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Aspects of ecology and conservation of Kalij *Lophura leucomelana* and Koklas *Pucrasia macrolopha* in the Kumaon Himalaya, India

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Abstract: We studied some aspects of the ecology of Kalij *Lophura leucomelana* and Koklas *Pucrasia macrolopha* pheasants in 23 oak patches of Kumaon Himalaya, India from March 1996 to July 1997. Seven hundred and fifty nine man hours of field searches yielded 111 sightings of the two species (67 groups of Kalij and 44 groups of Koklas). The direct sighting data were analysed by discriminant function analysis to investigate habitat factors affecting distribution of Kalij and Koklas. The first two discriminant functions extracted 78.6% and 12.5% of variance and were associated with gradients of altitude and tree cover respectively. While Kalij was related to tree cover gradient, Koklas was associated with gradient of altitude. Multiple regression analysis was performed to develop equations for predicting the abundance of Kalij and Koklas. Shrub species diversity, herb density and livestock density accounted for 74% of variation in Kalij abundance while herb species richness, herb species diversity, altitude and grass species richness accounted for 78% of variation in Koklas abundance. These results are discussed viz. conservation of these species in Kumaon Himalaya.

Resumen: Estudiamos aspectos de la ecología de los faisanes Kalij *Lophura leucomelana* y Koklas *Pucrasia macrolopha* en 23 fragmentos de encinar en Kumaon Himalaya, India, entre marzo de 1996 y Julio de 1997. Setecientas cincuenta y nueve horas hombre de búsqueda de campo produjeron 111 avistamientos de las dos especies (67 grupos de Kalij y 44 grupos de Koklas). Los datos de avistamientos directos fueron analizados por medio de un análisis de funciones discriminantes para investigar los factores de habitat que afectan la distribución del Kalij y del Koklas. Las primeras dos funciones discriminantes extrajeron 78.6% y 12.5% de la varianza y estuvieron asociadas con gradients de altitud y de cubierta arbórea, respectivamente. Mientras que el Kalij estuvo relacionado con el gradiente de cubierta arbórea, el Koklas estuvo asociado con el gradiente de altitud. Se llevó a cabo un análisis de regression multiple para desarrollar ecuaciones predictivas de la abundancia del Kalij y del Koklas . La diversidad de especies arbustivas, la densidad de hierbas y la densidad de Ganado explicaron el 74% de la variación en la abundancia del Kalij, mientras que la riqueza de especies herbáceas, la diversidad de especies herbáceas, la altitud y la riqueza de especies de pastos explicaron el 78% de la variación de la abundancia del Koklas. La discusión de estos resultados se centra en aspectos tales como la conservación de estas especies en Kumaon Himalaya.

Resumo: Foram estudados alguns aspectos da ecologia dos faisões 'Kalij' *Lophura leucomelana* e da 'Koklas' *Pucrasia macrolopha* em 23 núcleos de carvalho nos Himalaia Kumaon, Índia entre Março 1996 e Julho de 1997. Setecentos e cinquenta e nove homens-horas de investigação de campo possibilitaram 111 observações das duas espécies (67 grupos de 'Kalij' e 44 grupos de 'Koklas'). Os dados da observação directa foram analisados com o recurso à análise discriminante para investigar os factores de habitat susceptíveis de afectar a

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distribuição dos 'Kalij' e dos 'Koklas'. As duas primeiras funções discriminantes justificaram 78,6% e 12,5% da variância e encontravam-se associadas com o gradiente de altitude. Foi efectuada uma análise de multiregressão para predizer a abundância dos 'Kalij' e 'Koklas'. A diversidade das espécies arbustivas, a densidade do estrato herbáceo, e a densidade do armentio, foram responsáveis por 74% da variância da abundância dos 'Kalij' enquanto a diversidade do estrato herbáceo, a altitude e a riqueza específica das ervas justificaram 78% da variação quanto à abundância dos 'Koklas'. Estes resultados são discutidos na perspectiva da conservação destas espécies no Himalaia Kumaon.

