ACTIVITY PATTERNS AND HABITAT USE OF IBEX IN THE HIMALAYA MOUNTAINS OF INDIA

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Studies of Asiatic ibexes (*Capra ibex sibirica*) were conducted in the Himalaya Mountains of India during winter and summer 1985–1986, with activity data collected during November–December. Ibexes were observed in Ladakh at elevations of 4,000–4,800 m, on slopes averaging 31°, and predominantly within 50 m of rugged terrain or cliffs. Groups (median size = 11; range, 1–40) primarily were comprised of both sexes during summer and winter, although more males were in all-male groups during summer. Ibexes fed farther from cliffs than they bedded, and fed in larger groups the farther from cliffs; differences probably associated with avoidance of predation. During early winter, peaks in daily activity occurred near sunrise and sunset. Population and habitat-use characteristics of ibex appear to be related to site-specific predation pressure, winter snowpack, forage availability, and human activities.

Key words: ***Capra ibex*, activity patterns, habitat use, Himalaya Mountains**

The Asiatic ibex (*Capra ibex sibirica*) is one of the most common wild ungulates in the higher elevations of the northwestern Himalaya Mountains in India. The southeastern range limit for the ibex occurs in northwestern India, in the Baralacha La (pass) region on the north side of the main Himalayan crest and at the Sutlej River gorge on the south side, both in the state of Himachal Pradesh (Fig. 1). There are ca. 6,000 ibexes in the Transhimalayan Ladakh district of Jammu and Kashmir (Fox et al., 1991*a*) and possibly another 3,000 in ca. 17,000 km² of suitable habitat on the southern side of the main Himalaya Mountains in Jammu and Kashmir and Himachal Pradesh. The taxonomy of ibexes and similar *Capra* is confused (Nowak and Paradiso, 1983; Schaller, 1977) and some closely related forms cited here for comparative purposes are variously given subspecific or species distinction by different authors. Although the ecology is well known from this species' European and African ranges (Nievergelt, 1966, 1981), and some work has been done on *C. i. sibirica* in Soviet-central Asia (Heptner and Naumov, 1966) and the Hindu Kush of Pakistan (R. Hess, pers. comm.), little information is available on this subspecies in the Himalayan region save for limited data on populations, and descriptions of behavior and range (Prater, 1971; Roberts, 1977; Schaller, 1977).

Studies of behavioral patterns in ungulates have been instrumental in our understanding of social organization, foraging ecology, and evolutionary relationships (Geist, 1971; Jarman, 1974; Schaller, 1977). Such work also is of value in assessing effects of disturbance and other aspects of interest to wildlife managers (Geist and Walthers, 1974; Stockwell et al., 1991). We initiated

