24.	6	16	M	9	7							
25.	6	7	M	4	3							
25.	6	8	M			8						
28.	6	* 7	?			7						
28.	6	* 6	?								6	
TOTALS		341 *214	3M 10M-F	16	34	15	47	17	59	98	6	263

Date	Area	Group size	Group type	Adult male III	Adult male II	Adult male III-II	F-S	Yl	Yo	F-S-Yl	F-S-Yl-Yo	U
3.3.77	1	*13	?									13
5.	1	4	?									4
5.	1	21	M-F		2		8	10	1			
14.	1	4	F				2		2			
14.	1	1	F				1					
14.	1	39	?									39
15.	1	*21	?									21
15.	1	2	?									2
15.	1	1	F				1					
16.	1	11	F						2	9		
16.	1	8	F						2	6		
16.	1	8	?									8
16.	1	3	?									3
16.	1	1	?									1
16.	1	1	?									1
16.	1	1	F				1					
17.	1	*18	?									18
18.	1	*21	?									21
24.	1	*49	?									49
24.	1	9	F						2	7		
26.	1	14	F				6	2	6			
14.	2	11	F						3	8		
16.	2	13	F				6	3	3			1
16.	2	5	F				3	1	1			
15.	3	* 7	?									7
18.	3	*14	M-F		1		7	1	3			2
15.	4	* 8	?									8
15.	4	* 6	?									6
18.	4	*19	M-F		2				5	12		
8.	5	4	F							4		
8.	6	13	M			13						
8.	6	1	M			1						
TOTALS		175 *176	2M 12F 3M-F		5	14	35	17	30	46		204

Date	Area	Group size	Group type	Adult male III	Adult male II	Adult male III-II	F-S	Yl	Yo	F-S-Yl	F-S-Yl-Yo	U
4.4.77	1	* 4	?							4		
4.	1	*22	?									22
6.	1	50	M-F	1	2				7	24	16	
6.	1	2	F				1		1			
6.	1	5	F				4	1				
7.	1	14	M-F			5			2	7		
7.	1	* 5	?						1	4		
7.	1	2	F				1		1			
8.	1	16	M-F	3	2		5	5	1			
8.	1	23	F				11	5	7			
8.	1	59	M-F	2	7		25	16	9			
19.	1	7	F				6	1				
19.	1	4	F				3		1			
19.	1	*15	?				6		2			7
31.	1	*12	?									12
31.	1	* 2	?									2
7.	3	5	F				3	1	1			
19.	3	* 1	?				1					
19.	3	5	F				3	1	1			
19.	3	2	F				1		1			
21.	3	* 9	?									9
19.	4	1	F				1					
19.	4	22	M-F	1	3		11	7				
21.	4	*14	M-F	1	3						10	
21.	4	*19	M-F									19
20.	6	*14	M	9	4	1						
20.	6	6	M-F			1			1	4		
TOTALS		223 *117	1M 10F 8M-F	17	21	7	82	37	36	43	26	71

Yala Population

Date	Area	Group size	Group type	Adult male III	Adult male II	Adult male III-II	F-S	Yl	Yo	F-S-Yl	F-S-Yl-Yo	U
25.4.76	8	5	M	3	2							
26.	8	5	M	3	2							
27.	8	5	M	3	2							
18.6.76	7	24	M-F		3				9	12		
6.10.76	8	1	M	1								
16.12.76	7	15	?									15
26.	7	24	M-F	5	4				4	11		
14.1.77	7	23	M-F	6	4				3	10		
20.2.77	7	25	?									25
26.	7	1	M			1						
26.	8	6	M			6						
27.	7	21	M-F	4	4		7	3	3			
17.3.77	7	1	?									1
27.	7	1	?									1
21.4.77	7	40	M-F	5	5		14	8	8			
21.	8	6	M	4	2							
TOTALS		203	7M 5M-F	34	28	7	21	11	27	33		42

APPENDIX II

Group size

Data, concerning group size, for the Langtang and Yala populations are abstracted from Appendix I and amalgamated as in the table below.

