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Status, distribution and aspects of ecology of monal (*Lophorus impeyanus*) in Garhwal Himalayas, Uttarakhand, India

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Abstract
The Himalayan Monal (*Lophophorus impejanus*), state bird of Uttarakhand state is also the national bird of Nepal. The bird is of conservation priority species due to the nine coloured bird is distributed throughout the higher altitude of Himalayas and due to the bright coloured feather, they have been exploited for the feather as well as for the meat purposes. This species conservation priority species in its entire range because of its declining population due to anthropogenic threats. This bird is facing greatest threat of extinction due to poaching and habitat degradation. Out of the 17 species of Pheasant that occur in India are protected from capture by national and international legislation. Due to decrease in population they have been recognised as Schedule I species of Wildlife Protection Act (1972). However, it is highly desirable that status, distribution, and threats to conservation of monal pheasant should be given due importance. To understand the status distribution and habitat preference of the monal an intensive study was carried out. Surveys were conducted at 6 high altitude sites in Garhwal Himalayas including Kedarnath Wildlife sanctuary and the Nanda Devi Biosphere Reserve, between the altitudinal range from 2500m to 4000m a.s.l. The direct as well indirect methods were used and found that the number of faecal group was found to be maximum in Himtoli (2.64±2.2) followed by Madh Maheshwer (0.96±1.29), Saukhark (0.75±1.4). For the direct sighting the maximum number of monal were sighted in Tungnath (0.26±0.59), followed by Bansinarayan (0.14±.43), Madh Maheshwer (0.14±0.44). No direct sightings were recoded from Himtoli. Due to illegal poaching and habitat destruction the population of monal pheasant has declined and now confined to a few small fragmented patches and needs urgent attention for the conservation.

Keywords: Himalayan monal, *lophophorus impejanus*, abundance, habitat use, Garhwal Himalayas

Introduction
The Himalayan Monal, (*Lophorus impejanus*) is a pheasant of Phasinidae family and the national bird of Nepal and sate bird of Uttarakhand. The nine coloured bird is distributed throughout the higher altitude of Himalayas and it is conservation priority species in its entire range because of its declining population due to anthropogenic threats. This bird is facing greatest threat of extinction due to poaching and habitat degradation. The species distributed throughout the timber line from east to west Himalayas at an altitudinal range from 3000m to 4500m has been confined to small fragmented forests. Out of the 17 species of Pheasant that occur in India are protected from capture by national and international legislation. Due to decrease in population they have been recognised as Schedule I species of Wildlife Protection Act (1972).

The bulk of these pheasant species are endemic to the Himalayan range (Sathyakumar *et al.* 2011) [9], and they are most plentiful in the intermediate and high altitude valleys. They are extremely sensitive to anthropogenic disturbance and habitat degradation (Fuller & Garson, 2000) [6], making them bio-indicators. They also serve as a prey base for carnivores, birds, and mammals Johnsgard (1986) [8]. The Himalayan monal mostly occupies the upper temperate forests of conifer and oak with open grasslands slopes between the elevational ranges of 2400 – 4000 m Grimmett *et al.* (1998). The information available on the species is very scattered and mainly from Protected areas. No information from outside PA is available, and those habitats are the best habitats (Pers communication).

Being listed in schedule I species of Wildlife (P) Act 1972 it is highly desirable that preliminary status, distribution, aspects of ecology and threats to conservation of monal pheasant should be given due importance. To understand the status distribution and conservation strategy an intensive survey was conducted at six sites of high altitude Garhwal Himalayas including Kedarnath Wildlife sanctuary and the Nanda Devi Biosphere Reserve. The data was collected in 2004 and now findings are being presented as the base line data with the aim for the researcher to compare with the present time data to assess the decline/ increase in the population in the above said region.

Study area

To study the status, distribution and conservation status of Monal pheasant six sites were surveyed in Garhwal Himalayas during pre-monsoon season of 2004. The study was confined to the altitudinal range from 2500m-4500m. Since the monal is a territorial bird and belongs to family phasinidae, they do not go far from their territory. Along this range the protected area biosphere reserve and reserve forest were surveyed. Following are the surveyed site:

Kedarnath wildlife sanctuary

Kedarnath Wildlife Sanctuary is situated in Gopeshwer the revenue circle of Chamoli district of the Garhwal Himalayas. The area of the sanctuary is about 975 sq.km. During survey following areas with population of monal pheasant were covered.

(I & II) Mulakhark and Bansinarayan

The two areas are situated in the Joshimath the revenue circle of Chamoli district and are continuous patch and very good habitat for the monal and other many important pheasant species. Mulakherk is 2km far from the nearest village Basa. While Bansinarayan is 6 km far from the Mulakhark. The forest is dominated with *Quercus semicarpifolia* forest and *Thalmocalmus* (Rigal) species.