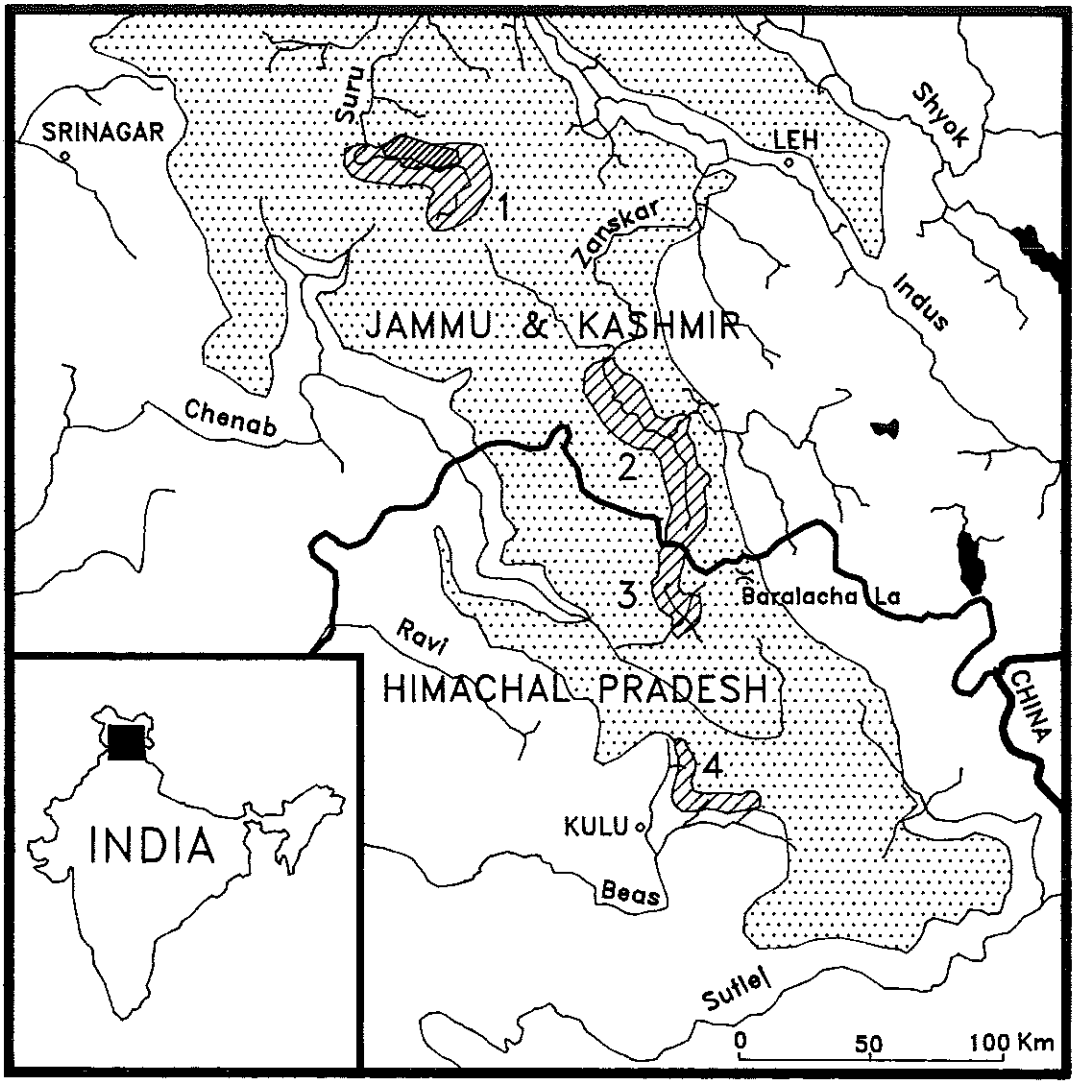

FIG. 1.—Study sites (hatched areas) shown within ibex distribution (stippled area) in the northwestern Himalaya Mountains of India. The upper Suru Valley (1) and the Tsarap-Kurghiak Valley are both in southwestern Ladakh, Jammu and Kashmir. The upper Bhaga Valley (3) and the upper Beas and Parbati valleys (4) are in Himachal Pradesh. The more heavily hatched zone in the upper Suru Valley is the area of intensive observation where activity data were taken.

the behavioral and habitat-use observations reported here to investigate habitat relationships of mountain ungulates in Ladakh, primarily in relation to habitat separation among Caprinae species and to potential competition and disturbance from domestic livestock. With different large-predator species locally dominant we also expect somewhat different patterns of habitat use by prey related to predator avoidance. We also were interested in evaluating some of the factors that affect the efficacy of survey counts for ibexes, such as observational biases associated with time of day.

MATERIALS AND METHODS

Ibexes were studied in several areas of the northwestern Himalaya Mountains in India.

Within the region of Ladakh to the north of the main Himalayan range in the state of Jammu and Kashmir, ibexes were observed in the upper Suru (site 1) and Tsarap-Kurghiak (site 2) valleys just to the north of the Himalayan crest (Fig. 1). They also were observed on the south side of the Himalaya Mountains in the upper Bhaga Valley of Lahul (site 3) and in the upper Beas and Parbati valleys of the Pir Panjal Mountains (a spur range of the main Himalaya Mountains) in the Kulu region (site 4), both sites in the state of Himachal Pradesh (Fig. 1). We observed daily activity and habitat use of ibexes in the Suru Valley between 4 November and 21 December 1985. Otherwise, observations were restricted to population composition and habitat use during 10–24 May in Kulu, 8–15 June in Lahul, and 16 June–8 July in the Tsarap-Kurghiak and Suru valleys, all in 1986.

