IMPACT OF HUNTING ON LARGE MAMMAL DENSITIES IN THE WEST INDIAN HIMALAYA

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Introduction

Hunting is the prime suspect in the global extinction of many species (Martin and Steadman, 1999) and is posing a major threat to populations of hundreds of species worldwide (Daimond and Case, 1986; Redford, 1992; Peres and Terborg, 1995; Alvard *et al.*, 1997; Bodmer *et al*., 1997; Wilkie and Carpenter, 1999; Robinson and Bennett, 2000; Mace and Balmford, 2000; Bakker *et al.*, 2001; Fa *et al*., 2002; Rosser and Manica, 2002) even in the absence of other forms of habitat destruction. However, hunting is apparently sustainable in some areas, either because vulnerable species have already been extirpated (Cowlishaw *et al.*, 2005) or because hunting pressure remains low (Hill and Pawde, 2000). Most efforts to investigate impact of wild animal extractions and its ecological consequences on native wildlife and forest structure have been primarily from Africa and Latin America and such information from Asia is largely lacking. This information is increasingly important for those areas where habitat loss is leading to decreasing populations of species that are increasingly fragmented. One such area is Himalaya, which is of global importance for the conservation of biological diversity (Olson and Dinerstein, 1988).

Previous studies (Kaul *et al.*, 2004; Hilaluddin and Naqash, 2006; Hilaluddin *et al.*, 2011) documented animal extraction levels, patterns of extractions, methods and reasons of hunting, and impact of hunting on galliformes from this landscape. It, however, remained unclear whether the current level of offtake was adversely affecting populations of mammals. Therefore, this study was designed to investigate impact(s) of wild ungulate offtakes on their populations in the forests in and around Chamba district of the Western Indian Himalaya.

Material and Methods

Study area

Chamba is located in Himachal Pradesh, falls within India's bio-geographic province "2B Western Himalaya" (Rodgers and Panwar, 1988) and forms part of "West Himalaya Endemic Bird Area" (Satterfield *et al.*, 1988). Evergreen temperate pine forests dominated by chir pine (*Pinus roxburgii*), evergreen temperate oak forests dominated by ban oak (*Quercus leucotrichophora*) and mixed evergreen temperate forests with extensive Southwest facing grasslands occur in Chamba (Champion and Seth, 1968). The associates of ban oak and chir pine are rhododendron (*Rhododendron arboretum*), deodar (*Cedrus deodara*), Himalayan blue pine (*Pinus wallichiana*), yew (*Taxus baccata*), and west Himalayan fir (*Abies pindrow*). The undergrowth is predominated by barberry (*Berberis* spp.) and hybrid berries (*Rubus* spp.) with some rose (*Rosa* spp.), daphne (*Daphne* spp.), and cape myrtle (*Myrsine* spp.). These vegetation communities in Chamba district support over 200 bird species, including restricted range red-browed finch (*Callacanthis burtoni*) and globally threatened cheer pheasant and western tragopan (*Tragopan melanocephalus*) (IUCN, 2004).

Hunting occurs mostly outside PAs in the West Indian Himalaya, to provide supplementary protein to an otherwise vegetarian staple, mainly targeting large mammals and galliformes (Kaul *et al.*, 2004). Effective community rules (restrictions on game extractions, protecting sensitive and globally threatened species, breeding seasons, age-sex classes, bag limits) with regard to hunting are lacking and people are increasingly switching over to modern hunting devices (guns) at the cost of traditional ones. With methods varying from snaring to firearms three major types of hunting activities are prevalent: (1) Organized hunting targeting large bodied species with specific market; (2) regular snaring targeting galliformes in village vicinities, to provide food for family; (3) opportunistic hunting trips in forests for subsistence requirements.

Animal estimations

Animal census

Five forest fragments were studied in and adjoining Chamba district within 1410 and 3290 meters amsl during summer 2006. Forest fragments here are defined as continuous blocks of forests surrounded by agriculture fields and human settlements. In this study, the greatest distance between sites was <150 km and quantitative hunting pressures were not recorded. Alternatively, however, sites were selected from documented animal extraction rates and patterns in the

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Table 1
Profiles of the sampled transects.

