INTRODUCTION

Current status and ecological information on pheasants was lacking in Kumaon Himalaya. Therefore, this study was carried to fulfill the gap in information for this bird group. This study was part of the long-term ecological project titled “A study of threats to biodiversity conservation of the middle altitude oak forest of Kumaon Himalaya, India” funded by the Ministry of Environment & Forests, Govt. of India. The study was conducted in the five districts; Almora, Bageshwer, Champawat, Naini Tal and Pithoragarh of Kumaon Himalaya (28° 43' 55" and 30° 30' 12" N latitude and 78° 44' 30" and 80° 45' E longitude) covering an area of 21032 km² of Uttarakhand hills in India.

The main objectives of this study are-

1. To study the status and abundance of different pheasant species of Kumaon Himalaya.
2. To study various ecological aspects of different pheasant species of Kumaon.
3. To study social organization of different pheasant species of Kumaon.
4. To study food and feeding ecology of different pheasants of Kumaon.
5. To assess various threats upon different pheasant species as well as surveyed localities of Kumaon Himalaya.
6. To prepare a conservation strategy for each pheasant species and to suggest recommendation for their management and conservation.
METHODOLOGY

Fieldwork was carried out from March 1996 to December 1998 in Kumaon Himalaya. Overall 902 sampling plots were laid in 23 oak patches for vegetation assessment. Plot sampling method following Dombois & Ellenberg (1974) was used for vegetation sampling. Trees were quantified in 10m radius circular plot. Ground vegetation (herbs and grasses) was estimated in 0.5m x 0.5m quadrate at four places within the 10m radius circular plot. Tree cover was measured by using gridded mirror of 10 x 10 inches dimension.

The map boundaries of Kumaon were digitized from toposheets published by Survey of India. The area of proposed sanctuaries was also carved from the same toposheet. The data on different aspects were collected on grids of 1 x 1 km for the proposed sanctuaries. GIS analyses were performed by ArcView 3.2 computer software program.

Extensive surveys were conducted status and distribution of various pheasant species in Kumaon Himalaya. Trail monitoring was conducted to obtain relative abundance estimate of different pheasants. Call counts were conducted during breeding season to document presence of pheasant species, which might not be encountered during trail monitoring.

For habitat use, at each direct sighting or/indirect evidences, following records were made: a) Identification of species, b) General angle of slope, c) Habitat types, d) Weather condition. Vegetation was also quantified at the places where the pheasant species was sighted. Assessment of different disturbance factors was done on ordinal scale. In Binsar Wildlife Sanctuary, four existing forest trails, two in oak habitat and two
in oak-pine, were used for monitoring while four trails were also selected for intensive monitoring in Pindari. Several threats on pheasants were identified and assessed.

ANALYSES

VEGETATION STUDIES

Densities for trees, shrubs and ground vegetation (herbs and grasses) were calculated. The diversity and richness for each layer (tree, shrub and ground vegetation) in different habitats and for each site was also calculated.

The vegetation of Kumaon was classified on the basis of all tree species sampled by using TWINSPLAN (Two-way indicator species analysis) computer program. The same data matrix was again used for ordination of species as well as sites by using computer program DECORANA for Detrended Correspondence Analysis (DCA).

STATUS AND ABUNDANCE

The sightings of different pheasant species were summarized to calculate overall encounter rates (groups / 100 man hours of observation) for different sites for each species. The data obtained out of monitoring for pheasant species and quantification of habitat variables were arranged into species-habitat parameters and site characteristic matrix for performing multiple regression analysis. For spatial analysis, abundance of different pheasant species was divided into low (0-20), medium (20.1-40) and high (>40) categories. The habitat attributes (tree cover, shrub diversity, herb diversity and herb richness) were used as base theme layer and abundance of different pheasant species was overlaid.
**HABITAT USE**

Discriminant Function Analysis (DFA) was applied for five pheasant species to separate them on the basis of habitat attributes and various disturbance factors in Kumaon Himalaya. Factor analysis was applied on habitat used (utilized) by each species. General vegetation sampling on the trails was considered as available (availability) habitat for pheasant species. Later logistic regression analysis was performed using extracted factor scores from the analysis to estimate the probability of correct classification of pheasant species plot (utilized) and general available habitat plot (available).