Ibexes were found to occur in rugged-mountainous habitats varying in vegetation cover from lush timberline sedge- and herb-dominated meadows on the southern side of the Pir Panjal Mountains in Himachal Pradesh to sparse dry grassland-steppe in the Transhimalayan region of Ladakh. Precipitation diminishes dramatically as one proceeds north and east over the western Himalaya Mountains, with annual levels of 1,500–2,000 mm common on the southern slopes, ca. 500–1,000 mm in areas immediately over the main Himalaya ridge, and ca. 100 mm in the upper Indus Valley near Leh (Hartmann, 1983; Polunin and Stainton, 1985). Temperatures (daily highs and lows) during the study in southwestern Ladakh at 4,300 m ranged between −5 and −20°C in November–December and 5–20°C in June–July.

The vegetation in southwestern Ladakh (sites 1 and 2), at elevations >4,000 m, is steppe and alpine meadow characterized by grassland and herbaceous species (*Stipa, Agrostis, Poa, Anemone, Artemisia, Polygonum*), with *Salix*-dominated shrublands locally restricted to moist gullies and valley bottoms (Dhar and Kachroo, 1983; Hartmann, 1983). The Lahul region of Himachal Pradesh (site 3) is a dry inner Himalayan valley and has similar vegetation to southwestern Ladakh, although it is somewhat moister and more alpine in character with scattered *Betula* and *Juniperus* trees present within the range of the ibexes. Habitat of ibexes in the Kulu region of Himachal Pradesh (site 4) is characterized by timberline *Abies, Betula,* and *Rhododendron,* and lush alpine grass, sedge, and herbaceous meadows (Champion and Seth, 1968). Large predators of ibexes in India primarily include snow leopards (*Panthera uncia*) and wolves (*Canis lupus*), with wild dogs (*Cuon alpinus*) and common leopards (*Panthera pardus*) present in some areas.

Ibexes were observed with the aid of 8 × 25-power binoculars and 15–60× spotting scopes. Since the ibexes apparently are at least occasionally hunted in most areas, they are noticeably wary toward people. Thus, our observations were made at distances averaging ca. 500 m (range, 300–1,000 m) to avoid influencing their behavior. Ibexes were classified by age and sex categories using criteria described by Schaller (1977); adult female, yearling (>1–<2 years old), kid (<1 year old), male (classes I, II, and III based on increasing horn length). The male classes differ somewhat from Schaller's in that they correspond to ages of ca. 2–3 years (I), 4–6 years (II), and >7 years (III).

Habitat variables recorded included elevation, slope, aspect, terrain type, distance from steep and broken terrain (escape cover), and vegetation type. Habitat data were recorded for each group of ibexes observed and the results presented reflect weighting according to number of individuals in the group. Additionally, in the Suru Valley study area (site 1), data on daytime activity were collected (feeding, bedded, moving) during November–December using scan sampling (sensu Altmann, 1974) at 0.5-h intervals. During this activity study, 6,898 observations were made of ibexes in 371 groups. These early winter data were gathered before any substantial snowfall in the study area, although additional limited observations were made following a 40-cm snowfall in late December.

In the upper Suru Valley study area (site 1), 1,205 observations of ibexes in 87 groups (using first daily sightings only) formed the data base for habitat-use comparisons with the same technique used in the other study sites. In Tsarap-Kurghiak (site 2), we made 313 observations of ibexes in 27 groups, and in the combined sites 3 and 4 in Himachal Pradesh we collected 68 observations of ibexes in 17 groups.

Sizes of groups were compared using a median test (Zar, 1984:145). Seasonal or area differences in group composition were tested using chi-square analysis, and means for habitat-use characteristics were compared using simple analysis of variance or paired *t*-tests where appropriate.