Transect name	Nearest village	Beat name	Forest division name	Transect characteristics		
				Length (km)	Area (km^2)	Altitude (msl)
Burnar-Grad	Tyari	20 A^H	Kishtwar ^{TRL}	5.0	1.50	2600-3075 m
Top-Grad	-do-	20 B^H	-do-	4.5	1.35	2890-3290 m
Top-Pangi	Ishtiyari	19 A^H	Chamba and Kishtwar ^{TRL}	5.0	1.50	2600-3232 m
Namba Naal	Suendi	Sarah^H	Chamba ^{TRL}	4.5	1.35	2740-3210 m
Dramni Ki Bhurjee	-do-	-do-	-do-	3.7	1.11	2285-2440 m
Grad Bah	-do-	-do-	-do-	3.0	0.90	2020-2539 m
Haath Pav	Lagga	Kiri^H	-do-	4.5	1.35	1470-1820 m
Sukha Naala	-do-	-do-	-do-	4.5	2.02	1410-2400 m
Kalatop-Lakarmandi	Kalatop	Kalatop^P	Chamba ^{WL}	3.0	1.80	2590-2860 m
Kalatop-Khajrot Nala	-do-	Lakar Mandi^P	-do-	6.0	1.80	2040-2860 m
Khajrot Nala-Khajjyar	Khajjyar	Khajrot^P	-do-	5.0	1.50	1610-2040 m
Sunil Lodge-Kuringarh	Rakh	Krangda^P	-do-	4.0	1.20	1400-1800 m
Kalatop-RFC9	Lakar Mandi	Talai^P	-do-	5.0	1.50	1820-2480 m
RFC 11-15	-do-	Kalatop^P	-do-	4.0	1.20	1400-1860 m
Kangroo DPF	Kugti	Lower Kugti^P	Bharmor ^{WL}	4.0	1.20	2190-2840 m
Karog Dhar	-do-	Upper Kugti^P	-do-	5.0	1.50	2632-3210m

^{P} protected site & ^{H} hunted site. While ^{TRL} denotes Territorial Forest Division, ^{WL} means Wildlife Division.

forest fragments of West Indian Himalaya in literature (Hilaluddin and Naqash, 2006; Kaul *et al.*, 2003) and discussions with hunters. These measures were used to define sites as "protected" and "hunted". The protected sites were located in Khajjayar-Kalatop and Kugti WLS; whereas, hunted sites were in Chamba and adjoining Kishtwar Territorial Forest Divisions (Table 1).

Ungulate populations were estimated using belt transect (pre-defined areas) surveys following sample count strategy (Sutherland, 1996) identified on topo maps after discussing with concerned wildlife officials and local hunters. For verification, these were re-identified on the ground during reconnaissance surveys and starting and ending points were permanently marked on trees with paint for future reference. Transect length was measured using Hip-Chain Method (Chaturvedi and Khanna, 1982). Covering all major vegetation types in two management units the, transects were spaced at a minimum distance of >1-km at a site to avoid double counts. Generally, for visibility, streams and prominent trails were utilized as sampling areas.

Each transect was scanned daily for ungulates, at least for three consecutive days following same census schedule. The animal counts in all transects within an area began simultaneously at sunrise and ended between 830 and 1000 hours depending upon transect length. Censuses involved walking slowly (approximately 1-1.5 km/ hour) and stopping briefly at every 50-100 meters interval (Emmons, 1984) with the intention of flushing animals. A team of 5 observers with prior training in identifying ungulates with local names and walking transects scanned the 10-15 meter area on both sides of the transect depending upon the terrain and visibility. Maintaining a fixed distance of 20-30 meters from each other and silence for the calm of animals on transect, observers recorded total number of animals seen, sighting time and movement direction in pilot surveys so that individuals evidently seen more than once by two different observers could be taken into account. Downward pilot surveys were conducted from top to bottom of hill. The study area hardly received snowfall during summer and had snow-free peaks during the course of the study.

Vegetation survey

The composition of trees, shrubs, and herbs within each belt transect was assessed by selecting 5 sample points at 500 m regular distances on 15 m either side of the transect in order to avoid relatively disturbed vegetation due to trampling by cattle and humans. Circular plots (10 m radius) were established for estimating populations of trees (> 31 cm in basal girth) and shrubs (3 m radius); whereas, herbaceous vegetation was quantified in 1 m X 1 m square plots. In addition, vegetation structure was measured at each sample point. While Grid Mirror Method (Rodgers, 1991) was adopted to quantify canopy cover of tree species, Line Intercept Method and Crown Diameter Method (Muller-Dombois and Ellenberg, 1974) were used to estimate crown cover of herbs and shrubs, respectively.