**FEEDING ECOLOGY**

The faecal matter (droppings) of Kalij, Koklass, Himalayan Monal and Satyr Tragopan were collected on the trails from Pindari reserve forest only. The collection was made season wise to compare difference in food items of these species. Major ground vegetation species were collected and identified from the places where droppings were found. A total of 40 reference slides of different plant species were prepared.

The prevalence of each food item was expressed as a Food Importance Index (Bhandary *et al.* 1986). By using the frequency and composition of food items the Food Importance Index (FII) was calculated by following formula,

\[ \text{FII} = \frac{\% \text{ Frequency} + \% \text{ Composition}}{2} \]

Kruskal-Wallis one-way ANOVA and t-test were performed (Zar, 1984) on different food items to observe significant difference among pheasant species season wise. Based on the composition of each food item identified from the droppings of pheasant species was categorized into three groups, 1) Major food components or those food items forming >10% of the total composition; 2) Minor food components or those
items forming <10% but >3% and 3) Trace items which formed <3% of the total composition.

SOCIAL ORGANIZATION

Chi-square goodness of fit was used to determine the differences in group composition between the seasons for both the intensive sites. Chi-square contingency test was performed to see the difference in either sex individual groups or the groups having both the sexes between the seasons. Groups of different species were also categorised as solitary, two or groups having ≥3 individuals and Chi-square contingency test was applied to observe the difference in the group size range between the seasons.

THREATS AND CONSERVATION STATUS

Trees were categorised arbitrarily into six GBH classes and height of fire was also categorized into eight classes. Tree species diversity and richness was calculated for different fire height categories and GBH classes. The Importance Value Index (IVI) for each tree species was calculated.

Percentage of overall dead trees and percent dead of each tree species was calculated for each fire affected patches. The Bonferroni confidence intervals were constructed following to detect significant differences in species-specific mortality pattern. Top five IVI ranking dead tree species and different GBH classes were taken into account for chi-square contingency test to pin point the association between the dead tree species and GBH classes while the same test was performed for top four IVI ranking dead tree species and different height categories to pin point the association between dead tree species and different height categories.
To generate threat index for all the surveyed sites, each threat parameter was converted into the ordinal scale ratings of low (1), medium (2), and high (3). All the converted ratings of threats were added together and then divided by number of threat parameters.

The surveyed sites were categorised, on the basis of generated mean threat score. A definite range of mean threat score was given to each threat category. The low threat category was taken between 0-1 mean threat score, the medium was between 1.1-2 and >2 was accounted for high.

Combined conservation value for Kalij, Koklass, Himalayan Monal, Satyr Tragopan and Cheer pheasant was calculated. Conservation value was also calculated for each surveyed patch on the basis of pheasant species composition. For this, six attributes were taken into consideration i.e. Altitudinal range occupied by each pheasant species in Kumaon, Extent of path size for species abundance, Degree of disturbance, Degree of restricted distribution of each species in Kumaon, Degree of endangerment for each pheasant species and Degree of legal status of the area provided to each pheasant species. Conservation value for each surveyed site was calculated by combining the conservation value of each species represented by the sites.

RESULTS

VEGETATION STUDIES

A total of 63 tree species, 56 shrub species, 90 herb species and 21 grass species were sampled in 23 oak patches of Kumaon Himalaya. Nineteen broad habitat types had been recognized in Kumaon. Total five homogenous groups in relation to environmental variables were identified.
DCA produced the extreme diversity of tree communities from low altitude to high altitude. Its first axis was altitude gradient, which represented ecological series from low altitude, middle altitude and high altitude communities. Axis 2 reflected shrub characters and canopy cover gradient. 17 broad communities of 52 shrub and herb species had been recognized by TWINSPAN, which identified major identical homogenous groups.

The tree density was significantly high at Gasi (995.2 ± 269.4) while shrub density was highest for Gager (24504.6 ± 11280.7). The tree layer was dominated by Rhododendron arboreum (3861.41 / ha). Myrcine africana (91299.86 / ha) was the dominant shrub species and it was maximum at Kunjakharak (13269.64/ha). Tree species diversity was maximum at Daphiadhura (1.53). Tree species richness was maximum at Daphiadura (1.76). Shrub diversity and richness were highest in Vinaiyak (1.61, 1.54).

