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Population structure and grouping tendency of Asiatic ibex *Capra sibirica* in the Central Karakoram National Park, Pakistan

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Abstract

Studies of Asiatic ibex *Capra sibirica* were conducted in Hushey valley (*ca.* 832 km²), the south-eastern part of CKNP, Pakistan during spring and winter of 2011-2013. Ibex were observed at elevations of 3342-4973 m, and based on winter assessment the average density was 1.2 animals km^{-2} and biomass 84 kg km^{-2}. Minimum count, based on winter observations was 368 animals (±146) of which 29% were adult males, 28% adult females, 15% yearlings, 23% kids while 5% could not be aged or sexed. In spring (pre-parturition) male to female sex ratio was 1:1.14 with 31 yearlings and 46 kids to per 100 females while in winter it was 1:0.9 with 54 yearlings and 80 kids per 100 females. Adult sex ratio in the population was almost at unity. Groups (typical size=18, mean size=13, range 1-40 in winter and 1-49 in spring) were mostly comprised of mixed herds (90%) while female-young, female and male groups were rarely encountered. The mean group size and group type did not varied significantly across different seasons and habitat types. However large males were relatively more frequent in snow-covered areas while kids and female-young groups in grassland. Despite a decade-long community-based conservation programme and having a good reproductive potential, the limited growth of Asiatic ibex population may be due to various factors such as severe winters, predation pressure and dietary competition with domestic stock, which need to be explored and dealt with appropriate conservation measures.

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Introduction

Pakistan is one of the most important countries for conservation of wild *Caprinae*, providing home to seven species with 11 sub-species of which 10 are believed to be threatened (Hess *et al*., 1997). Asiatic ibex *Capra sibirica* Pallas, 1776, also known as Siberian or Asiatic ibex is believed to be the most abundant Caprinae in Pakistan (Schaller, 1977; Anonymous, 1997; Hess *et al*., 1997) and found in the relatively arid mountain ranges, well above the treeline in higher precipitous regions in Himalaya, Karakoram and Hindukush (Roberts, 1997; Anwar, 2011). Globally Asiatic ibex is distributed in Afghanistan, Kashmir to Mongolia and China (Mcdonald, 1984), also found in the mountains of Central Asia, Tien Shan and Koh Altai (Habibi, 2003).

In Pakistan Asiatic ibex inhabit the most rugged mountainous habitats at elevation of 3,660 to 5,000 m a.s.l. in Gilgit Baltistan, Chitral, Swat Kohistan, around Machiara National Park and Neelum valley in Azad Jammu & Kashmir (Roberts, 1997; Ali *et al*., 2007; Anwar, 2011). Total population size in Northern Pakistan, including Khyber Pakhtun Khwa and Gilgit-Baltistan, is believed to range between 10,000 and 12,000 animals (Anonymous, 1997). In Gilgit-Baltistan the Asiatic ibex population is distributed in Baltistan, Haramosh,upper Hunza, Ishkoman and Yasin valleys (Roberts, 1997).

The Asiatic ibex has been listed as "Least Concern" in the Red List of Pakistan's Mammals (Sheikh and Molur, 2005) however; they face risk of severe shortage of forage in arid alpine ranges and dietary competition from yak, domestic goats and sheep (Anwar, 2011). Other factors such as seasonal severity, hunting and natural predation pressure (Fox *et al*., 1992) and death from avalanches on snow bound slopes also affect population and group dynamics (IUCN, 2009a). Sometimes the excessive number of livestock grazing in the area may compel the animals to move to undesired locations (Ali, *et al*., 2007).