Group size G	Number N		Animal sightings GN		GN x 100 / ΣGN	Group size G	Number N		Animal sightings GN		GN x 100 / ΣGN
1	37		37			43	0		0		
2	18	62	36			44	1	2	44		
3	7		21			45	1		45		
4	14		56			46	0		0	320	9.0%
5	11	34	55			47	0	1	0		
6	9		54	531	15.0%	48	1		48		
7	10		70			49	0		0		
8	10	28	80			50	2	3	100		
9	8		72			51	1		51		
10	5		50			52	1		52		
11	5	16	55			53	0	1	0		
12	6		72			54	0		0		
13	6		78			55	0		0		
14	7	16	98			56	2	2	112	332	9.4%
15	3		45			57	0		0		
16	6		96	701	19.8%	58	1		58		
17	4	14	68			59	1	2	59		
18	4		72			60	0		0		
19	3		57			61	1		61		
20	3	12	60			62	0	1	0		
21	6		126			63	0		0		
22	3		66			64	1		64		
23	4	12	92			65	0	2	0	326	9.2%
24	5		120			66	1		66		
25	1		25			67	1		67		
26	3	6	78	649	18.3%	68	1	2	68		
27	2		54			69	0		0		
28	1		28			70	0		0		
29	0	3	0			71	0	0	0		
30	2		60			72	0		0		
31	0		0			73	0		0		
32	3	6	96			74	0	0	0		
33	3		99			75	0		0	77	2.2%
34	0		0			76	0		0		
35	2	5	70			77	1	1	77		
36	3		108	609	17.2%	78	0		0		
37	0		0			79	0		0		
38	1	3	38			80	0		0		
39	2		78								
40	3		120				239		3545		
41	1	5	41								
42	1		42				(ΣN)		(ΣGN)		

APPENDIX III

Test for homogeneity of group sizes for different seasons

The number of sightings of different categories of group size (Appendix I) are shown in the first table for each month. In order to test for homogeneity, using X^2, various rows and columns of this table were amalgamated, as indicated by the heavy lines, so that expected values exceeded about five for statistical purposes. The data from the first table are shown in their amalgamated form in the second table, together with values of X^2 which were calculated from the observed (O) and expected (E) numbers of sightings.

Season	Pre-parturition			Post-parturition				Rut				Pre-part.		
Group size	A	M	J	J	A	S	O	N	D	J	F	M	A	TOTALS
1-10	9	7	13	9	10	9	16	8	9	7	4	17	11	129
11-20	3	8	3	3		4	3	8	2	3	4	5	2	48
21-30	2	2	5	2	1	3	1		1	3	4	1	2	27
31-40		2	2	2	3		1		1	2	2	1	1	17
41-50			2		2			1					1	6
51-60		1			1				2	1			1	6
61-70					1		2		1		1			5
71-80											1			1
TOTALS	14	20	25	16	18	16	23	17	16	16	16	24	18	239

Group size	Months	M A M J	J A S O	N D J F
1 - 10	O	57	44	28
	E	54.51	39.40	35.08
	$(O-E)^2/E$	0.11	0.54	1.43
11 - 20	O	21	10	17
	E	20.28	14.66	13.05
	$(O-E)^2/E$	0.03	1.48	1.20
21 - 30	O	12	7	8
	E	11.41	8.25	7.34
	$(O-E)^2/E$	0.03	0.19	0.06
31 - 40	O	6	6	5
	E	7.18	5.19	4.62
	$(O-E)^2/E$	0.19	0.13	0.03
41 - 80	O	5	6	7
	E	7.61	5.50	4.90
	$(O-E)^2/E$	0.90	0.05	0.90

$$X^2 = \sum \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$$

$$= \sum \frac{(O - E)^2}{E}$$

$$= 7.27 \qquad (\text{d.f.} = 8 \; ; \; P > 0.05)$$

APPENDIX III (cont.)

Test for homogeneity in the pattern of feeding activity

The number of sightings of animals feeding (a), together with the total number of sightings (n) is shown at each half-hour interval for every month. X^2 is calculated from Brandt & Snedecor's formula:-

$$X^2 = \frac{\sum \frac{a^2}{n} - \frac{A^2}{N}}{\frac{A}{N} \cdot \frac{(N-A)}{N}}$$

Time		May	June	Oct	Nov	Dec	Jan	Feb	March	April		TOTALS	X^2
0800	a	57	106	524	169	77	28	322	267	193	A	1743	6.02
	n	62	122	620	199	89	30	338	305	240	N	2005	
0830	a	101	54	509	191	106	213	541	290	188	A	2193	39.04
	n	132	97	755	217	131	234	564	400	237	N	2767	
0900	a	40	67	411	495	298	271	635	164	201	A	2582	77.71
	n	71	98	652	546	346	305	660	294	330	N	3302	
0930	a	72	192	256	406	605	247	585	91	70	A	2524	82.13
	n	104	264	433	447	657	297	684	186	181	N	3253	
1000	a	46	128	176	283	504	163	348	90	117	A	1855	73.91
	n	67	154	443	342	558	213	472	191	242	N	2682	
1030	a	67	125	186	187	350	74	150	85	194	A	1418	40.76
	n	86	181	450	309	457	179	251	247	263	N	2423	
1100	a	76	104	112	104	301	229	99	136	214	A	1375	39.49
	n	80	144	294	294	500	295	148	299	354	N	2408	
1130	a	59	41	87	102	211	139	141	100	151	A	1031	21.18
	n	69	121	267	267	364	335	269	161	266	N	2119	
1200	a	17	41	255	126	336	135	174	75	196	A	1355	23.38
	n	38	132	345	238	510	338	333	132	330	N	2396	
1230	a	40	83	80	162	308	129	220	181	111	A	1314	19.10
	n	66	181	108	260	482	287	301	248	135	N	2068	
1300	a	52	62	97	172	332	123	361	142	106	A	1447	26.99
	n	53	156	130	267	425	211	431	200	150	N	2023	
1330	a	31	78	19	74	194	119	429	149	97	A	1190	26.66
	n	32	142	56	145	267	195	499	210	127	N	1673	
1400	a	29	88	50	65	279	74	387	166	94	A	1232	12.19
	n	32	156	62	129	348	104	520	221	143	N	1715	