**STATUS AND ABUNDANCE**

Five pheasant species were documented from the surveyed region.

**Whitecrested Kalij (Lophura leucomelana):** It was found at 14 sites out of 23 sites between the altitude range from 1660 - 2550m.

**Koklass (Pucrasia macrolopha):** The species was found to be most abundant and widely distributed among all the pheasant species found in Kumaon. The species was sighted or heard at 15-20 at sites between the altitudinal range from 1830 - 3180m.

**Cheer pheasant (Catreus wallichii):** This species was found to be the most threatened species among all the pheasant species occurring in the Kumaon Himalaya and the species was encountered at two sites only between the 2300- 2520m altitude range.
Himalayan Monal (*Lophura impejanus*): The species was seen between the altitude range from 2520-3300m. The Monal was encountered at four sites out of 23 surveyed sites.

Satyr Tragopan (*Tragopan satyra*): The species was seen at three locations in Kumaon with few encounters between the altitude range from 2280-3140m.

**HABITAT USE**

The analysis produced four functions DF1, DF2, DF3 and DF4 accounting for 100% variation between the species. The first discriminant function represented variation in altitude from low to high. The second function described vegetation components while function third represented areas from open to close canopy forest with simultaneously increase in percentage of cover in shrub layer. Kalij was distributed in the areas having low percentage of grass cover with enough herb density at low altitude. Koklass preferred areas having very low grass cover and abundant herb density at middle altitude. Cheer was associated with the areas having high percentage of grass cover with limited number of herbs at middle altitude while Satyr Tragopan was present in the areas with low percentage of grass cover at higher altitude. Monal was separated from the rest by holding areas having medium percentage of grass cover and medium herb density at higher altitude.

**Binsar Wildlife Sanctuary**

*Kalij*: During premonsoon season, PCA extracted seven components for Kalij. PC1 described high altitude, close canopy, mature forest with low rocky area having less grass cover, PC II was highly positively correlated with grass density, grass diversity, grass richness and herb diversity, herb richness and negatively correlated with tree richness and
PC III was related with low altitude, open canopy forest with high ground cover. These three components showed significant difference in the use of random and bird plots (PC I $U = 250$, $p < 0.004$; PC II $U = 214$, $p < 0.001$; PC III $U = 278$, $p < 0.01$).

Postmonsoon season PCA extracted 7 factors (72.32% variance). PC I described close canopy, high tree density, more shrub cover and shrub richness and more bare ground with less grass cover and grass density habitat. PC II explained more ground cover and low tree cover and less withered stone area. PC III explained close canopy dense forest with low percentage of herb cover.

**Koklass:** Eight components were extracted by PCA, which explained 82.66% variance for premonsoon season. First factor represented high altitude, more tree cover and shrub cover area with low grass density. II factor was associated with high grass density, diversity, grass richness and herb density with low tree richness. III factor again described more ground cover with less canopy cover habitat. U-test revealed significant difference in the random and bird plots on the basis of PC II.

Seven factors were extracted by PCA (71.90% variance) for premonsoon season. PC I described mature forest of high tree density and shrub density, shrub diversity and shrub richness with high litter cover and low grass cover. PC II had high positive loadings of grass density, grass diversity, grass richness and grass cover while negative loadings of tree cover and litter. PC III depicted the forest of high tree density and tree diversity with low herb cover on gentle slope. There was significant difference in available and utilized habitats by Koklass on the basis of PC III ($U = 576$, $p < 0.008$).
**Pindari Reserve Forest**

Koklass groups were encountered more in mixed habitat while groups of Monal were encountered maximum in oak-coniferous habitat. Satyr did not show any significant difference between different habitat types during premonsoon while during postmonsoon significant difference were observed. Koklass was seen more in mixed habitat while Monal was encountered more in oak-coniferous habitat during postmonsoon season also.

**Kalij:** Overall 9 factors were extracted by PCA, which accounted for 82.44% of variance for premonsoon season. The first factor described mature forest at low altitude and gentle slope with low grass diversity. II factor reflected the forest with high ground cover and low shrub cover at high altitude and III factor was summarized as low altitude, high shrub cover area with high tree richness at steeper slope.