Key words: Abundance predictors, Kalij, Kumaon Himalaya, *Lophura leucomelana*, Oak forests, *Pucrasia macrolopha.*

Introduction

Animal species show variation in their distribution and abundance in time and space. Developing an understanding of factors governing the variation in distribution and abundance of animal species has been a central theme in ecology (Krebs 1972). Both abiotic and biotic factors have been shown to govern these population parameters. While abiotic factors may often govern the distribution of a species at landscape level, biotic factors may influence species abundance and micro habitat use within different elements of landscape. Such ecological information is thus a necessity for conservation of species as well as sound protected area planning.

In this communication, we investigate the factors governing distribution and abundance of two pheasant species i.e. Kalij pheasant *Lophura leucomelana* J.E. Grey and Koklas pheasant *Pucrasia macrolopha* Lesson in the Kumaon Himalaya. Both species are widely distributed throughout much of Himalaya and were common in the Kumaon region. However, large scale destruction and degradation of oak forests and also illegal hunting throughout the Kumaon Himalaya in past has apparently led to general decline in distribution and abundance of both species.

Materials and methods

Study area

The study was conducted in three districts i.e. Almorah, Nainital and Pithoragarh of the Kumaon Himalaya (28°43′55″ and 30°30′12″ N lattitude and 78°44′ 30″ and 80°45″ E longitude). Twenty three oak patches of varying sizes, were covered during the present investigation (Fig. 1 & Table 1).

The Kumaon Himalaya is mountainous and is divisible into subtropical (300 to 1500), temperate (1500 to 3500) and alpine (>3500) zones (Saxena *et al.* 1985). There is an altitudinal gradient in climate with a decrease of 0.55°C temperature for every 100 m in elevation (Saxena *et al.* 1985). The annual rainfall increases with altitude and peaks at about 1200 m (4100 mm) and then gradually declines to 670 mm at 2700 m (Saxena *et al.* 1985). The maximum rainfall (73-89% of the total) occurs during rainy season (June to September).

The vegetation in the Kumaon Himalaya is predominantly forest and mostly belongs to moist temperate type (Champion & Seth 1968). There are five main forest types found in the whole of Kumaon Himalaya. These are sal forests (found up to 1200 m), pine forests (1200-2400 m), oak forests (1300-3300 m), mixed broadleaf forest (foothills to 3300 m) and *Betula utilis* forest (3200-3500 m). The surveys conducted in this study largely covered oak patches at 23 sites in an altitude range of 1200-3500 m.

The major tree species found in different sites included *Quercus leucotricophora* Roxb., *Quercus lanata* Roxb., *Quercus floribunda* Roxb., *Quercus semecarpifolia* Sm., *Rhododendron arboreum* Sm. in association with *Viburnum coriacium* Bl., *Myrica esculenta* Thunm., *Alnus nepalensis* D. Don., *Lyonia ovalifolia* D Don., and *Lindera pulcherrima* Benth-Sym. The dominant shrub species were *Myrsine africana* Linn., *Berberies aristata* Linn., *Rubus ellipticus* Sm., *Daphnae cannabina* Wall., *Mahonia napaulensis* DC. The tree and shrub species composition, which varied between sites and along the altitudinal gradient,