Results and Discussion

Some 250–350 ibexes inhabit the upper Suru Valley beyond the Nun-Kun massif in southwestern Ladakh; we made intensive observations on 100–150 individuals present within ca. 2.5 km up and down the valley from Zulidok village. Additional observations were obtained on ca. 250 ibexes in the Tsarap-Kurghiak Valley of southwestern Ladakh, and ca. 50 individuals in Himachal Pradesh. Based on maximum-group size and composition within our 25-km^2 area of intensive observation in early winter (November–December) of ranges of ibexes in the upper Suru Valley, population density of ibexes was 4–6/km^2. Within the entire region surveyed in the upper Suru Valley (potential year-round habitat) density was ca. 0.5–0.6/km^2; the same as was found in site 2 of southwestern Ladakh (Fox et al., 1991*a*). Ibexes were much less abundant in the areas studied in Himachal Pradesh; only 27 different ibexes were observed in 550 km^2 of suitable alpine habitat surveyed in this region. Density of ibexes in southwestern Ladakh, however, is apparently lower than the 0.8–1.2/km^2 found in areas farther north in central Ladakh (Fox et al., 1991*a*). Although central Ladakh is drier and less vegetated, higher density of ibexes there may be related to the lack of deep snowpack, which leaves more area available for winter feeding (possibly allowing larger over-wintering populations) in central as opposed to southwestern Ladakh. Densities of ibexes in southwestern Ladakh appear to be lower than in the Khuhsyrh Reserve in Mongolia (Dzieciolowski et al., 1980), although the somewhat higher density from central Ladakh is comparable to the Mongolian figures and perhaps indicates similar habitat conditions in these two regions.

Population structure (based on a ratio to 100 adult females) from winter and spring combined (pre-parturition) counts was 91 males : 100 females : 33 yearlings : 78 kids (n = 312). Age distribution of males was 43% class III : 34% class II : 23% class I. The number of kids/100 adult females was 85 during November–December and 52 in June before new births. The first newborn kids were observed in mid-June. We suggest that the relatively high reproduction indicated in our data probably is fairly consistent from year to year in southwestern Ladakh due to abundant and high-quality summer forage, whereas significant mortality (especially of young animals) associated with harsh winters and predation acts as a factor limiting population growth. As a contrast, we might expect lower reproduction where greater competition for food is probable among the denser populations of ibex present in the more sparsely vegetated areas of central Ladakh.

During November–December in Ladakh, the median group size for ibexes was 11 (range, 1–40; n = 87). The 27 groups of ibexes observed during June–July in Ladakh ranged in size from one to 35, with no significant difference in median size from the early winter samples. In the areas surveyed on the south side of the Himalaya Mountains, the 17 groups of ibexes seen during May–June varied in size from one to 15 with a median of two, significantly lower ($P < 0.05$) than in southwestern Ladakh. Herds in Ladakh primarily were mixed-sex in both summer and winter. Although the proportion of all-male groups (11%) did not change with the seasons sampled, a larger component of the male population ($P < 0.05$, chi-square test) was in all-male groups in summer (25%) than in winter (14%). Herds were smaller in our study area than reported for Asiatic ibexes in Mongolia (Dzieciolowski et al., 1980), and our lack of an increase in group size during winter (as was the case in Mongolia) probably is due to our observations being conducted before winter snows restrict available habitat. Compared with ibexes elsewhere (Dzieciolowski et al., 1980; Nievergelt, 1974), segregation of the sexes appears less common in our study area and other Himalayan sites (Schaller, 1977), although a seasonal trend toward greater male

segregation in summer is common to all areas. The preponderance of mixed herds in our early winter sample was related to the occurrence of rutting behavior, which became common in late November and reached its peak by mid-December.

Ibexes under continuous observation in the Suru Valley study area appeared to remain generally associated with the same groups from 1 day to the next (based on recognizable individuals), although occasional interchange was seen and group composition changed over periods of days and weeks. During the rut large males sometimes were seen moving several kilometers between groups with females and young. Average group size, however, remained relatively constant during the day. Daily movement of ibex groups was generally <300 m and the largest movements noted were ca. 3–4 km, although it must be noted that groups (or individuals) that disappeared from our view could have travelled more.