Scant information is available about distribution of wild ungulates in the Central Karakoram National Park (CKNP), Pakistan. Asiatic ibex are reportedly found in all valleys around the Park with noticeable populations in Hushey, Thalley, Shigar, Stak, Tormik, Haramosh, Bagrot, Rakaposhi, Hoper and Hisper (Hagler Bailly, 2005). Local estimates for ibex in Hushey valley are in the thousands (Hagler Bailly, 2005) but the exact number is not known. Most of the literature is still silent on the exact number, distribution and social organization of Asiatic ibex in specific locations or zones of CKNP, which is one of the key challenges for conservation of these species in and around the Park. Non-availability of reliable quantitative data on species status and distribution is the key challenge for conservation and management of biological diversity of the Park (IUCN, 2009a). For effective conservation, long-term monitoring of key species in protected areas has been widely emphasized (Spellberg, 1992; Danielsen *et al*., 2000; Boddicker *et al*., 2002; Danielsen *et al*., 2005; Lovari *et al*., 2009). The CKNP, established two decades ago, still requires comprehensive assessments to explore the unique ecological features. The draft management plan for CKNP (IUCN, 2009a; Ev-K2-CNR, 2013) also prescribes to fill the gaps in information on ecology and living requirements of indicator species, through collecting quantitative data. In addition, the Government of Gilgit-Baltistan has declared some important habitat of wild ungulates around CKNP such as Hushey valley as community-managed conservation area (CMCA) to facilitate trophy hunting of Asiatic ibex. Scientific monitoring of species has also been emphasized for initiating a trophy-hunting programme. Shackleton (2001) while reviewing the trophy hunting programme of wild Caprinae in Pakistan has recommended allocating hunting permits primarily based on biological considerations such as advocate population data.

Therefore, this study was designed to determine current density, biomass, population structure and grouping tendency of Asiatic ibex in Hushey valley of CKNP. Based on this information, appropriate

conservation measures are recommended for government and private stakeholders to maintain ecologically viable populations of Asiatic ibex in the valley.

Methods

Study Area

Situated at 45 km north of Khaplu, the administrative centre of the Ghanche District in Baltistan, Hushey valley (76° 20′ E, 35° 27′ N) forms the south-eastern part of the Central Karakoram National Park (CKNP) (**Fig. 1**), which is the largest protected areas in Pakistan. The famous tourist and expedition destinations such as Aling, Masherbrum, Ghondogoro, Chogolisa, K7, and Tsarak Tsa valleys, which lead to glaciers of the same name, occupy the northern part of the valley. The K6 and Nangma valleys occupy the central eastern parts. Aling Nalla, Mashabrum and Saicho are the main pastures and lie in between the valley settlement and the Park (Hagler Bailly Pakistan, 2005). Spread over 832 km² (WWF-Pakistan, 2008), the bottom of the main valley ascends from 2,500 m in the south to about 3,100 m in the north. Next to the valley bottom, steep slopes rise to an altitude between 3,700 m and 5,000 m.