**Koklass:** Six factors were extracted by PCA (70.05% of variance) for premonsoon season for Koklass. First factor depicted a high ground cover forest area. II factor was highly positively correlated with herb diversity, richness, density and shrub density and negatively correlated with slope and tree cover. III factor represented low altitude area with high tree diversity and richness. PC I was significant suggesting that there was significant difference in the use of habitat variables in the random and bird observed plots.

First three factors explained 43.92% variance for postmonsoon season. First component described high herb cover, herb density, grass density, cover and low tree cover, density and litter. II factor summarized high herb and grass density, diversity and low shrub richness and rock cover. III factor represented forest areas at lower altitude having high tree diversity and richness. U-test also revealed that significant difference in
the use of habitat variables in the random and bird observed plots on the basis of PC I and PC II.

**Monal:** PCA extracted six components, which explained 71.43% variance. The first three components explained 50.68% variance for Monal for premonsoon season. First component represented forest areas at low altitude having high tree diversity, richness and density. II component represented areas with low altitude, high ground cover and dense and rich shrub cover. III component described high ground cover and low litter. U-test showed significant difference in the random and Monal observed plots on the basis of PC I, PC II and PC III.

During postmonsoon season, PCA extracted seven components, which accounted for 73.89% of variance. PC I summarized the forest areas at low altitude, high ground cover and low shrub cover with gentle slope. PC II showed high positive loading of tree cover, density and litter while negative loading of grass density, herb density and shrub richness. PC III represented areas with high ground cover with low shrub density and litter. Mann-Whitney U-test showed significant difference in the use of habitat variables in the Monal observed and random plots on the basis of PC I (U = 38, p < 0.00) and PC II (U = 268, p < 0.001).

**Satyr Tragopan:** PCA extracted seven components (75.27% of variance) for Satyr Tragopan for premonsoon season. The first factor represented low altitude forest with high tree density and litter and low ground cover. II factor explained the forest with high ground cover with low litter and III factor represented low altitude, steep slope and high shrub density, shrub cover and shrub richness. U-test revealed significant difference in the use of habitat variables on the basis of PC II (U = 255, p < 0.00).
During postmonsoon season, PCA extracted eight components, which accounted for 78.58% of variance. First component described the forest areas with high ground cover and low tree cover, tree density and litter. II component represented high ground cover and lower shrub area at lower altitude. III component seemed to be a wooded forest with high tree diversity and richness on low altitude. The use of the PC II (U = 51, p < 0.00) showed significant difference in the use of habitat variables in the random and bird plots.

**FEEDING ECOLOGY**

Total 38 food items were identified in Kalij, Koklass, Himalayan Monal and Satyr Tragopan from faecal matter. Out of these 38 items, 36 were plant materials whereas rest were grit and invertebrates.

Total 11 food items were identified from the droppings of Kalij during premonsoon season and postmonsoon seasons. No significant difference occurred in composition of different food items identified for premonsoon season (F = 1.82, d.f. = 10,100, p > 0.07) but significant difference (F = 5.13, d.f. = 10, 100, p< 0.00) in composition of different food items occurred in Kalij droppings during postmonsoon season. The occurrence of invertebrates during premonsoon and postmonsoon was not significant whereas other food items were significantly different during seasons.

A total of 14 food items were identified from the Koklass dropping during premonsoon season while 15 food items were identified for postmonsoon season. Significant difference in different food items in premonsoon season (F = 5.31, d.f. = 14, 135, p < 0.00) was observed.
A total of 13 food items were identified during premonsoon season in the droppings of Himalayan Monal. Significant difference in different food items obtained from the faecal analysis of Monal \((F = 5.22, \text{d.f.} = 12, 126, p < 0.00)\). Out of 13 food items of Monal, the percent composition of three of them fluctuated in both the seasons.

A total of 17 food items from were recorded from the faecal droppings of Satyr collected in postmonsoon season. Fifteen of these were plant material. Significant difference was observed in various food items \((F = 2.54, \text{d.f.} = 15, 144, p < 0.002)\).