Time	May	June	Oct	Nov	Dec	Jan	Feb	March	April	TOTALS		x^2
1430	a 36	105	47	61	349	50	352	183	49	A	1232	28.15
	n 42	153	59	118	433	82	447	234	144	N	1712	
1500	a 36	79	60	74	203	91	351	187	74	A	1155	17.98
	n 42	99	73	84	248	117	448	241	166	N	1518	
1530	a 28	96	36	41	84	136	562	223	65	A	1271	1.03
	n 31	111	42	50	95	153	647	270	78	N	1477	
1600	a 11	9	43	14	181	160	449	145	123	A	1135	9.01
	n 12	17	49	15	185	170	518	170	130	N	1266	

APPENDIX IV

Horns

Specimen No.	1	2	3
Date of collection	26.4.76	27.5.76	31.3.77
Locality in Fig. 2	Area 8	Area 8	Area 1
Keel length (cm)	34.4	> 29.2	21.9
Basal circumference (cm)	19.6	21.9	12.7
No. growth rings	14	> 13	c.8
Age	15	> 14	c.9
Sex	male	male	female
Comments	-	tip worn	keel worn above base

NOTE: All measurements were taken from left horns.

Molar Teeth

Specimen No.	1	2	3
Maximum no. white bands in dentine	-	10	9 + 3

NOTES: i. First molars of the lower jaw were examined.

ii. The first figure indicates the number of bands of consistent thickness, the second figure indicates the number of thicker, irregular bands.

APPENDIX V

Daily activity sightings of various age and sex categories (May 1976 - April 1977)

Adult females and juveniles (both sexes)

	MAY								JUNE							
Hours	F	L	S	M	D	A	G	TOTAL	F	L	S	M	D	A	G	TOTAL
0600	32							32								
30	66							66	27	1	3					31
0700	152							152	92		2			2		96
30	84	4	2					90	86	8	5					99
0800	57	5						62	106	2	1	13				122
30	101	29	2					132	54	29	9	5				97
0900	40	20	11					71	67	22	8		1			98
30	72	22	8		2			104	192	59	8	2			3	264
1000	46	16	4		1			67	128	18	4	4				154
30	67	18	1					86	125	42	13				1	181
1100	76	2	2					80	104	33	7					144
30	59	7	3					69	41	34	41	5				121
1200	17	21						38	41	80	8				3	132
30	40	24			2			66	83	87	9				2	181
1300	52		1					53	62	64	9	12		2	7	156
30	31				1			32	78	34	29				1	142
1400	29	3						32	88	45	19	3			1	156
30	36	6						42	105	24	23				1	153
1500	36	6						42	79	2		7	11			99
30	28	1	2					31	96	9	5	1				111
1600	11		1					12	9	8						17
30	15							15	10	1						11
1700	4		2					6	12		2					14
30									8		1					9
1800																
TOTAL	1210	184	39	0	6	0	0	1439	1693	602	206	52	12	4	19	2588

Adult females and juveniles (both sexes)

	JULY								AUGUST							
Hours	F	L	S	M	D	A	G	TOTAL	F	L	S	M	D	A	G	TOTAL
0600	58		19	1				78								
30	124	1	34	5				264	24		15	6				45
0700	64		3	49				116	72		34	26		2		134
30	149	94	17	3			3	266	297	8	45	54		2	4	410
0800	180	129	47			2	4	362	488	65	55	113			6	727
30	179	120	17	4				320	444	98	30	131		4	9	716
0900	218	93	44	12		2		369	364	162	38	105			9	678
30	124	59	34	2			1	220	67	31	17	14				129
1000	117	57	9					183	33	12	16					61
30	86	34	17	3				140	40	12	15					67
1100	63	39	19	3				124	15	10	5	2				32
30	78	30	4	1			1	114	1			4				5
1200	55	4	5	4				68								
30	17		1					18								
1300																
30																
1400	26		2					28								
30	8		1					9								
1500									10	6	5					21
30									27	11	1					39
1600																
30									15		4					19
1700																
30																
1800																
TOTAL	1546	660	273	87	0	4	9	2679	1897	415	280	455		8	28	3083

Adult females and juveniles (both sexes)