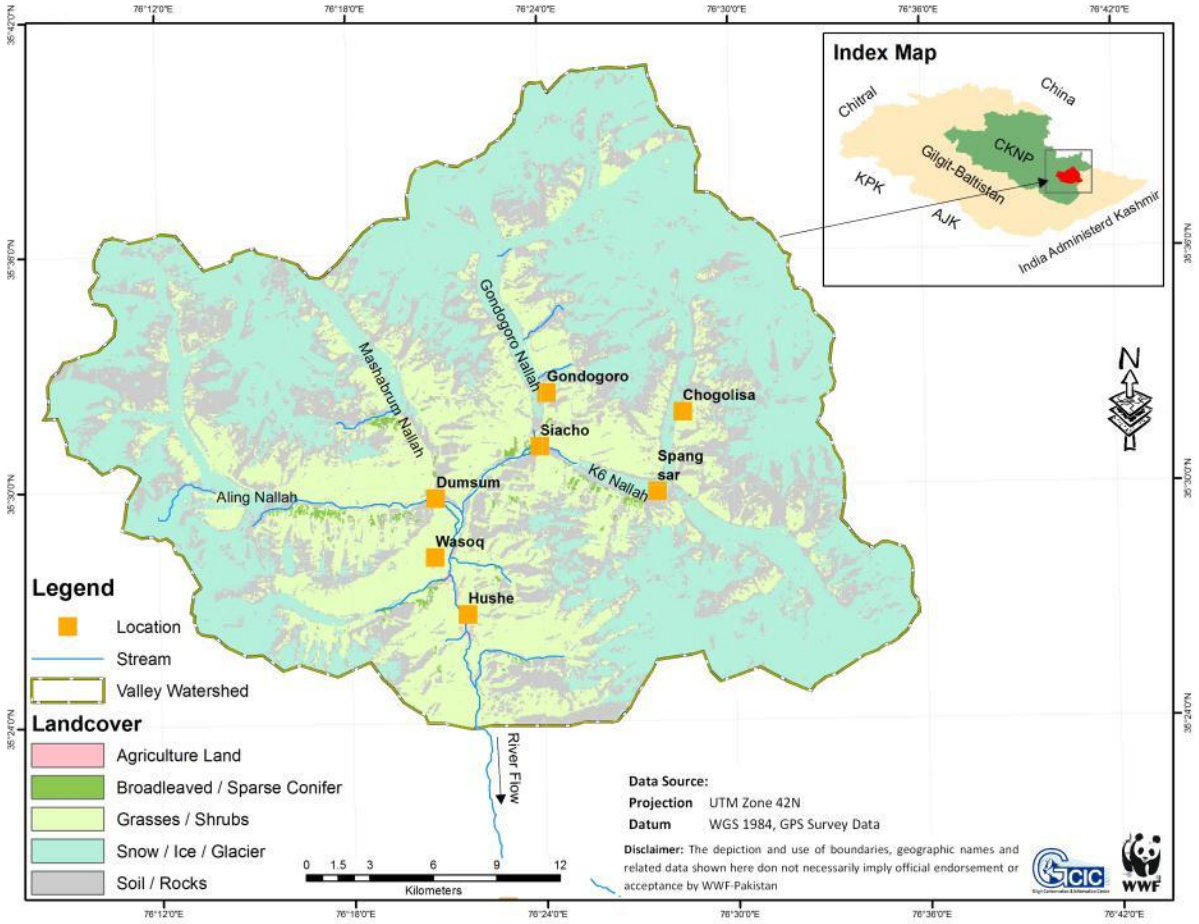

Fig. 1. Map of Hushey valley in CKNP, Pakistan.

Hushey valley falls under the cold desert mountain ecosystem, where it receives most of its precipitation in the form of heavy snow fall from November to March and the average rainfall rarely exceeds 200mm.The average temperature drops below -10 to -15 °C from December to February while in June and July the maximum temperature rises up to 20 °C (WWF-Pakistan, 2008).

The valley is inhabited by 1,365 people (Government of Pakistan, 1998 with projected 2.5% annual increase), living in 150 households. Major sources of livelihoods in Hushey are agriculture and livestock

herding, supplemented with cash incomes earned from tourism and services in the army and the public sector in some of the households (Hushey Valley Conservation Committee, 2011). In Hushey village the local community owns 2, 412 heads of livestock (WWF-Pakistan, 2011) including sheep, goats, cattle, yak and crossbreeds of yak and cow known as *zo* and *zomo*.

The valley is a refuge area not only for threatened species, such as the snow leopard, but also for not threatened but important "flag" species, such as Asiatic ibex, lynx and grey wolf (Roberts, 2005; Lovari and Bocci, 2009). The vegetation of the area is dominant with plant species such as *Artemisia maritima*, *Ephedra gerardiana*, wild rose *Rosa webbiana*, scurbu *Berberis* spp, sea buckthorn *Hippophae rhamnoides*, and *Myricaria germanica*, whereas tree species include Junipers, Salix, Poplars and *Betula utilis*. (WWF-Pakistan, 2008; Anwar *et al.*, 2011).

Since 1997 a community-based conservation programme is operational in the valley with support of national and international organizations such as IUCN Pakistan, WWF-Pakistan, Ev-K2-CNR, CESVI, BWCDO, in collaboration with the Directorate of CKNP and Gilgit-Baltistan Forests, Parks and Wildlife Department. The valley is a Community Controlled Hunting Area, allowing trophy hunting of Asiatic ibex in limited numbers. The number of Asiatic ibex in the valley is said to have increased and, starting from 1997, each year national and international hunters hunt 2-4 animals for trophies and 42 trophy animals have been taken till January 2012 (Aslam, personal communication, 01 March 2012).