Data analysis

Animal densities per unit area at a given day were calculated as the total number of individuals of a species seen on a particular transect on a particular day divided by the total area of that transect, although the aim of this study was not to estimate species densities for the region but to generate indices of abundances across the two management units which could be compared to examine variations in animal abundances in the hunted and protected sites. Man-Whitney U test was used to compare densities of each species in protected sites with their corresponding values in the hunted sites to investigate impact(s) of hunting on their populations.

It was assumed, there might be differences in the vegetation characteristic between hunted and protected sites independent of hunting pressure, although all of the patches were once part of the same continuous forest and are of the same geological origin. Therefore, vegetation structural and compositional heterogeneity between hunted and protected sites was statistically compared using Man-Whitney U test. Vegetation densities of trees, shrubs and herbs at each sampled point were calculated following Curtis and McItonish (1950). Their general diversities (H') were computed in accordance with Shannon and Wiener (1963), whereas species richness was calculated as total number of a species occurring in a sample unit (Ludwig and Reynolds, 1988). All statistical tests were performed following Sokal and Rohlf (1995).

Results

Sample size and survey efforts

A total of 16 belt transects (eight each in protected and hunted sites) (Table 1) were actively scanned for searching ungulates. On three consecutive day of estimation period, the team traveled a total of 212.1 km (108 km in the protected sites; 104.1 km in the hunted site) in 157.48 hours (77.11 hours in the protected site; 80.37 hours in the hunted site). All species were observed on more than 5 occasions, ranging from 5 for serow to 39 for goral (Table 2). The survey teams spent a mean of 9.65 hours/ transect 0.69 95% CI in hunted site and an average of 10.01 hours/ transect 1 0.88 95% CI in protected site for active search of animals.

Table 2

Ungulate species sighted and number of animals observed during Belt Transect Count sampling.

Species: Common name	Species: Scientific name	Number of observations
Barking deer	*Muntiacus muntjak*	12
Goral	*Nemorhaedus goral*	49
Himalayan tahr	*Hemitragus jemlahicus*	09
Serow	*Capricornis sumatraensis*	05

Vegetation structure and composition

With the exception of statistically significant higher shrub densities in protected site as compared to hunted site, the vegetation characteristics between the two management units statistically remained same (Table 3). Densities, diversities, richness and cover of trees, shrubs, and herbs were generally higher in protected site as compared with their corresponding values in hunted site.

Animal abundance

The comparisons showed significant differences in animal densities between hunted and protected sites. Animals were seen more often in protected sites than hunted ones. The densities of barking deer, Himalayan

Table 3

Vegetation characteristics (mean±median) with statistical variations in the hunted and protected sites.

Plant bio-morph type	Vegetation structural and compositional variables	Hunted site	Protected site	Statistical values: Mann-Whitney U test	Statistical values: P
Tree	Density (# of plants/km^2)	307.4 ± 238.8	332.8 ± 302.54	$U_{78} = 721.5$	0.45
	Diversity (H')	0.6 ± 0.56	0.6 ± 0.56	$U_{78} = 797.5$	0.98
	Richness (N_0)	2.3 ± 2.0	2.3 ± 2.5	$U_{78} = 765.5$	0.73
	Tree cover (%)	36.0 ± 30.0	30.1 ± 30.0	$U_{78} = 731.0$	0.50
Shrub	Density (# of plants/km^2)	2226.4 ± 1783.45	4024.5 ± 2547.8	$U_{78} = 570.5$	0.03*
	Diversity (H')	0.5 ± 0.5	0.7 ± 0.68	$U_{78} = 664.5$	0.19
	Richness (N_0)	2.2 ± 2.0	2.9 ± 2.9	$U_{78} = 663.0$	0.18
	Shrub cover (%)	29.7 ± 25.0	24.1 ± 20.0	$U_{78} = 730.0$	0.50
Herb	Density (# of plants/km^2)	35540.0 ± 30500.0	39582.0 ± 32200.0	$U_{78} = 751.5$	0.64
	Diversity (H')	1.01 ± 1.01	1.3 ± 1.21	$U_{78} = 603.5$	0.06
	Richness (N_0)	4.6 ± 4.0	4.8 ± 4.0	$U_{78} = 672.0$	0.21
	Herb cover (%)	37.65 ± 30.0	31.3 ± 20.0	$U_{78} = 735.0$	0.53

* Denotes significant values.