Hours	SEPTEMBER F	L	S	M	D	A	G	TOTAL	OCTOBER F	L	S	M	D	A	G	TOTAL
0600									238		4	22				264
30	9		8	3				20	369		19	16				404
0700	55	2	9	57			3	126	284	1	10	33			2	330
30	115	1	23	62		2	5	208	342		56	6		2	4	410
0800	154	32	11	101			7	305	524	2	44	44		2	4	620
30	141	62	31	59			3	296	509	31	56	253			6	755
0900	85	53	31	37		2	1	209	411	78	69	86	2		6	652
30	110	26	14	62		2	4	218	256	61	73	42			1	433
1000	173	41	22	102			5	343	176	161	82	21			3	443
30	105	50	42	8				205	186	168	34	60			2	450
1100	8	57	43					108	112	111	37	29		4	1	294
30	3	57	44				1	105	87	113	24	42			1	267
1200	5	19	15					39	255	44	35	10			1	345
30									80	20	7	1				108
1300									97	11	21				1	130
30									19	20	14				3	56
1400									50	1	9	2				62
30									47	1	6	5				59
1500									60	1	4	8				73
30									36		4	2				42
1600									43		5				1	49
30																
1700																
30																
1800																
TOTAL	963	400	293	491		6	29	2182	4181	824	613	582	2	8	36	6246

Adult females and juveniles (both sexes)

	NOVEMBER								DECEMBER							
Hours	F	L	S	M	D	A	G	TOTAL	F	L	S	M	D	A	G	TOTAL
0600	4							4								
30	33		3					36	3							3
0700	56		14	6			1	77	23		1					24
30	126		21	4			1	152	38		3					41
0800	169		26	1	2		1	199	77	1	11					89
30	191	1	11	11	2		1	217	106	5	4	15			1	131
0900	495	11	35	4			1	546	298	4	36	8				346
30	406	15	26					447	605	22	29				1	657
1000	283	26	33					342	504	24	23	5	2			558
30	187	100	20				2	309	350	68	33		6			457
1100	104	154	36					294	301	144	48		7			500
30	102	132	29	3			1	267	211	126	27					364
1200	126	82	22	8				238	336	144	30					510
30	162	28	49	21				260	308	149	23	1	1			482
1300	172	33	60	2				267	332	68	25					425
30	74	30	26	14			1	145	194	47	25				1	267
1400	65	17	43	4				129	279	43	24			2		348
30	61	3	29	11	14			118	349	55	21	8				433
1500	74		6	2	1		1	84	203	21	23	1				248
30	41		3	4		2		50	84	4	6	1				95
1600	14		1					15	181		3	1				185
30	50		9					59	179		4					183
1700	77		23					97	111		3	20			1	135
30																
1800																
TOTAL	3069	632	525	95	19	2	10	4352	5072	925	402	60	16	2	4	6481

Adult females and juveniles (both sexes)

Hours	JANUARY F	L	S	M	D	A	G	TOTAL	FEBRUARY F	L	S	M	D	A	G	TOTAL
0600																
30																
0700																
30									118	1	4					123
0800	28		2					30	322		16					338
30	213	8	10				3	234	541	2	18				3	564
0900	271	7	27					305	635	5	19		1			660
30	247	19	27	3			1	297	585	25	39	35				684
1000	163	29	12	9				213	348	73	44	1		4	2	472
30	74	26	61	18				179	150	86	12			2	1	251
1100	229	54	11	1				295	99	39	9	1				148
30	139	180	15				1	335	141	105	21				2	269
1200	135	188	15					338	174	144	13				2	333
30	129	123	33				2	287	220	57	18	5			1	301
1300	123	42	43	3				211	361	58	12					431
30	119	49	27					195	429	47	21				2	499
1400	74	15	15					104	387	94	35	3			1	520
30	50	21	11					82	352	59	33			2	1	447
1500	91	9	17					117	351	66	27	1		2	1	448
30	136		17					153	562	54	26	2			3	647
1600	160		5	4			1	170	449	17	37	10			5	518
30	222	2	9	4				237	285	11	32	16				344
1700	176		10					186	29	4	4					37
30									41		2	1				44
1800																
TOTAL	2779	772	367	42	0	0	8	3968	6579	947	442	75	1	10	24	8078

Adult females and juveniles (both sexes)