Survey

Surveys were conducted in spring and winter during 2011 to 2013 by fixed-point direct count method using specified vantage points. This method has been effectively used to determine population structure and animal densities under similar mountainous conditions (Fox *et al.*, 1992; Feng *et al.*, 2007; Ali *et al.*, 2007; Khan, 2012). The points were selected across all the nullahs or sub-catchments where sightings of animals could easily be made and the same points were used in the subsequent surveys. The timing of observation at each site, from each vantage point, was adjusted in a way to avoid the chance of double counting. Following standards survey protocols developed by experts of the University of Siena, the spring surveys were conducted in April-May while the winter surveys in December, with the help of survey teams comprising of one member each representing Gilgit-Baltistan Wildlife Department, CKNP Directorate, WWF, local community (an experienced ex-hunter) and Village Wildlife Guards (VWGs). The winter surveys carried out from 15 to 31 December during the rut were considered to be the best time to evaluate population structure when different age classes group together (Dzieciolowski, *et al.*, 1980; Habibi, 1997) and concentrated population at wintering sites lead to efficient observations (Fox *et al.*, 1992).

Most of the observations were made during early morning and late afternoon when the animals were comparatively more active for feeding and drinking (Khan, 2012). We used binoculars (Nikon 12 x 50) and spotting scope (Swarovski ATM 80 HD) to count animals; a hand-help GPS (Garmin 78) was used to record locations and elevation of vantage points and a compass to note down bearings (angle), while distance from vantage points to location of herds was estimated approximately. A digital camera (SONEY DSLR A 200) was used to take photographs wherever possible. The data were noted down in a prescribed format including additional information such as weather, habitat conditions and other observations. Each herd was classified into age and sex groups, based on the criteria defined by Schaller (1977) and Lovari and Bocci (personal communication), i.e. kids (< 1 year old), yearling (>1 - <2 years old), females and males, also recording those individuals of which age/sex could not be determined. Trophy size males (>7 years old) were also noted apart. To minimize repeated counts, distinguishing features (e.g. broken

or bent horn) of one or more individuals in a herd were noted down whenever possible. Age and sex composition of a herd were sometimes used to distinguish between herds observed in adjacent areas (Oli, 1994; Khan 2012).

Data Analysis

IBM SPSS *v.* 20 was used to analyze data, tabulated as adult males, adult female, yearlings, kids, undetermined individuals, trophy size males, group sizes, group types, density and ratios of age and sex classes. In addition to mean group size, typical group size was also calculated based on animal-centred measurements (Jarman, 1974), by squaring the sizes of groups, summing up across all groups and dividing the sum by the total number of individuals observed. The typical group size was calculated because the former is an observer-centred measurement that gives equal weight to groups of all sizes, and it may not reflect the experience of the average individual species in the same manner as done by the latter (Raman, 1997). Corrected densities were calculated by measuring the area between 3,200 to 5,000 m above sea level (year-round potential habitat of Asiatic ibex – Roberts, 2005; Ali *et al.*, 2007), excluding glaciers using land-cover data (WWF-Pakistan, 2008). The calculated density was then multiplied with average live weights (kg) to obtain estimated total biomass for the study area. (Anwar, 2011; Khan, 2012). Mann-Whitney U test and Kruskal-Wallis test were applied to evaluate occurrence of various ages, sex classes and group sizes across various group types, habitat conditions and seasons.

Results

Density, distribution and population structure

Asiatic ibex are widespread in Hushey valley of CKNP, with greater numbers in several sub-catchments i.e. Alingnullah, K6nullah, Ghondogoro, Humbroq and Charry. Results of counts are given in table 1. On average, 368 animals (SE±146) were counted in winter and 102 animals (SE±12) in spring, during 2011-2013. Keeping in view winter observations, the average population density of Asiatic ibex in Hushey valley was 1.2 animals $km^{-2}$and biomass density 84 kg km^{-2}, calculated on 317 $km^2$of the year-round habitat, ranging between 3200 m to 5000 m, excluding glaciers and permanent snow areas in the valley. Ibexes in Hushey valley, during winter and spring, were found at elevations of 3442 to 4973 m. In summer they probably used higher elevations.