Ibexes in southwestern Ladakh were found at elevations of 4,000–4,725 m, with an average ($\pm SD$) of 4,300 ± 170 m, showing no change between the early winter and early summer observations. In mid- to late-summer they probably use higher elevations to take advantage of the delayed phenology of alpine plants and to avoid herders and their livestock. In Himachal Pradesh during May–June, ibexes were found at elevations of 3,400–4,400 m (average = 3,900 ± 230 m), which is significantly lower ($P < 0.05$) than those observed in Ladakh. The ibexes in Himachal Pradesh probably were seeking out new-growth vegetation at low elevations in spring; however, deep snowpack in this region made most habitats above ca. 4,400 m essentially unavailable at this time of year. Furthermore, it must be noted that in the southwestern Ladakh study areas valley bottoms did not descend below 3,800 m.

During early winter ibexes predominantly were found on the southern-facing side of the Suru Valley, reflected in their 61% use of southerly aspects (17% northerly) in the area, with such habitat use being similar to that of alpine ibex (*C. i. ibex*—Nievergelt, 1966). Southerly aspects include south, southwest, and southeast; because there was no difference in ibex use of east and west aspects, these are not reported separately. In the early summer, ibexes also tended to be found on southerly aspects (69%), with many of the northerly slopes still snow-covered.

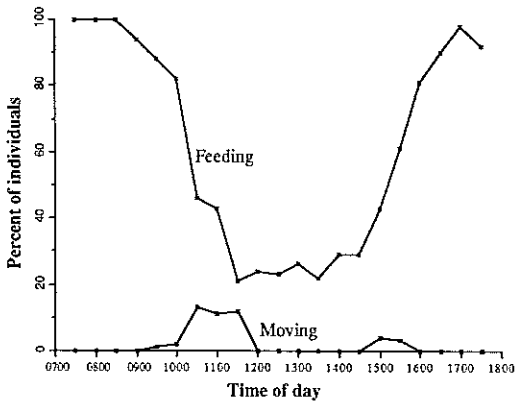

FIG. 2.—Daytime activity pattern of ibexes during November–December 1985 in the upper Suru Valley of Ladakh, Jammu and Kashmir, India.

During November–December, ibexes showed two distinct activity peaks of feeding each day. On the basis of sample sizes of 215–400 individuals at 0.5-h intervals, ibexes were most active in the early morning hours before and after sunrise, with a slightly lower activity peak again around sunset (Fig. 2). Midday was a period of inactivity with most animals bedded, and after the sunset feeding bout animals began to bed again for the night. Following a heavy snowfall and drop in temperature in late December, however, our limited observations indicated that the ibexes apparently switched to a single midday activity peak, remaining bedded until midmorning and feeding through the middle of the day before bedding down again before sunset. Such a change is consistent with seasonal shifts in activity patterns found in both alpine ibex in Europe (Hofmann and Nievergelt, 1972)

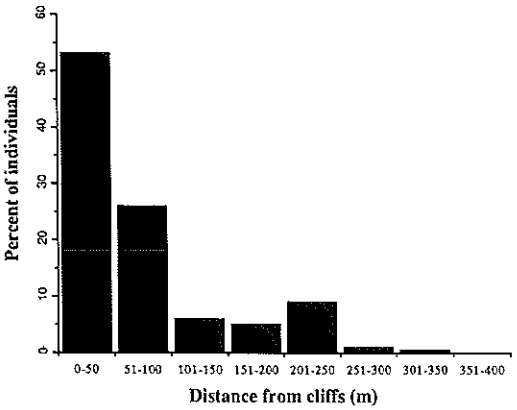

FIG. 3.—Distribution of distances from escape terrain for ibexes during November–December 1985 in the upper Suru Valley of Ladakh, Jammu and Kashmir, India.

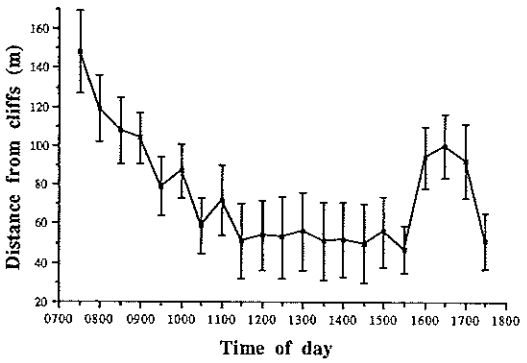

FIG. 4.—Distances (±*SE*) from escape terrain for ibexes through the day during November–December 1985 in the upper Suru Valley of Ladakh, Jammu and Kashmir, India.

and the ecologically similar American mountain goat (*Oreamnos americanus*) in Alaska (Fox et al., 1989).