Table 4

Ungulate abundance (mean±median) with statistical variations in the hunted and protected sites in the Western Indian

Species	Number of animals/km ^{2}			Statistical values	
	Hunted site	Protected site	Overall	Mann-Whitney U test	P
Barking deer	0.4 ± 0	0.9 ± 0.4	0.7 ± 0 (0)	$U_{14} = 10.1$	0.01*
Goral	3.2 ± 2.2	5.8 ± 4.3	4.5 ± 3.4 (0.21)	$U_{14} = 11.5$	0.03*
Himalayan tahr	0.5 ± 0	1.6 ± 0	1.0 ± 0 (0)	$U_{14} = 12.0$	0.03*
Serow	0.1 ± 0	0.3 ± 0	0.2 ± 0 (0)	$U_{14} = 15.5$	0.05*

* Denotes significant values. Values in parentheses depicted in column 4 are quartiles.

tahr, goral and serow were significantly higher in protected sites than hunted ones (Table 4). Himalayan tahr, serow, barking deer, and goral abundance was lower by 69%, 66%, 55% and 45%, respectively, in hunted site when compared with their corresponding densities in the protected site.

Discussion

Three types of sources of variations might affect animal abundance among different forest patches (Hill *et al.*, 1997; Cullen *et al,.* 2000). First, vegetation structure and compositional heterogeneity, which independent of hunting, may cause changes in species abundance between the two sites. Secondly, hunting may affect the behaviour of certain species and make them less easy to sight than non-hunted species. Third, animals in the protected site may be less wary and, therefore, easier to sight than the same species in hunted site.

Comparisons of vegetation characteristics in the hunted and protected sites showed that hunting pressures within the two forest types were independent of vegetation structure and composition as there is little detectable difference between the two sites, at least on the basis of the vegetation heterogeneity measured as part of the present study. Moreover, the studied forest fragments were once part of the same continuous forest, and are of the same geological origin. Also, habitat heterogeneity does not lead to gross differences in wildlife densities, specifically for species with large geographical ranges and broad ecological tolerances (Eisenberg, 1989; Emmons, 1990; Redford and Eisenberg, 1992). All species examined as part of the present study have large geographical ranges and, therefore, little differences in habitat heterogeneity between the forest patches are unlikely to affect differences in quantitative animal abundance between the two management units. Further, vegetation characteristics of hunted and protected forests measured as part of present study did not differ statistically significantly (Table 3). Thus, homogeneity in vegetation between hunted and protected sites will outweigh variations in animal densities, if any occur, as a consequence of landscape heterogeneity across two management units. Moreover, streams and prominent trails were utilized as sampling areas across protected and hunted sites. Since this factor remained constant across the two management regimes hence is unlikely to impact animal abundance across hunted and protected sites due to bias in transect site selection, although densities of ungulates reported here can't be relied for their absolute abundance in the study area.

In the present census exercise, forest fragments in hunted and protected sites were scanned for ungulates with their total numbers by a team comprising of wildlife staff, hunters, and nomadic graziers. Each member searched for animals within 10-15 m area on his both sides. It was quite unlikely to miss animals in such a narrow strip during the combing operation and; thus, ungulate abundance between the two management units are unlikely to be affected due to changed animal behaviour (more wary in protected site).

Thus, it could be concluded that hunting appeared to have a significant effect on populations of ungulates in this landscape. The results suggest that hunting has severely reduced the abundances of barking deer, Himalayan tahr, goral and serow in the study area. Globally threatened species (e.g. Himalayan tahr, goral, serow) are specifically vulnerable because of high commercial gains to the hunters. Further, forests of the Western Indian Himalaya have been much reduced in area and are increasingly fragmented as a result of logging (FSI, 2005). Against a back grown scenario of burgeoning human population (0.07 ha per capita) in this landscape (Anon, 2000) and presumably accelerated protein demand, thereof, survival prospects for game species in hunted area is less certain than for those in protected area. Burgeoning adoption of modern hunting devices and lack of effective community rules is expected to further exacerbate the situation. This accentuated by logging, agriculture, and road network expansion may result in local extinctions of certain game species from several un-protected forest areas.