Table 1. Sex-age structure of the Asiatic ibex population in Hushey Valley of the CKNP, Pakistan (F=adult female, M=adult male, Y=Yearling, K=kids, ND=not-determined).

Period	Numbers Seen							Ratios		
	Adult Male	Adult Female	Yearling	Kids	ND	Total	Trophy size male	M-F	Y-F	K-F
Spring 2011	33	33	17	23	4	110	0	1:1	0.52:1	0.7:1
Winter 2011	26	25	12	21	3	87	0	1.04:1	0.48:1	0.84:1
Spring 2012	35	34	8	13	29	119	0	1.03:1	0.24:1	0.38:1
Winter 2012	155	178	104	137	6	580	64	0.87:1	0.58:1	0.77:1
Spring 2013	22	36	7	11	2	79	7	0.61:1	0.19:1	0.31:1
Winter 2013	141	109	51	92	43	436	31	1.29:1	0.47:1	0.84:1
Average Winter	107.3	104.0	55.7	83.3	17.3	367.7	31.7	1.03:1	0.54:1	0.8:1
Average Spring	30.0	34.3	10.7	15.7	11.7	102.3	2.3	0.87:1	0.31:1	0.46:1

Analysis of age and sex structure of the population was possible for 95% of the animals encountered during winter and 89% during spring. This indicates much suitable conditions for observations in winter when compared to spring.

The results (table 1) showed following population structure in winter: 29% adult males, 28% adult females, 15% yearlings, 23% kids; and in spring: 29% adult males, 34% females, 10% yearlings, 15% kids. During winter, trophy size males were 8.6% of the total population or 30% of the male population of the valley, while during spring it was 2.3% of the total population or 7.8% of the male population of the valley.

Sex ratio (male to female) was 1:1.14 with 31 yearling and 46 kids per 100 female in spring (pre-parturition) and 1:0.9 with 54 yearlings and 80 kids per 100 female in winter. Thus the sex ratio in spring ibex population was in favour of females, while in winter it skewed towards males but not significantly (χ^2=6, df=5, P=0.306). Realized increment estimated based on kids encountered in winter was 0.8 which declined by almost 50% in spring, as indicated by 54 yearlings per 100 females.

Group tendencies

Four group types were distinguished in the population, *viz* mixed herds, female-young (female, yearlings and kids), male and female. Mixed herds, composed of males, females and young were the most common groups encountered, accounting for 90.7% of the herds seen (n=108). Only 4.6% of the animals were observed in male groups, of which the largest herd comprised of 7 animals. Female-mixed groups were accounted for 3.7% of the herds. The female groups were rarely encountered (1% only). The number of males and females was highest in mixed groups (x =4 for both), followed by kids (x =3) and yearlings (x=2) (**Table 2**). Except kids (Kruskal Wallis test *H*=6.8, df=3, *P*=>0.076), the distribution of various age-sex categories significantly differed across various group types (Kruskal Wallis test male: *H*=14.6, df=3, *P*=>0.002; female: *H*=17.1, df=3, *P*=>0.001; yearlings: *H*=9.9, df=3, *P*=>0.019)

Table 2. Mean number of each age-sex class of the Asiatic ibex in different social group types in Hushey valley of CKNP, Pakistan (n=108 groups).

Sex-age classes	Group types				
	All groups	Mixed	Female-young	Male	Female
Male	4	4	-	4	-
Female	4	4	2	-	1
Yearling	2	2	2	-	-
Kids	3	3	2	-	-
Not determined	1	1	-	-	-
Trophy size males	1	1	-	-	-

The typical average group size was 18. Mixed groups were the largest ones with an average group size of 20 animals (**Table 3**). The largest group observed during spring comprised of 49 animals (12 adult male, 13 adult female, 3 yearlings, 5 kids and 16 not-determined individuals), while the one observed during winter comprised of 40 animals (10 male, 15 female, 10 yearlings and 5 kids). In Hushey valley the mean group size of all age-sex categories was 13 animals, which did not change significantly from spring to winter (**Table 4**, χ^2=26, df=29, *P*=0.588). In spring, the majority of the animals were seen in groups numbering 4-10 animals, while in winter 4-20 animals (**Fig. 2**).