	MARCH								APRIL							
Hours	F	L	S	M	D	A	G	TOTAL	F	L	S	M	D	A	G	TOTAL
0600																
30									60		4			2		66
0700	25	1	6	1				33	165	4	39	6				214
30	216	1	35	1			1	254	233		45	2			1	281
0800	267	9	28				1	305	193	6	37	1			3	240
30	290	79	30				1	400	188	24	19	4			2	237
0900	164	109	18				3	294	201	78	23	27			1	330
30	91	82	11	2				186	70	98	10	3				181
1000	90	91	9				1	191	117	110	12	1			2	242
30	85	157	5					247	194	52	14	1	2			263
1100	136	137	14	10			2	299	214	111	25	2			2	354
30	100	37	19	5				161	151	105	9				1	266
1200	75	53	4					132	196	38	81	9	2		4	330
30	181	56	10				1	248	111	11	4	8			1	135
1300	142	52	6					200	106	36	7				1	150
30	149	45	15	1				210	97	20	8	1			1	127
1400	166	27	27				1	221	94	12	24	13				143
30	183	33	17				1	234	49	86	7				2	144
1500	187	20	24	6			4	241	74	64	7	20			1	166
30	223	28	19					270	65	6	6				1	78
1600	145	5	15	5				170	123	3	3	1				130
30	102	2	3	4			1	112	135		2					137
1700	77	2	2	2			1	84	126		4				1	131
30	136		23	3			1	163	44		4	3				51
1800	96		12	9				117	22		1					23
TOTAL	3326	1026	352	49	0	0	19	4772	3028	864	395	102	4	2	24	4419

Adult Males

Hours	MAY								OCTOBER							
	F	L	S	M	D	C	G	TOTAL	F	L	S	M	D	C	G	TOTAL
0600																
30																
0700	4							4			2					2
30	14		1					15	7		3				1	11
0800	8							8	5	1	1					7
30									15		2					17
0900																
30									5			1				6
1000																
30	2							2								
1100	3							3								
30	1	2						3								
1200																
30																
1300																
30	11		1					12								
1400	18							18	6							6
30	30		4	2				36	2							2
1500	16		2					18								
30	24	1	2					27								
1600	8							8								
30	14			2				16								
1700	23							23								
30	11							11								
1800																
TOTAL	187	3	10	4	0	0	0	204	40	1	8	1	0	0	1	51

Adult Males

Hours	NOVEMBER F	L	S	M	D	C	G	TOTAL	DECEMBER F	L	S	M	D	C	G	TOTAL
0600			1					1								
30	2		6					8	1							1
0700	8							8	5		2	1		1		9
30	11		1	2				14	8		7					15
0800	8		2	2				12	9		3					12
30	10		6	6		2		24	18		4					22
0900	26	9	22			3		60	39	2	17	3	1	2		64
30	33	9	11			4		57	27	7	41			11		86
1000	18	5	25	1		4		53	46	8	42	1		4		101
30	15	22	12			2		51	38	13	41		1	6		99
1100	11	15	16			1		43	41	32	34	1	1	2		111
30	8	4	10	2				24	26	29	27			1		83
1200	2	13	4	1				20	33	25	26			8		92
30	9	4	8	3				24	31	10	35	2		4		82
1300	6	8	2	1		4		21	32	7	26			4		69
30	4	1	4					9	15	4	16			1		36
1400	5	5	5			1		16	24	1	35			5		65
30	10		3					13	34	5	24	1		4		68
1500	1		3					4	26	2	40	1		2		71
30	4							4	15	2	8			2		27
1600	3							3	21		8			1	1	31
30	2		1					3	16	5	3					24
1700	2		2					4	9		7			1		17
30																
1800																
TOTAL	198	93	146	18	0	21	0	476	514	152	446	10	3	59	1	1185

Adult Males

Hours	JANUARY F	L	S	M	D	C	G	TOTAL	FEBRUARY F	L	S	M	D	C	G	TOTAL
0600																
30																
0700									8							8
30	4		2					6	26		3					29
0800	6		4					10	21		4	3				28
30	21	4	5			1		31	23		11					34
0900	30	4	17	1				52	28	1	8					37
30	30	14	10	1		1		56								0
1000	25	18	7	1		2		53								0
30	6	7	34	6		2		55								0
1100	26	11	16			2		55	1							1
30	14	34	16			6		70	3							3
1200	19	59	11	2		1		92	7							7
30	29	36	21			4		90	10							10
1300	31	12	18	1		4		66	22	2	1					25
30	20	9	17			2		48	23	2	3					28
1400	10	5	10			4		29	13							13
30	3	1	9			5		18	10	3						13
1500	18	1	11			3		33	10							10
30	9	1	4			1		15	16		2					18
1600	38		10					48	7							7
30	34		14	1		2		51	15							15
1700	38		13					51	6							6
30																
1800																
TOTAL	411	216	249	13	0	40	0	929	249	8	32	3	0	0	0	292