Sorenson's similarity index showed the highest similarity between the food composition of Koklass and Satyr \((SI = 0.64)\) while Kalij and Monal were least similar in their diet composition \((SI = 0.17)\).

Grit and invertebrates were the common food items in all pheasants in both the seasons. Significant difference in the percent composition of invertebrates was found in all pheasants \((F = 3.78, \text{d.f.} = 3, 36, p < 0.018)\) during premonsoon season and postmonsoon season \((F = 14.7, \text{d.f.} = 3, 36, p < 0.00)\). The percent composition of grit was not significantly different in all pheasants in both the seasons.

**SOCIAL ORGANIZATION**

**Binsar Wildlife Sanctuary**

**Kalij:** Overall 66 separate groups of Kalij were seen during premonsoon season. The overall mean group size was 2.31. More solitary birds than individuals of two or three in a group were encountered. The overall sex ratio was 150 males / 100 females. No significant difference \((\chi^2 = 0.533, \text{d.f.} = 2, p > 0.05)\) was observed between all male groups, all female groups and the groups having both sexes between premonsoon and
postmonsoon seasons. The sex ratio was 137 males / 100 females during postmonsoon season.

**Koklass:** Overall 13 groups comprised all male individuals and 7 groups had all female individual groups and on 11 occasions they were found together. No significant difference ($\chi^2 = 1.9$, d.f = 1.9, $p > 0.05$) was observed across the season in the groups having all males, all females or mixed individuals. The overall sex ratio was 115 males / 100 females while it was 175 males / 100 females during premonsoon season with equal sex ratio during postmonsoon season.

**Pindari reserve forest**

**Kalij:** A total of 6 sightings comprised all male individual groups, 5 groups contained all females and 13 groups had mixed individual groups. The group size for postmonsoon season was 2.25. Equal sex ratio (1:1) was observed across the seasons.

**Koklass:** Overall 33 groups had all male individuals, 23 groups had all females in their groups and 51 groups had both the sexes. The overall group size was 1.7. Koklass formed more groups having $\geq$3 individuals during premonsoon while they preferred to form solitary or two individuals in their groups during postmonsoon season. The sex ratio of the area was 105 males / 100 females.

**Himalayan Monal:** Overall 23 groups had all male individuals in their groups, 6 groups were all female groups and 12 groups contained mixed individuals. Overall significant difference ($\chi^2 = 10.91$, d. f = 2, $p < 0.05$) was observed in the encounters with either sex groups or with mixed individual groups. The overall mean group size for the area was 1.7 while it was 1.4 for premonsoon season and 2.2 for postmonsoon season. The overall sex
ratio for the area was 214 males / 100 females, which differed significantly between the seasons.

**Satyr Tragopan:** 13 groups comprised 4 groups of all male, 6 all females groups and 3 groups represented both sexes. Overall mean group size for the area was 1.4. The overall sex ratio for the species was 100 males / 100 females.

**THREATS AND CONSERVATION STATUS**

In the burnt patches, maximum mean density of tree species was quantified for Jageshwer and minimum for Daphiadhura. Maximum regeneration of different tree species was observed at Daphiadhura while minimum in Binsar. Tree species diversity and richness was maximum at Jageshwer while minimum diversity and richness was in Binsar.

Maximum tree species mortality (48.37%) was observed for *Quercus leucotricophora* and minimum mortality (0.001%) in case of *Pyrus pashia* Binsar WS. The maximum IVI (95.51) was accounted for by *Quercus leucotricophora* and considered as the most dominant tree species. The minimum IVI was calculated for *Euonymous* species (2.93). While at Daphiadhura (AWS) *Quercus lanuginosa* had the maximum IVI (120.3), while minimum IVI (4.85) for *Myrica esculenta*, *Quercus floribunda* etc.

Significant difference was observed between GBH classes of dead trees ($F = 33.85$, d.f $= 5, 20; p < 0.01$) in BWS. Significant difference was also observed in the dead trees of different tree species ($F = 5.28$, d.f $= 4, 20; p < 0.01$). The highest mortality was found in the GBH class 0-25 cm and maximum mortality was found in 0-26 cm GBH class for *Viburnum mullaha* and least mortality was found in >51 cm for *Lyonia*
**ovatifolia** in BWS. In Daphiadhura the result was not significant for top five IVI ranking tree species ($\Sigma \chi^2 = 6.74$, d.f. = 6; $p > 0.06$).