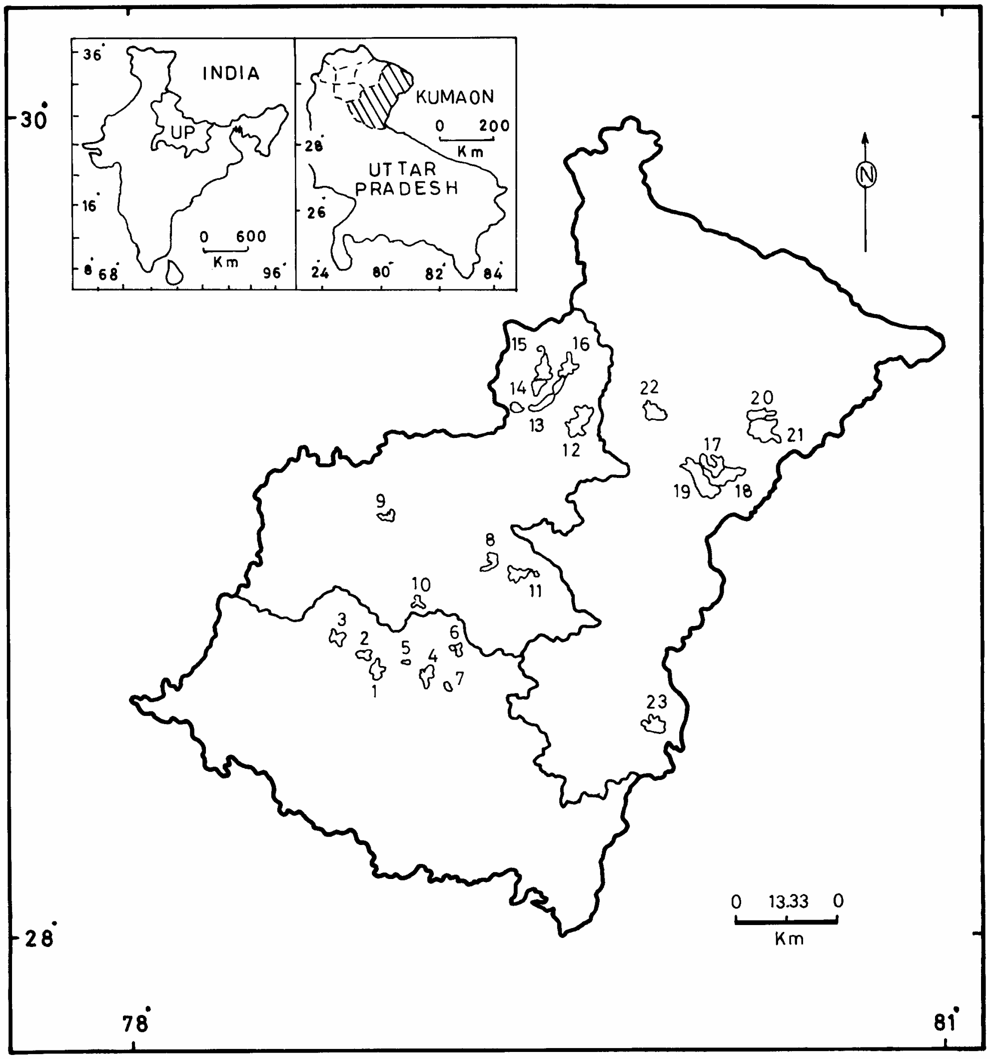

Fig. 1. Locations of sites surveyed in the Kumaon Himalaya (for site names, see Table 1).

has been documented well in past (e.g. Saxena *et al.* 1985).

Data collection

During the surveys at each site, existing forest trails and transects on set bearings were monitored to obtain information on pheasant species composition. The trails and transects passed through all the major habitat types at each site to allow sampling of different species found in different habitats. Data were collected on following parameters during the monitorings: (a) total time spent in each monitoring of trail/transect, (b) total distance covered in each monitoring of trail/ transect, (c) species encountered, (d) sighting time, (e) group composition, (f) altitude, (g) aspect, (h) slope, (i) habitat type, (j) weather condition, and (k) perpendicular distance. There were 208 monitorings of trails and transects involving 759 hours of search efforts during the entire study period which resulted in sightings of 67 groups of Kalij and 44 groups of Koklas, 12 groups of monal (*Lophura impejanus* Latham), 5 groups of chir (*Catreus wallichii* Hardwicke) and 10 groups of common hill partridge (*Arborophila torqueola* Valencienes).

Each sighting was characterised by a number of habitat parameters. Tree layer was quantified by counting the nearest ten trees and their respective species from the point where the bird was en-

Table 1. Details of different patches covered during surveys in Kumaon Himalaya.