(iii) Madh Maheshwer

The Madh Maheshwer is the part of Kedarnath Wildlife Sanctuary and the altitude of the Madh Maheshwer is around 3800m from sea level. It is a pilgrimage for the people. The motor able road is only upto Unyana and from Unyana one has to trek at least 24 km to reach to Madh Maheshwer passing through different villages ie. Rasi, Gonar, Khatara and Nanu.

(iv & v) Saukhark and Tungnath

Saukhark and Tungnath are the part of the Kedarnath Wildlife Sanctuary. Saukhark is 1.5 km far from the motor able road. The 2.5 sq km area has good forest with dominated tree species such as *Quercus floribunda, Quercus semicarpifolia*, *Betula utilis* and *Rhododendrom companulatum* species. Tungnath is 3 km far from the motor able road in Chopta as well as from Saukhark it is 1.5 km far. It is a Hindus pilgrimage, and area is dominated with *R. companulatum*, *Betula utilis* and *Abies pindrow* forest.

(vi) Nanda devi biosphere reserve

Nanda Devi Biosphere Reserve (30°05'-31° 02N Latitude, 79°12-80°19'Longitude) is located in the northern part of the west Himalayas in Biogeographical classification zone 2B. The reserve is spread over Chamoli district in Garhwal and Bageshwar and Pithoragarh district in Kumaon in Uttaranchal state. It has wide altitudinal range (1800-7817m). It covers an area about 5860.69sq km area with core zone (712.12km²), buffer zone (5,148.57km²) and transition zone 545.34km²). The buffer zone is inhabited by 47 villages, whereas transition zone is inhabited by 52 villages. Himtoli was surveyed for the status survey of musk deer. Himtoli is 6 km far from Suraithota, nearest town in Joshimath of Chamoli district.

Vegetation structure

The selected altitudinal ranges are very close to the glaciers, and being very close to many glaciers the area experience extreme weather conditions. The vegetation of the area is moist temperate type (Champion & Seth, 1968) [4]. The major tree species in the study area included *Quercus semicarpifolia, Quercus floribunda, Abies pindrow, Taxus baccata, Betula utilis* in association with *Rhododendron barbatum, Acer* sp. *Lyonia ovalifolia, Alnus nepalensis, Aesculus indica*. The dominant shrub species included *Arundinaria* species, *Athyrium* sp, *Polystichum, Pteris* species, *Arjimon, Nerium* and Pyracantha species etc.

Methodology

(a) Status, distribution and abundance

The data on status, distribution and abundance of monal was collected by quantification of direct and indirect evidences at the surveyed sites in Garhwal Himalayas. Trail were monitored during early morning hours.

(b) Habitat utilisation

Intensive data on the habitat use pattern was collected on the line transects. Monal fecal droppings was found to be the best indicators for the habitat use in a given habitat. The fecal matters were identified on the basis of shape and size. The line transects was laid in different selected forest patch. The droppings were counted in 10m radius circular plot at every 100m distance on the line transects. Along with the dropping the habitat data were also assessed at each 10m radius circular plot. Tree species and their individuals were assessed in 10m radius circular plot for density, diversity and species richness estimation at each plot. Tree cover was measured at four points around the sampling plot using a mirror of 25 X 25 cm, divided in 100 equal grids. The mirror was kept horizontally at 1.25 m above the ground level and grids covered more than 50% by tree foliage was counted and converted into percentage tree cover.

Shrub species and their individuals were counted in 3m radius circular plot. Shrub height was measured using a measuring tape and shrub cover was measured by ocular estimation using an ordinal scale of 0-5 with 0 representing no shrub cover and 5 representing maximum shrub cover. Tree species seedlings and the saplings were also measured in 3m radius circular plot.

The grass and herb composition were quantified by laying four quadrates of 0.50 x 0.50m dimension at four different locations around the plot and all grass and herb species and their individuals were counted. The ground cover was estimated by point intercept method (Canfield 1941) [3]. A meter tape will be laid on the ground in four directions and intercepting materials (herbs, grass, litter, bare ground, weathered stone and rock) will be recorded at 5 cm interval. All these data would be analysed following Zar (1984) [12] and

analysis would be performed using computer program SPSS (Norosis 1992).

(c) Threat assessment

Number of cut trees, lopped trees, cattle dung piles, grazing signs and evidence of fire will also be recorded in 10m radius circular plot for assessment of general disturbance in Garhwal Himalayas. Questionnaire survey were carried out to assess the intensity of illegal killing of the bird is going on in Garhwal Himalayas. All these data were analysed following Zar (1984) [12] and analysis would be performed using computer program SPSS (Norosis 1992).