Significant difference was observed between different fire height categories in the dead trees ($F = 4.3$, d.f. = 7, 28, $p < 0.01$) in BWS. Maximum mortality was found in >801 cm fire height category while it was least in <200 cm category. In Daphiadhura the category 801-1600 cm was most affected while in Jageshwer category >801 cm was most affected. *Viburnum mullaha* representing the fire height category 401-800 cm was most affected and the category >800 cm was least affected in the same species.

In BWS mortality of *Rhododendron arboreum* (18.79%), *Euonymous* sp. (0%), *Symplocos theifolia* (0%) and *Toona serrata* (0%) was significantly less than expected according to availability while other species had significantly higher mortalities than expected. *Quercus lanuginosa* (18.85%) in Daphiadhura, *Pyrus pashia* (0%) and *Litsea umbrosa* (0%) in Jageshwer had significantly less mortality than expected according to availability. But *Lyonia ovalifolia* (72.42%) had significantly more mortality than expected in Jageshwer.

Total 18 regenerating tree species were encountered in BWS. Maximum regeneration was accounted for by *Swida oblonga* (31.14%) and minimum regeneration (0.2%) was recorded for *Persea duthiei*. A total of nine and 12 regenerating (seedlings) tree species were found in Jageshwer and Daphiadhura respectively. Maximum regeneration was observed for *Quercus leucoticophora* (43.75%) at Jageshwer while *Quercus lanuginosa* (42.02%) at Daphiadhura. Minimum regeneration was observed for *Litsea umbrosa* (0.89%) at Jageshwer while *Pyrus pashia* (0.36%) and *Lindera pulcherrima* (0.36%) at Daphiadhura. 11 tree species at sapling stage were recorded from
Binsar. Maximum mortality was found in *Lyonia ovalifolia* (64.29%). Total eight and nine tree species (saplings) were recorded from Jageshwer and Daphiadhura respectively. Maximum mortality at Jageshwer was recorded for *Rhododendron arboreum* (60%). The maximum mortality observed for the *Lyonia ovalifolia* (26.31%) while minimum mortality was recorded for *Pyrus pashia* (0.58%).

The generated mean threat score for surveyed sites varied from 0.78 to 2.3. On this basis, the sites Jilling and Sunderdunga have fallen under low threats (0-1 mean threat score) while Binsar Wildlife Sanctuary, Sitlakhet, Jageshwer, Pindari, Gandhura (AWS) and Munsiary under high threats (>2 mean threat score) and rest of the sites had fallen under medium threat category (1.1-2 mean threat score). The regression coefficient of fuel wood collection was highly related with human population, land area available for different purposes and source of income through different means. The factors human population and source of income together accounted for 68.6% of variation in fuel wood collection (*F* = 21.86, *p* < 0.001).

The Satyr Tragopan was the highest ranked species followed by the Himalayan Monal and Cheer pheasant while Whitecrested Kalij and Koklass obtained least conservation status. None of the pheasant species in Kumaon were found in the category ‘substantial portion of the global range in the Himalayas’. The maximum conservation status was obtained for Pindari (3.76), followed by Wachham (3.16), Sunderdunga (2.55), Munsiary (2.55) and Vinaiyak (2.23). All the five species of pheasants were found in Pindari while the presence of Cheer pheasant at Wachham and Vinaiyak upgraded the conservation status of these sites. The localities such as Sitlakhet and Gasi were having
nil conservation status in terms of pheasants. Kilbery and Kunjakharak also had low conservation status by having Kalij and Koklass.

No significant relationship between pheasant species composition and threat index in spatial analysis was observed. Map showed that only Pindari had maximum pheasant species in spite of being a high threat area. While Binsar, Munsiary and Gandhura had medium species composition. Sunderdunga and Jilling had fallen under low threat category and also had medium species composition. Except Dhakuri, Sunderdunga, Pandavkholi, Maheshkhan, Jilling, and Sobala all patches experienced high threats in terms of set of threat parameters (cutting, lopping, grazing, grass harvesting, human & livestock population and surveyed forest patch size) experienced by each surveyed forest patch.