Adult Males

	MARCH								APRIL							
Hours	F	L	S	M	D	C	G	TOTAL	F	L	S	M	D	C	G	TOTAL
0600																
30	15							15								
0700	20		4					24								
30	7							7	8		2	1				11
0800								0	26		2				1	29
30	26							26	17	6	2					25
0900	39							39	10		3	1				14
30	57							57	14		3				1	18
1000	53							53	11	3	3	2				19
30	37	6	3					46	12	11	5					28
1100	6	2						8	14	19	5	3				41
30	4		2					6	34	7	4	2				47
1200	5							5	25		6	1				32
30	13							13	70		3	5				78
1300	35	5	1					41	44	3	6					53
30	41	8	1	1				51	14	2	2	2				20
1400	22	15	2					39	16		6					22
30	16	8						24	2	18						20
1500	32	1	5					38	26	7	2					35
30	55	6						61	12							12
1600	44		1					45	11							11
30	12							12	18							18
1700	5							5	6		1				1	8
30									3							3
1800																
TOTAL	544	51	19	1	0	0	0	615	393	76	55	17	0	0	3	544

Young

JULY

Hours	F	L	S	M	P	TOTAL
0600	10		1	31		42
30	16		9	19		44
0700	4			6		10
30	17	6		4	3	30
0800	7	34				41
30	8	41		8		57
0900	6	7	9		5	27
30	4	2	1			7
1000	1	7				8
30	1		3	4	4	12
1100						
30						
1200						
30						
1300						
30						
1400						
30						
1500						
30						
1600						
30						
1700						
30						
1800						
TOTAL	74	97	23	72	12	278

Abbreviations:- F = Feeding
L = Lying
S = Standing
M = Moving
D = Drinking
A = Aggression
G = Grooming
C = Courtship
P = Playing

APPENDIX VI

Plant Reference Collection

The commoner plants found growing in Area 1 are listed below:-

Agrostis nervosa
A. pilosula
Berberis concinna
Brachypodium pinnatum
Bromus himalaicus
Bryophyta
Caragana nepalensis
Carex hirtella
Cirsium sp.
Cotoneaster microphylla
Danthonia schneideri
Dryopteris sp.
Ephydra gerardiana
Festuca gigantea
F. ovina
F. rubra
Geranium collinum
Impatiens sp.
Iris decora
Juniperus wallichiana
Kobresia curticeps
K. nepalensis
K. trinervis
Ligularia amplexicaulis
Mecanopsis sp.
Oryzopus lateralis
O. munroi
Poa pagophila
Polygonum sp.
Potentilla fruticosa
Potentilla pendunculata
Primula aureata
Rheum moorcraftianum
Rhododendron lepidotum
Rosa macrophylla
R. sericea

BIBLIOGRAPHY

Aitken, R.J. (1974). Cementum layers and tooth wear as criteria for ageing Roe deer (Capreolus capreolus). J. Zool., Lond. 175: 15-28.

Anderson, J.A. and Henderson, J.B. (1961). Himalayan thar in New Zealand. New Zealand Deerstalkers' Assoc. Special Publ. No. 2.

Anon, (1977 a). Himalayan thar. What's New in Forest Research 45. (Based on the work of K. G. Tustin).

Anon, (1977 b). A safe home for the Arabian tahr in Oman. Oman 16.

Banwell, D.B. (1970). Tahr or thar? New Zealand Wildl. 31: 5-9.

Baumgartner, L.L. and Martin, A.C. (1939). Plant histology as an aid in squirrel food-habit studies. J. Wildl. Mgmt. 3: 266-8.

Beddard, F.E. (1902). The Cambridge Natural History: Mammalia. Macmillan & Co. Ltd., London.

Bonnemaire, J. and Teissier, J.H. (1976). Le Yak; son rôle dans la vie matérielle et culturelle des éleveurs d'Asia centrale. Sociéte d'Ethnozootechnie, Paris.

Burrard, G. (1925). Big game hunting in the Himalayas and Tibet. H. Jenkins, London.

Burt, W.H. (1943). Territoriality and home range concepts as applied to mammals. J. Mammal. 24: 346-52.

Caughley, G. (1965). Horn rings and tooth eruption as criteria of age in the Himalayan thar, Hemitragus jemlahicus. New Zealand J. Sci. 8: 333-51.

_________ (1966). Mortality patterns in mammals. Ecology 47: 906-18.

_________ (1967). Calculation of population mortality rate and life expectancy for thar and kangaroos from the ratio of juveniles to adults. New Zealand J. Sci. 10: 578-84.

_________ (1969). Wildlife and recreation in the Trisuli Watershed and other areas in Nepal. FAO/UNDP Report No. 6.

_________ (1970a). Eruption of ungulate populations with special emphasis on Himalayan thar in New Zealand. Ecology 51: 53-72.

_________ (1970b). Fat reserves of Himalayan thar in New Zealand by season, sex, area and age. New Zealand J. Sci. 13: 209-19.

_________ (1970c). Liberation, dispersal and distribution of Himalayan thar (Hemitragus jemlahicus) in New Zealand. New Zealand J. Sci. 13: 220-39.