Site code	Site name	District	Altitude range (m)	Size of patch (km^2)
1.	Kilbury	Nainital	2000-2600	16.25
2.	Vinayak	Nainital	1900-2400	15.32
3.	Khunjakharak	Nainital	1900-2500	14.50
4.	Maheshkhan	Nainital	1900-2300	22.00
5.	Gagar	Nainital	1700-2300	3.25
6.	Mukteshwar	Nainital	1500-2400	15.75
7.	Jilling	Nainital	1700-2100	2.50
8.	Binsar Sanctuary	Almora	1600-2500	11.25
9.	Pandavkholi	Almora	1800-2500	13.23
10.	Sitlakhet	Almora	1700-2200	11.25
11.	Jageshwar	Almora	1800-2300	21.00
12.	Gasi	Almora	2100-3000	49.50
13.	Dhakuri	Almora	2000-3000	32.50
14.	Wachham	Almora	1900-3500	11.00
15.	Sundardunga	Almora	2500-3500	25.27
16.	Pindari	Almora	2500-3500	21.50
17.	Daphiadhura	Pithoragarh	1200-2500	34.36
18.	Majthan	Pithoragarh	1300-3200	25.00
19.	Gandhura	Pithoragarh	1500-2600	54.00
20.	Sobla	Pithoragarh	1900-3500	28.12
21.	Duku	Pithoragarh	1290-2700	52.00
22.	Munsiari	Pithoragarh	2300-3000	30.50
23.	Mecch	Pithoragarh	1800-2200	23.25

countered to estimate the tree density, diversity and species richness. The distance of 10th and 11th tree from the sampling point was measured to calculate the area of sampling plot. The shrub layer was quantified in 3 m radius circular plot around the point where the animal was encountered. Shrub species and their numbers were recorded for estimation of density, diversity and species richness. Ground vegetation (herbs and grasses) was sampled in 1 m^2 quardrat laid exactly at the place where the bird was encountered. Herb and grass species and their numbers were recorded for density, diversity and richness estimation. Abundance of potential food materials (insects, fruits and berries) was also recorded in 1 m^2 quadrat.

The tree cover was measured by using a gridded mirror of 25 x 25 cm dimension, divided into 25 equal grids. The mirror was placed horizontally at 1.25 m above the ground touching the body of the observer. Tree cover was measured at 5 m distance from the sampling point in four different directions. The grids covered with more than 50% foliage were counted and expressed in terms of percent tree cover. The shrub cover was measured by occular estimation on ordinal scale of 0-5 with 0 representing no shrub cover and 5 representing maximum shrub cover. The shrub height was measured by using a straight bamboo stick placed vertically beside the shrub species of maximum height and later measured. Ground cover was measured following the line intercept method (Canfield 1941) by placing a metre tape on the ground at the sampling point and the intercepting material (grass, herb, litter, bare ground, rock and weathered stone) at the interval of 5 cm was recorded and converted into percent ground cover.

Apart from monitorings of trails, call counts (Gaston 1980) were carried out at each site to estimate Koklas abundance. Vantage points (hill tops and facing valleys) were selected at each site to record the calling individuals from different directions. The selected vantage points were attended from half an hour before sunrise and stay was made upto half an hour after the last call of Koklas was heard. Following information was recorded during the call count (a) time spent from first to last call, (b) time and direction (c) number of calls/individuals, (d) wind speed and (e) weather condition.

Besides trail monitoring and call counts, intensive sampling of vegetation of each site (on the same trails/transect which were followed for monitoring to asses the galliform abundance) was also carried out to asses the overall density, diversity and species richness for three layers (tree layer, shrub layer and ground layer). A total of 790 sampling plots were sampled on 10 m either side of the trail to avoid sampling the relatively disturbed vegetation along the trails. Sampling plots were established at 50 m interval along each trail. Trees of > 4 m height were considered as mature trees and were recorded in 10 m radius circular plot following Mueller-Dombois & Ellenberg (1974). Shrub species were counted in 3 m radius circular plot within the 10 m radius sampling plot. The shrub species and their number were recorded for the estimation of density, diversity and species richness. Ground vegetation (herbs and grasses) was quantified by randomly placing four 0.25 m^2 quadrat within the 10 m radius sampling plot. The ground layer (herbs and grasses) species and their numbers were recorded for the estimation of density, diversity and species richness.