Table 3. Typical and mean group size of the Asiatic ibex in the different social group types observed from 2011-2013 in Hushey valley of CKNP.

	Group type				
	All	Mixed	Female-young	Male	Female
Typical group size	18	20	6	6	1
Mean group size	13	14	5	4	1
S.D	9	9	2	3	
Range	1-49	2-49	3-7	1-7	0-1

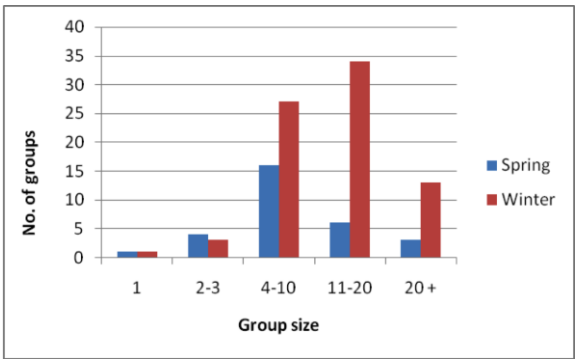

Fig. 2. Distribution of group sizes of Asiatic ibex (spring n=30, range=1-49 and winter n=78 range 1-40) in Hushey valley of CKNP.

Distribution of group types and group size across different habitat conditions (snow covered, grassland and barren land) remained at unity (Kruskal-Wallis test, n.s.). Among age-sex classes, distribution of adult male, adult female and yearlings also remained the same across different habitat conditions (Kruskal-Wallis test, n.s), whereas the distribution of kids and trophy size males differed significantly across different habitat conditions (Kruskal-Wallis test, H=8.06, df=2, P=0.018 and H=13.8, df=2, P=0.001, respectively). Trophy size males were more numerous in snow-covered habitat than barren land (Man-Whitney U test, α=0.001).

Table 4. Typical and mean group sizes of Asiatic ibex during 2011-2013 in Hushey valley of CKNP, Pakistan.

Season	Typical group size	Mean group size	Standard Deviation	Minimum	Maximum
Spring	17.8	10	10	1	49
Winter	18.3	14	9	1	40
Both seasons	18.05	13	9	1	49

Table 5. Estimated density of Asiatic ibex from different areas in south Asia.

Location	Density (Animals km^{-2})	N	Reference
Khuhsyrh Reserve, Mongolian Altai	0.4-4.8	539-748	Dzieciolowski, *et al.*, 1980
South-western Ladakh, Himalayas	0.5-0.6	250-350	Fox *et al.*, 1992
Central Ladakh, Himalayas	0.8-1.2	-	Fox *et al.*, 1991
Hoper Valley, Central Karakoram, Pakistan	1.2-1.6	194-270	Hess, 1986
Neelum valley, Azad Kashmir	1.3	122	Ali *et al.*, 2007
Khunjerab and Taxkorgan, Pakistan-China border area	0.04-0.7	491	Khan, 2012
Hushey valley, CKNP, Pakistan	1.2	367	Present study

Table 6. A comparison of population structure of Asiatic ibex in Asia.

Location	Adult female (%)	Adult male (%)	Yearlings (%)	Young (%)	n=	Reference
Himalayas	33.1	30.1	10.9	25.8	312	Fox et al. 1992
Tien Shan (Zailiiskiy Alatau)	52.5	21.9		25.6	1,067	Fedosenko and Savinov, 1983
Altai	48.0	32.1		19.9	unknown	Sobanskiy, 1988
West Sayan	48.1	27.4		24.5	9600	Zavatskiy, 1989
Mongolian Altai (winter)	46	21		33	1000	Dzieciolowski et al. 1980
Karakoram, Pakistan, China	33	39	16	11	889	Khan, 2012
Karakoram, Pakistan (winter)	28	29	15	23	368	Current study*