Caughley, G. (1970d). Habitat of the Himalayan tahr Hemitragus jemlahicus (H. Smith). J. Bombay Nat. Hist. Soc. 67: 103-5.

__________ (1971a). The season of births for northern-hemisphere ungulates in New Zealand. Mammalia 25: 204-19.

__________ (1971b). The name of the Himalayan ***. New Zealand Wildl. 32: 20-1.

Charles, R. (1957). Morphologie dentaire du thar et du bouquetin espèces actuelles et sub fossiles des gisements préhistoriques. Mammalia 21: 136-41.

Christie, A. and Andrews, J. (1964). Introduced ungulates in New Zealand. (a) Himalayan tahr. Tuatara 12: 69-77.

Daniel, J.C. (1970). The Nilgiri tahr, Hemitragus hylocrius Olgilby, in the High Range, Kerala and the southern hills of the Western Ghats. J. Bombay Nat. Hist. Soc. 67: 535-42.

Das, S.M. (1966). Palaearctic elements in the fauna of Kashmir. Nature 212: 1327-30.

Dasmann, R.F. (1973). A system for defining and classifying natural regions for purposes of conservation. IUCN occasional paper No. 7. IUCN, Morges.

Davidar, E.R.C. (1963). Census of the Nilgiri tahr, Hemitragus hylocrius (Ogilby) in the Nilgiris. J. Bombay Nat. Hist. Soc. 60: 251-2.

______________ (1968). The Nilgiri Wildlife Association and status of wildlife in the Nilgiris. J. Bombay Nat. Hist. Soc. 65: 431-43.

______________ (1971). A note on the status of the Nilgiri tahr (Hemitragus hylocrius) on the Grass Hills in the Anamallais. J. Bombay Nat. Hist. Soc. 68: 347-54.

______________ (1975). The Nilgiri tahr. Oryx 13: 205-11.

______________ (1976). Census of the Nilgiri tahr in the Nilgiris, Tamil Nadu. J. Bombay Nat. Hist. Soc. 73: 142-8.

Dobremez, J.F., Jest. C., Toffin, G., Vartanian, M.C., Vigny F. (1974). Carte écologique du népal région kathmandu - everest 1/250 000. Centre national de la recherche scientifique, Paris.

Donne, T.W. (1924). The Game Animals of New Zealand. John Murray, London.

Douglas, M.H. (1967). Control of thar (Hemitragus jemlahicus): evaluation of a poisoning technique. New Zealand J. Sci. 10: 511-26.

D U H E (1976a). Durham University Himalayan Expedition First Report. National Parks & Wildlife Conservation Project, Kathmandu (unpublished).

________(1976b). Durham University Himalayan Expedition Second Report. National Parks & Wildlife Conservation Project, Kathmandu (unpublished).

________(1977a). Durham University Himalayan Expedition Third Report. National Parks & Wildlife Conservation Project, Kathmandu (unpublished).

________(1977b). Langtang National Park management plan. National Parks & Wildlife Conservation Project, Kathmandu.

Field, D.I. and Pandey, K.R. (1969). Pasture, fodder and livestock development. Trisuli Watershed Development Project Report No. 15. Kathmandu.

Flower, W.H. and Lydekker, R. (1891). An introduction to the study of mammals living and extinct. Adam & Charles Black, London.

Fox, J.L. (1974a). Some ecological notes on the proposed Langtang National Park. National Parks & Wildlife Conservation Project, Kathmandu (unpublished).

________ (1974b). An ecological survey of the proposed Langtang National Park. National Parks & Wildlife Conservation Project, Kathmandu (unpublished).

Geist, V. (1971). Mountain sheep. Univ. Chicago Press, Chicago.

Goodwin, H. and Holloway, C. (1972). IUCN red data book, Mammalia. Heliographia, Lausanne.

Green, M.J.B. (1978). Himalayan musk deer (Moschus moschiferus moschiferus). In Threatened deer. Proceedings of Survival Service Commission Deer Specialist Group. IUCN, Morges (in press).

Grubb, P. and Jewell, P.A. (1974). Movement, daily activity and home range of Soay sheep. In Island survivors, ed. P. A. Jewell, C. Milner and J. Morton Boyd, pp. 160-94. Athlone Press, London.

Hansen, R.M. and Flinders, J.T. (1969). Food habits of North American hares. Science Series No. 1. Colorado State Univ., Fort Collins.

__________ and Gold, I.K. (1977). Blacktail prairie dogs, desert cottontails and cattle trophic relations on shortgrass range. J. Range Mgmt. 30: 210-4.

Hansson, L. (1970). Methods of morphological diet micro-analysis in rodents. Oikos 21: 255-66.

Harrison, D.L. (1968). The mammals of Arabia, Vol. 2. Ernest Benn, London.