Data on various disturbance parameters such as cutting, lopping, cattle dung and grazing were also collected at each sampling plot by counting the number of cut, lopped trees and number of cattle dung piles in 10 m radius circular plot. The number of dependent villages on the forest patch at each site were identified and the human and livestock population of all villages at each site were recorded to calculate human and cattle density.

Data analysis

The tree, shrub, grass and herb densities were calculated following Grieg-Smith (1983) for each sampling plot. The tree, shrub, grass and herb diversity was calculated by using Shannon-Weiner's diversity index following Grieg-Smith (1983):

$$H' = - \Sigma \, pi \times \log pi$$

where, pi is the proportion of the ith species in the sample. The species richness was calculated by using Margalef's species richness index:

$$r's = \frac{s - 1}{\ln N}$$

where, s is the number of species in a sample and N is the total number of individuals in a sample.

The sightings of groups of both species were summarised to calculate encounter rates (groups/100 hours) for individual monitorings as well as overall encounter rates for different site for each species.

The direct sightings data were organised into species habitat variables matrix and was subjected to stepwise Discriminant Function Analysis. The analysis matrix also included sightings of monal, chir and common hill partridge. Before carrying out the analysis, the variables were converted to 0-1 scale by dividing all values of a variable by its highest value to bring uniformity in the magnitude of variation each variable possesed. Each variable was further adjusted by transformation using natural log and Arcsine transformation function. Direct sighting-habitat variable matrix was further subjected to pearson-product moment correlation analysis (two tailed significance) to check for intercorrelations. Appendix 1 provides the list of variables with details of transformation and variables discarded from inclusion into Discriminant Function Analysis (DFA). The DFA analysis was performed on matrix of 102 sighting x 10 habitat variables.

The abundance data of Kalij and Koklas and quantification of habitat parameters on 790 sampling points at 23 sites were organised into a species abundance-habitat parameters matrix for performing the multiple regression analysis (MRA). For each site, data on habitat parameters from individual sampling points were used to generate the mean value for each parameter and its 95% confidence intervals. The parameters were again converted on 0-1 scale to bring uniformity in magnitude of variation in each variable. The variables were adjusted by suitable transformation by log and arcsine function and subjected to correlation analysis to check for multiple collinearity (Zar 1984). Variables showing intercorrelation were excluded from MRA analysis. All statistical analysis were performed on computer programme SPSS (Norusis 1990) following Zar (1984) and Fowler & Cohen (1986).

Results

Distribution

Table 2 provides the U statistics and F ratios for habitat variables included in DFA analysis for Kalij and Koklas. Only three variables viz. altitude, shrub height and tree cover have significant F values and therefore, are capable of individually discriminating between species. These variables co-vary with species occurrence whereas other variables do not. The variables with least discriminating powers between species are shrub cover (SC) and tree density (TSD).

Table 3 provides values of standardised canonical discriminant function coefficients for all variables indicating the variables which have largest absolute canonical correlation with each function. The DFA produced four functions DF1, DF2, DF3 and DF4 accounting for 100% variation in the data. The four functions DF1, DF2, DF3 and DF4 accounted for 78%, 12% 6% and 4% variance in the data. The last two functions extracted <10% of variance and therefore, it may be considered by chance.

Table 2. U statistics and univariate F ratios for variables included in discriminant function analysis (4 & 89 degrees of freedom [for variable name, see Appendix 1]).

Variables	Wilks Lambda	F	Significance
ALT	0.59239	15.6535	0.0000
GR	0.95265	1.1309	0.3470
HR	0.93873	1.4848	0.2133
SC	0.97994	0.4657	0.7607
SHT	0.82036	4.9818	0.0011
TC	0.89274	2.7335	0.0337
TSD	0.96022	0.9424	0.4432

Table 3. Standardized canonical discriminant function coefficients for 7 variables from a discriminant function analysis of 5 species. Percentage of total variance extracted by each DF is noted in each column (for variable name, see Appendix 1).