The impact of hunting on animal populations in the West Indian Himalaya is similar to other studies conducted elsewhere across the world. For example, mammal abundance, body mass and population densities in protected and hunted sites in Makokau, Gabon were negatively co-related with impact on species (Lahm, 1993). Similarly, mean body mass of all targeted species was significantly reduced in response to hunting pressures in Amazonian forest patches (Peres, 1999a and 1999b). The animal abundance and crude & metabolic biomass greatly declined in the hunted sites in Atlantic forest patches (Hill *et al.*, 1997). Densities of large mammals declined significantly in response to hunting in Nagarhole, India (Madhusudan and Karanth, 2002). However, observed patterns of current study are contrary to that of Peres (2000), who found non significant differences in overall game densities in hunted and protected sites, although he observed a reduction in vertebrate game in over-harvesting areas of Amazonian forests. Biomass of small and medium-bodied species greatly increased as a proportion of the overall community, whereas that of the large bodied mammals was significantly depressed at moderately to heavily hunted sites due to their selective hunting in these forest fragments.

The present study has demonstrated the impact of ungulate offtake on their densities in the West Indian Himalaya. It, however, remains unclear how hunting is affecting the population dynamics of game species. Further, no information exists on population age structures and demographics of hunted versus protected sites, impact of hunting on animals of different age classes, impact of hunting on vegetation characteristics and demographics of plant populations in hunted versus protected sites, and ecological sustainability of wildmeat from Asia, in general, and India in particular. These require immediate investigations.

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SUMMARY

Game species are lost when forest areas are subjected to hunting and populations of already threatened species may become locally extinct from many such patches. The present study tested this hypothesis in the temperate forests of West Indian Himalaya. The animal densities were estimated in predetermined Belt Transects, whereas vegetation abundance was estimated using point count strategy. The study provides solid evidence that hunting seriously impacts populations of hunted species. The results show that barking deer (*Muntiacus muntjak*), goral (*Nemorhaedus goral*), Himalayan tahr (*Hemitragus jemlahicus*) and serow (*Capricornis sumatraensis*) are encountered more frequently in protected sites than hunted sites. The fate of globally threatened species, specifically Himalayan tahr and serow, seems to be heavily impacted; and, both species are at high risk of local extinctions from many forest patches in this landscape of the world.

Key words: Ungulate Densities, Hunting Impact, Extraction, Wildlife.

पश्चिमी हिमालय भूभाग में बड़े स्तनियों के घनत्व पर उनका आखेट किये जाने से पड़ता प्रभाव

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सारांश

जब वन क्षेत्रों में जानवरों का शिकार किया जाता है तो आखेट की जाने वाली जातियों और पहले से विलुप्ति की संकट में आई प्राणि जातियों की संख्या ऐसे बहुत से टुकड़ों से स्थानीय रूप में पूरी तरह समाप्त ही हो जाती है। प्रस्तुत अध्ययन में इस प्रस्थापना का पश्चिमी हिमालयी भूभाग के समशीतोष्ण वनों में परीक्षण किया गया। पहले से विनिश्चित कर लिए गए पट्टी संक्षेत्रों में, पशु घनत्व का अनुमान लगाया गया तथा वनस्पति प्रचुरता का आकलन किसी जगह गणना करने की समरनीति अपनाकर किया गया। यह अध्ययन निश्चित रूपेण यह साक्ष्य उपस्थित करता है कि शिकार खेला जाना आखेट पशु–जातियों की संख्या पर गंभीर प्रभाव डालता है। परिणाम दिखाते हैं कि काकड़ (*मुण्टियाकस मुंतजक*) , घुड़ल (*नेमारेहडस गोरल*) , हिमालयी *टैहर* (या भेड़) (*हेमिट्रागस जेम्लाहिकस*) और सेराऊ (*कैप्रिकोर्निस सुमात्रैंसिस*) ने शिकारी स्थलों की तुलना में सुरक्षित किए क्षेत्रों में बहुधा उसका कुप्रभाव ज्यादा झेला है। विश्वत: संकटापन्न प्राणिजातियों, विशेषत: हिमालयी *टैहर* और सैराऊ पर भारी कुप्रभाव पड़ा दिखता है और ये दोनों जातियां विश्व के इस भूदृश्य के अनेक वन–टुकड़ों में स्थानीयत विलुप्ति के भारी खतरे में आई हुई हैं।

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