*6% of the animals could not be aged and sexed due to distant observations

Discussion

Density, distribution and population structure

Density of Asiatic ibex estimated in the current study, when compared with those from other areas in South and Central Asia (**Table 5**), revealed that Hushey valley of the CKNP shows a relatively higher density than the neighbouring Khunjerab area in Pakistan, while it was almost at unity with the estimates in Neelum valley, Azad Kashmir and Central Ladakh and fairly less than those estimated in Mongolian

Altai. The density estimates were comparable to those reported as the highest ones in Gilgit-Baltistan by Hess (1986) in Hoper valley, Central Karakoram, Pakistan. Comparing with Khunjerab, Hushey valley is drier and less vegetated, thus a higher density of ibexes may be related to lack of deep snow in shrubland along the valley bottoms, which leaves more areas for winter feeding (Fox *et al.*, 1992). Population density increases from periphery towards interior part of mountain because of reduction in snow level in interior (Sokolov, 1959 cited in Fedosenko and Blank, 2001). Another factor for a relatively higher abundance of ibex in Hushey valley could be the result of ban on illegal hunting through a community-based conservation programme initiated in the valley since 1997 (Nawaz *et al.*, 2009). Contrary to a previous assessment (e.g. Hagler Bailly, 2005) of ibex in Hushey valley to be in the thousands, the number of Asiatic ibex in the valley is several hundreds.

The population structure was also comparable to those from other areas in Himalaya and Karakoram (**Table 6**). The sex ratio differs in different types of habitats and range conditions, *e.g*., the male to female ratio after birth in Tien Shan, Dzhungarskiy Alatau and Himalayas was recorded to be 1:1.09, 1:1.21 and 1:1.11 respectively (Fedosenko and Savinov, 1983; Fox *et al.,* 1992), while in Mongolia and west Sanjay the female bias was greater, 1:2.13 and 1:1.87, respectively (Dzieciolowski *et al.*, 1980; Zavatskiy, 1989). Nutrition and range conditions affect ratio of male to female after birth, *e.g*., a female tends to produce more male offspring in unfavourable range conditions (Hoef and Nowlan, 1994). In a population, a minor number of males than that of females may also be due to various reasons such as a higher mortality rate of young males, death of old males due to weakness after the rut and trophy hunting; furthermore, an apparent more killing of males than females by predators such as snow leopard and wolf (Fedosenko and Savinov, 1983; Heptner *et al.*, 1961; Savinov, 1962). Applying these factors to CKNP, we can assert that in valleys where illegal hunting is strictly banned like Hushey, male to female ratio was almost at unity, showing a relatively larger number of males in the population.

The kids to females ratio in winter accounting for 80 kids to 100 female in Hushey valley was fairly consistent from year to year indicating a good reproduction, possibly due to vast alpine pastures with good quality forage in summer. A significant mortality, especially of young animals can be observed while looking at the ratio of kids to female (46 kids/100females) and yearlings to females (31yearling/100females) during spring. Harsh winter and predation pressure can be the factors limiting population growth as also observed by (Fox *et al.*, (1992) in Himalayan Mountains of India.

Ibexes in Hushey valley during winter and spring were found at elevations of 3342 to 4973 m. In summer they probably use higher elevations. The migration begins in late October until heavy snowfalls in winter and animals descend to as low as 3300 m near cultivated areas, overlapping their locations with those of domestic stock. Initially females with kids and young individuals migrate to their winter ranges followed by adult males. Village people quite often observe movement of animals above and in front of the village, enjoying watching them from their rooftops. Trophy hunting of adult's males occurs in wintering areas during January to early March. The upward migration starts in April to June, old males are the first to start climbing, after the gradual melting of snow, and they reach the glaciers by mid-June.

In addition to snowfall, the factors influencing seasonal migration include livestock movement, poaching, midges and gadflies. In winter they move down from north- to south-facing slopes, *e.g*. in Pamir, Central Tien Shan and Altai, 20-30 km in distance, with 700-800 m change in elevation and 40-50 km, with an elevation drop 1500 to 2000 m in Gissar Range, Talasskiy and Zailiiskiy Alatau (Fedosenko and Blank, 2001).