Variables	DF1 78.6%	DF2 12.5%	DF3 6.14%
ALT	0.94861*	0.21255	0.34927
GR	-0.06217	-0.27675*	-0.01301
HR	-0.10828	0.37737	-0.75404
SC	0.13260	0.05769	0.30572
SHT	-0.30309	0.19583	0.47947*
TC	-0.29282	0.67303*	0.0995
TSD	0.16497	0.29890*	0.25523

* Variables showing largest absolute correlation with each function.

The first discriminant function represents gradient in altitude from low to high. The second function is a gradient of tree cover from open forest to closed canopy forest. The third function is a gradient of shrub height from low shrub layer to a tall mature shrub layer. The combined variance of these three functions is 96% which together explains the variation in habitat selection by two pheasant species in increasing order of their magnitude. Fig. 2 a-c provides the species centeroids in relation to the three functions separately.

The relative position as well as location of species in these figures determine the extent to which each species is associated with each function. Fig. 2c is a plot of function 1 with respect to 2. While Koklas is associated with altitude gradient, Kalij is associated with tree cover gradient. The separation of two pheasant species along three gradients may be used to describe the habitat of each species. The Kalij occupies forested areas with medium tree cover and a tall shrub layer at lower altitudes while Koklas occupies forested areas with low tree cover and shrub layer of intermediate height at middle altitudes.

Abundance predictors

The results of stepwise multiple regression analysis to identify habitat variables governing abundance of two species within their respective habitats are summarised in Tables 4 and 5. The multiple regression model of Kalij abundance included shrub diversity (SDIV), herb density (HD) and livestock population density (LIP). These variables together accounted for 74% of variation in Kalij abundance ($r = 0.86$, $P<0.001$). While herb density and livestock density were negatively correlated, shrub diversity was positively correlated with Kalij abundance. The regression of Kalij abundance with these habitat variables was significant ($F_{2, 20} = 17.55$ $P<0.001$) with regression coefficients also being significant ($P<0.001$ & $P<0.01$).

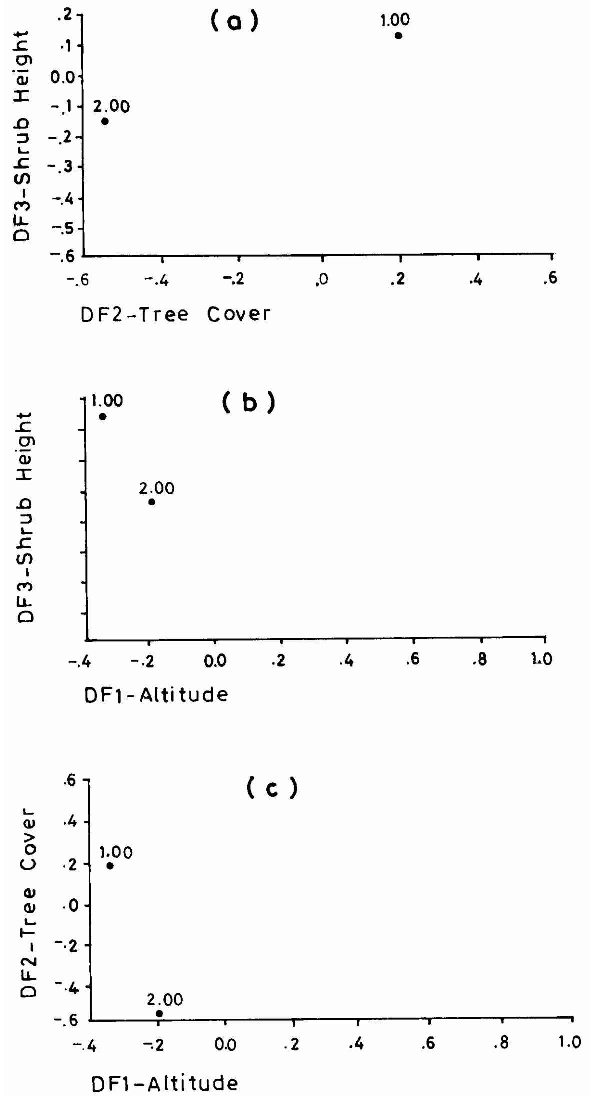

Fig. 2. Distribution of Kalij (1) and Koklas (2) in relation to three discriminant functions.