____________ and Gallagher, M.D. (1974). A park to save the Arabian tahr. Oryx 7: 547-9.

__________________________ (1976). Plans for reserves in Oman. Oryx 13: 287-8.

Hoefs, M.E.G. (1974). Food selection by Dall's sheep (Ovis dalli dalli Nelson). In The behaviour of ungulates and its relation to management, ed. V. Geist and F. Walther, pp. 758-86. IUCN Publ. No. 24. IUCN, Morges.

Holmes, J.R.S. (1970). A note on Himalayan tahr. J. Bombay Nat. Hist. Soc. 67: 103-5.

Hoogstraal, H. (1971). Haemaphysalis (Allophysalis) warburtoni Nuttall: description of immature stages, adult structural variation, and hosts and ecology in Nepal, with a redefinition of the subgenus Allophysalis Hoogstraal (Ixodoidea: Ixodidae). J. Parasitology 57: 1083-95.

Hope, A.C.A. (1968). A simplified Monte Carlo significance test procedure. J. Royal Stat. Soc. 30: 582-98.

Kinloch, A.A. (1876). Large game hunting in Thibet, the Himalayas, Northern and Central India. Thacker, Spink & Co., Bombay.

Kurten, B. (1968). Pleistocene mammals of Europe. Weidenfeld & Nicolson, London.

Lent, P.C. (1974). Mother-infant relationships in ungulates. In The behaviour of ungulates and its relation to management, ed. V. Geist and F. Walther, pp. 14-55. IUCN Publ. No. 24. IUCN, Morges.

Lydekker, R. (1924). The game animals of India, Burma, Malaya and Tibet. Rowland Ward, London.

McDougall, P. (1975). The feral goats of Kielderhead Moor. J. Zool., Lond. 176: 215-46.

Milner, C. and Gwynne, D. (1974). The Soay sheep and their food supply. In Island survivors, ed. P. Jewell, C. Milner and J. Morton Boyd, pp. 273-325. Athlone Press, London.

Nelson-Rees, W.A., Kniazeff, A.J., Malley, R.L. and Darby, N.B., Jr. (1967). On the karyotype of the tahr Hemitragus jemlahicus and the Y-chromosome of goats and sheep. Chromosoma (Berl.) 23: 154-61.

Prater, S.H. (1971). The book of Indian animals. Third (revised) edition. Bombay Nat. Hist. Soc., Bombay.

Rammell, C.G. (1964). Composition of thar's milk. New Zealand J. Sci. 7: 667-70.

Riney, T. (1955). Identification of big game animals in New Zealand. Dominion Museum Handbook. No. 4.

Roberts, G. (1971). Chamois and thar in New Zealand. Animals 13: 772-5

Rudge, M.R. (1969). Reproduction of feral goats Capra hircus L. near Wellington, New Zealand. New Zealand J. Sci. 12: 817-827.

__________ (1970). Mother and kid behaviour in feral goats (Capra hircus L.). Z. Tierpsych. 27: 687-92.

Rudge, M.R. (1972). Horns as indicators of age in goats (Capra hircus L.). New Zealand J. Sci. 15: 255-63.

Schäfer, V. (1950). Über den Schapi (Hemitragus jemlaicus schaeferi). Zool. Anzeiger 145: 247-60.

Schaller, G.B. (1970). Observations on the Nilgiri tahr (Hemitragus hylocrius Ogilby, 1838). J. Bombay Nat. Hist. Soc. 67: 365-89.

__________ (1973). Observations on Himalayan tahr (Hemitragus jemlahicus). J. Bombay Nat. Hist. Soc. 70: 1-24.

__________ (1977). Mountain monarchs. Univ. Chicago Press. Chicago.

__________, and Laurie, A. (1974). Courtship behaviour of the wild goat. Z. Säugetierk. 39: 115-27.

Shank, C.C. (1972). Some aspects of social behaviour in a population of feral goats. (Capra hircus L.). Z. Tierpsychol. 30: 488-528.

Simpson, G. (1945). Principles of classification and a classification of mammals. Bull. Am. Mus. Nat. Hist. 85: 1-350.

Sparks, D.R. and Malechek, J.C. (1968). Estimating percentage dry weight in diets using a microscopic technique. J. Range Mgmt. 21: 261-5.

Stockley, C. (1928). Big game shooting in the Indian Empire. Constable & Co., London.

Thenius, E. and Hofer, H. (1960). Stammesgeschichte der Säugetiere. Springer Verlag, Berlin.

Walther, F.R. and Rice, C.G. (1977). A census and study of Nilgiri tahr. Dept. Wildl. & Fish. Sci., Texas A and M Univ. (unpublished manuscript).

Wodzicki, K.A. (1950). Introduced mammals of New Zealand. New Zealand Dept. Sci. Indust. Res. Bull. 98: 1-255.

Zuckerman, C.B. (1953). The breeding seasons of mammals in captivity. Proc. Zool. Soc. Lond. 122: 827-950.