Group dynamics

Asiatic ibex like other members of Caprinae, are highly gregarious, living in different types and sizes of groups depending on various factors, *e.g*., overall population size (Sokolov, 1959), type of habitats (Alados, 1985) and seasons (Raman, 1997). The mean group size of Asiatic ibex in Hushey valley was 13 (range 1-40 in winter and 1-46 in spring), which is comparable with similar mountainous conditions such as those in Ladakh (Fox *et al*., 1992) but less than ibex numbers in Mongolia (*e.g*. Dzieciolowski *et al*., 1980). In Altai most of the groups of Asiatic ibex comprised <30 individuals, while up to 70 individuals occurred in regions of Pamirs and as many as 150 individuals in west Sanjay, south Siberia, during the rut in November (Sokolov, 1959; Zavatskiy, 1989).

The size of mixed herds was greater than that of other groups, as it happens in case of other ungulates such as Ladakh urial (Schaller, 1977) and Spanish ibex (Alados, 1985).

The majority of the herds were in mixed groups. Less segregation of sexes in our study area, during winter and spring, corresponded to previous assessments carried out in similar mountainous conditions such as southwestern Ladakh (Fox *et al*., 1992) and other Himalayan sites (Schaller, 1977). The number of trophy size males was very low in spring population than that in winter, which is common during the rut. The group types and sizes did not change with changes in habitat conditions, viz. snow covered, grassland and barren land. However trophy size males were more frequently seen in snow covered areas and female-young groups were more abundant in grassland, during spring. Less segregation of adult males and females has been attributed to low population density (Couturier, 1962). Female-young groups rarely occurred in Hushey valley of CKNP. This phenomenon has been attributed to sparsely vegetated habitats, as in our study area, probably in relation to the need of protection by female-young groups against predators and human. On the contrary mixed group are more frequent in areas of less vegetation density (Alados, 1985).

Conclusion and implications for conservation

Hushey valley is one the most important areas of the CKNP, in terms of distribution and abundance of Himalayan ibex (ibex population in Hushey valley is highest among all other 20 sub-catchments or valleys of the Park, Khan *et al*., unpublished data). Despite a strict ban on illegal hunting and a good reproductive potential (100 females/80 kids) the low density of Asiatic ibex (1.2 animals km^{-2}) is due to mass mortality of overwintering ibex kids, presumably due to seasonal severity and killing of young cohort by mammalian predators. These factors need to be evaluated and addressed through appropriate conservation measures.

In winter, during heavy snowfall, Asiatic ibex descend to valley bottoms in search of food and overlap their movements with domestic stock, which may lead to a dietary competition and shortage of forage primarily for young segment of the population. With a view to allow a larger overwintering population of ibex, the local community should manage grazing of their livestock, primarily aimed to reduce extensive grazing in winter pastures. For this purpose one of the options could be raising fodder on cultivable lands to supplement dietary requirement of domestic animals.

Habitat improvement is urgently needed at lower elevations (especially in spring and winter grazing areas) along the Hushey riverbanks including areas of heavy influence by agro-pastoral activities. These areas contain patches of salix and sea buckthorn *Hippophae rhamnoides* providing food to overwintering population of ibex and other herbivores. These patches can be improved by reducing extensive grazing and extraction of firewood. If possible, constructing some irrigation channels or repairing the already developed channels can bring more areas under perennial vegetation.

To evaluate impact of the on-going trophy hunting of Asiatic ibex in the valley, Hushey VCC should maintain proper record by noting vital information such as s date and location of hunt, age and horn size of trophy animals. Granting hunting permits need to be conditional with reliable population assessment carried out following standard monitoring protocols.

Some amount earned from trophy hunting of Asiatic ibex in the valley should be spent on habitat improvement measures such as growing fodder to offset pressure from pastures; fencing some winter feeding areas of ibex to protect against livestock grazing; hiring skilled herder for systematic grazing improved guarding of domestic livestock throughout all seasons.

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