In case of Koklas, altitude (ALT), grass richness (GRIC), herb diversity (HDIV) and herb richness (HRIC) together explained 78% of variation in its abundance. All these variables were positively correlated with Koklas abundance ($r = 0.88$, $P<0.001$). The regression was significant (F 3, 19 = 15.8, $P<0.001$) with null hypothesis regarding regression coefficient is equal to zero being rejected at $P<0.01$.

Discussion

All pheasant species except grey jungle fowl (*Gallus sonnerattii* Temminck) and peafowl (*Pavo cristatus* Linn.) in India are distributed in the Himalayas. Surveys in past to document status and distribution of pheasants have largely been conducted in Himachal, Arunachal Pradesh and Uttar Pradesh (Gaston *et al.* 1981; Kaul & Ahmed 1993; Sathyakumar *et al.* 1993). While habitat destruction was found to be the main factor responsible for decline in abundance of different pheasant species in Himachal Pradesh (Gaston *et al.* 1981), large scale hunting and trapping in Arunachal Pradesh are responsible for their low abundance (Jamal Khan, pers. obser.) since there are still large chunks of prime habitat available in this state. Our recent surveys in the Kumaon Himalaya to document the status and abundance of pheasants have shown that different peasant species including the once abundant Kalij and Koklas occur in fairly low abundance in fragmented oak patches (Hussain *et al.* 1997; Khan 1997). These species have suffered as a consequence of large scale destruction of oak forests in past and poaching which is still very rampant throughout the Kumaon Himalaya.

The Kalij and Koklas pheasants are found throughout their distribution range in the Himalaya between 1200-2500 m and 1300-3000 m respectively (Gaston *et al.* 1981). While their range overlap a great deal occurring together at 22 sites out of 23 surveyed sites, the Kalij and Koklas

Table 4. Multiple regression analysis for Kalij abundance. V = variable (for variable name, see Appendix 1), MR = multiple R, C = correlation, R^2 = coefficient of determination, F = F values.

S. No.	V	MR	C	R^2	F	Significance
1.	SDIV	0.60	+	0.37	11.8	0.003
2.	HD	0.75	-	0.57	12.6	0.001
3.	LIP	0.86	-	0.74	17.5	0.001

Table 5. Multiple regression analysis for Koklas abundance. V = variable (for variable name, see Appendix 1), MR = multiple R, C = correlation, R^2 = coefficient of determination, F = F values.

S. No.	V	MR	C	R^2	F	Significance
1.	HRIC	0.68	+	0.47	18.0	0.001
2.	HDIV	0.76	+	0.58	13.2	0.001
3.	ALT	0.82	+	0.68	12.8	0.001
4.	GRIC	0.88	+	0.78	15.8	0.001

out of 23 surveyed sites, the Kalij and Koklas abundance also co-varied positively (rs = 0.47, P<0.05). This suggests that sites surveyed offered habitat conditions suitable to both species as our analysis showed that Kalij and Koklas are governed by different set of habitat factors at macro and micro habitat level.

The factors affecting macro and micro habitat use of Kalij included its requirements for forested areas with medium tree cover supported by a diverse and mature shrub layer with sparce ground layer without livestock disturbance. This contradicts the subjective observations of Gaston *et al.* (1981) who concluded that Kalij has a positive association with people and occurs in disturbed areas. The Koklas differs markedly from Kalij as shrub layer and tree layer played insignificant role in governing its distribution. It rather requires a well developed and diverse ground layer along with positive association with altitude. Gaston *et al.* (1981) also recorded increasing abundance of Koklas with increase in altitude. In relative terms, Koklas emerges as more sensitive to degradation than Kalij in the Kumaon Himalaya.