In Ladakh, ibexes were found on smooth (as opposed to broken) terrain 72% of the time, reflecting to some extent the relatively open (non-rugged) nature of much of the habitat in the areas studied. However, ibexes were never found >350 m from escape terrain, which was defined as a patch of at least 30 m^2 of broken terrain with a slope of 45° or greater. Ibexes in Ladakh used slopes averaging 31° (±7°) and 90% of the time were within 200 m of escape terrain (Fig. 3). During early winter, ibexes were farthest from escape terrain during the sunrise feeding period, closest during the midday bedding period, with a second movement away during the evening feeding period before returning to the vicinity of cliffs at dusk (Fig. 4). Groups of feeding ibexes (>50% feeding) averaged twice the distance from cliffs (97 ± 77 m) as bedded groups (45 ± 62 m, paired *t*-test, $P < 0.05$). Furthermore, large groups (>25 individuals) of feeding ibexes were found significantly farther from cliffs (132 ± 74 m) than smaller groups (85 ± 75 m), whereas no such differences were found when most animals were bedded. These differences are similar to those found in bighorn sheep (*Ovis canadensis*—Risenhoover and Bailey, 1985), and probably are related to trade-offs between forage acquisition and avoidance of predation.

In the midwinter period of deep snow in southwestern Ladakh, habitat use probably is even more restricted (than indicated by the above figures) to the steep rocky outcrops where food remains available. However, outside of midwinter, affinity of ibexes for steep-rugged terrain probably is primarily associated with avoidance of predation (Schaller, 1977) and may possibly be influenced by predation intensity. Snow leopards, wolves, and wild dogs are all predators of ibexes in Ladakh, and evidence of ibex kills by both snow leopards and wolves is known from different parts of the Suru Valley (Nath, 1982). Future studies may be productive in addressing habitat use by ibexes as influenced by the presence of one or more of these predators. When feeding outside of escape terrain, ibexes may remain closer to cliffs in wolf areas than in snow leopard areas because wolves chase on open slopes whereas leopards stalk on rock outcrops.

Ibexes in Himachal Pradesh were found in much more rugged terrain than those in Ladakh. The mean slope used by ibexes here was 37° (±7°); only 35% of the ibexes observed were on smooth terrain and all ibexes

were within 100 m of escape terrain. Both the low density and significantly greater affinity for rugged-escape terrain by ibexes on the southern side of the Himalaya Mountains probably are a result of the effects of greater human activities (e.g., hunting, livestock grazing) in the relatively more accessible areas that we visited in this region. However, snow leopards apparently also are less common in alpine areas on the south side of the Himalaya Mountains than in Ladakh (Fox et al., 1991*b*), thus making cliffs and their proximity even safer for ibexes.

Because of difficult travel in midwinter and highly dispersed populations in summer, late autumn and spring probably are the best seasons for population-survey counts of ibexes in southwestern Ladakh and the south side of the Himalaya Mountains. During these seasons, the best times for counting individuals are the early morning and late afternoon active periods because ibexes are most visible when feeding or moving. In the drier areas of central Ladakh, however, the minimal snow accumulation makes midwinter surveys practical and probably efficient because ibexes are relatively concentrated at wintering sites; midday counting may be feasible due to the expected shift of activity peak by ibexes to this time of day.

The daily activity and habitat-use patterns reported here also must be considered in the design of habitat-use studies. In our study, the comparative habitat-use data were gathered opportunistically at the different sites, and were based on the first daily sighting of a group. This technique probably biases the results toward observing greater use of smooth areas far from cliffs by ibexes because these areas are associated with animals that are actively feeding and relatively easy to find.

Population and group dynamics of ibexes are likely to vary considerably among regions of the northwestern Himalaya Mountains, associated with differences in seasonal severity, grazing competition, hunting, and natural predation pressures. Such differences can significantly affect population dynamics of ibex and should be addressed when carrying out research and management in the region.

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