The findings of this investigation have wider conservation implications. The landscape in Kumaon Himalaya is a mixture of oak forests, chir pine forest, agricultural fields and human habitations. Land use practices in past have led to many fold increase in coverage of chir pine forest at the expence of oak forests. The extant oak patches, highly fragmented, are under tremendous lopping and grazing pressure. Even the two declared protected areas (Binsar and Askot Wildlife Sanctuaries) are not free from grazing, lopping, cutting and fire pressures. In such conditions both species will continue to suffer due to their requirements for undisturbed habitat conditions. We suggest that managers responsible for wildlife take steps to halt further degradation of oak patches to ensure survival of Kalij, Koklas and other associated faunal and floral elements. Firstly the protected area coverage needs to be increased substantially in Kumaon Himalaya as suggested by Hussain *et al.* (1997). Secondly the managers need to evolve guidelines for regulation of grazing and lopping for protected area as well as outside protected areas which should be implemented rigorously. Thirdly the Wildlife Protection Act (1972) should be strictly enforced to curb widespread poaching of all wildlife species.

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Appendix 1. List of variables used in discriminant function analysis and multiple regression analysis.

S.No.	Variable code	Variable	Transformation
Discriminant function analysis			
1.	ALT	Altitude in m	log
2.	SLP	%Slope	log, correlated with GR dropped
3.	TSD	Tree density in ha	log
4.	TRIC	Tree species richness	log, correlated with TDIV, dropped
5.	TC	% of tree cover	arcsine
6.	TDIV	Tree species diversity	log, correlated with ALT, dropped
7.	SSD	Shrub species density in ha	log, correlated with ALT, dropped
8.	SDIV	Shrub species diversity	log, correlated with SHT, dropped
9.	SRIC	Shrub species richness	log
10.	SC	% of shrub cover	arcsine
11.	SHT	Shrub height in cm	log
12.	HD	Herb density in m^2	log, correlated with HDIV, dropped
13.	HDIV	Herb species diversity	log, correlated with HR, dropped
14.	HRIC	Herb species richness	log, correlated with HDIV, dropped
15.	GD	Grass density in m^2	log, correlated with GR, dropped
16.	GDIV	Grass species diversity	log, correlated with SC, dropped
17.	GRIC	Grass species richness	log, correlated with GDIV, dropped
18.	GR	% of grass cover	arcsine
19.	HR	% of herb cover	arcsine
20.	LT	% of litter cover	arcsine, correlated with GD, drooped
21.	RK	% of rockiness	arcsine
22.	BG	% of bareground	arcsine, correlated with LT, dropped
Multiple regression analysis			
1.	TSD	Tree density in ha	log, correlated with ALT, dropped
2.	TDIV	Tree species diversity	log
3.	TRIC	Tree species richness	log, correlated with TDIV, dropped
4.	SSD	Shrub species density	log

Contd...

S.No.	Variable code	Variable	Transformation
5.	SDIV	Shrub species diversity	log
6.	SRIC	Shrub species richness	log, correlated with SDIV, dropped
7.	HD	Herb species density	log
8.	HDIV	Herb species diversity	log
9.	HRIC	Herb species richness	log
10.	GD	Grass species density	log, correlated with SRIC, dropped
11.	GDIV	Grass species diversity	log, correlated with ALT, dropped
12.	GRIC	Grass species richness	log
13.	CUT	Number of cut trees	log, correlated with SRIC, dropped
14.	LOP	Number of tree lopped	log, correlated with HDIV, dropped
15.	CD	Number of cattle dung piles	log
16.	PSZ	Patch size	log
17.	HUP	Human population	log
18.	LIP	Livestock population density	log
19.	NV	Number of villages	log
20.	ALT	Altitude	log