Data analysis

The diversity and species richness of trees, shrubs, and grasses for each plot were calculated by Shannon-Weiner diversity Index (*H'*) and Margelefs richness index (*RI*) by using the following formulae: *H*' = - ∑pi x log pi and *RI* = S-1/In N, Where pi is the proportion of i^{th} species in sample, S is the number of species in sample and N is the total number of individual.

The number of fecal droppings of the monal in each plot were used to calculate dropping density (Faecal dropping/ha) for monal in each plot along with the standard deviation.

To understand the habitat, use by monal, data were subjected to Principal Component Analysis (PCA). All the quantitative data in the data matrix were transformed using Log and Arcsine transformation and were standardised following Zar (1984) [12]. Factor analysis was used to reduce the dimensionality of the habitat variables. The first two factors were used for interpretation as these explained maximum variation in the data set. Before using PCA most of the auto-correlated variables were dropped. PCA was performed using *Varimax* rotation and factor scores were saved. Extracted factors were subjected to Pearson Product Moment correlation analysis with habitat variables to find out significant correlations between habitat variables and factors. Availability and utilized plots were plotted in two-dimensional space defined by PC I and PC II. All the extracted factors with *Eigen* values of more than one was saved and used for the logistic regression analysis. Logistic regression was done on the random and animal centered plots. One way Analysis of variance (ANOVA) was performed on the Qualitative and percentage data to find out the significant differences between the Monal faecal groups Vis a habitat parameters.

Results and Discussion

Status and Distribution

The trail transects were traversed and for direct sighting and Indirect faecal group count. The faecal droppings were recorded in 10m radius circular plots at either sides of the trail transects. The maximum faecal group density was recorded from Himtoli (81.74±12.92) followed by Madh Maheshwer (28.72±5.58) as these sites are comparatively less disturbed while minimum faecal density was recorded from Mulakherk area (3.18±3.18), may be because of high anthropogenic pressure. The results were found to be significant (F5 172=10.81 p<.000). The post host Shiffies test shows that all the sites differ significantly from each other (table 1).

Table 1: Direct and indirect evidences of musk deer in surveyed sites of Garhwal Himalayas, Uttaranchal during pre-monsoon 2004

Site code & Site name	District Status	Altitudinal Direct range	Fecal group sighting density ± SE
Tungnath	Chamoli KWLS	3200-3500 4	6.36±3.4
Saukhark	Chamoli KWLS	3000-3400 1	25.02±5.15
Madh Maheshwer	Chamoli KWLS	2500-3500 8	28.72±5.58
Himtoli	Joshimath NDBR	3000-3600 6	81.74±12.92
Bansinarayan	Chamoli Van Pchyat	3200-3800	9 22.29±6.5
Mulakhark	Chamoli Van Pchyat	2500-2800 3	3.18±3.18

Habitat use by monal at different surveyed sites of Garhwal Himalayas: The first three principal components accounted for 49.46% of variance in data matrix (Table 2). The first factor was highly positively correlated with Shrub density (r=.934 p<.01), Altitude (r=0.927, p<.01), Shrub height (r=0.91, p<.01) and tree cover (r=.844, p<.01). The second factor was positively correlated with natural tree falling (r=.664, P<.01), Sapling density (r=.661, P<.01), seedling density (r=.631, p<.01) and burnt and unburnt area (r=.567, p<.01). The third factor was found to be positively correlated with grazing (r=.845, p<.01), cattle dung (r=.770, p<.01) and tree lopping (r=.714, P<.01). Figure 1 shows the distribution of utilized and available plots in relation to first, second and third principal component. The figure 1 shows that the monal prefers the habitat with low shrub density, low to medium altitude, low to medium shrub height and low to medium tree cover with areas having naturally fallen trees with medium tree sapling and seedling density, They also prefer the areas where the effect of fire is medium since they have many new plants growing. Monal avoid the disturb areas as third factor is showing that the species is avoiding the areas with grazing, cattle dung and tree lopping.

Figure 2 shows that among different altitudinal range the mean faecal density of monal was recorded from the medium to high altitude range but the results were not found to be significant (F2 175=0.2 p>.819). Figure 3 shows the mean faecal group density at different cover categories Monal prefers the area with low tree cover, medium shrub cover but high ground cover, and the result was found to be significant only for ground cover (F3 174=4.17 P<.01) and for tree cover and shrub cover results were not found to be significant (F3 174 =.181 p<.696 and F3 174= .297 P>.827 respectively)

Figure 4 shows that the monal prefers area with very high slopes (>60°) (43.22±11.49) but the results were not found to be significant (F2 175=1.62 p>.201). While figure 5 shows the fecal density at different habitat and it was found that the faecal density was found to be maximum at Oak forest followed by alpine meadows (42.61±5.9 and 33.83±8.3 respectively), but the results were not found to be significant (F4 173=2.30 P>.06).

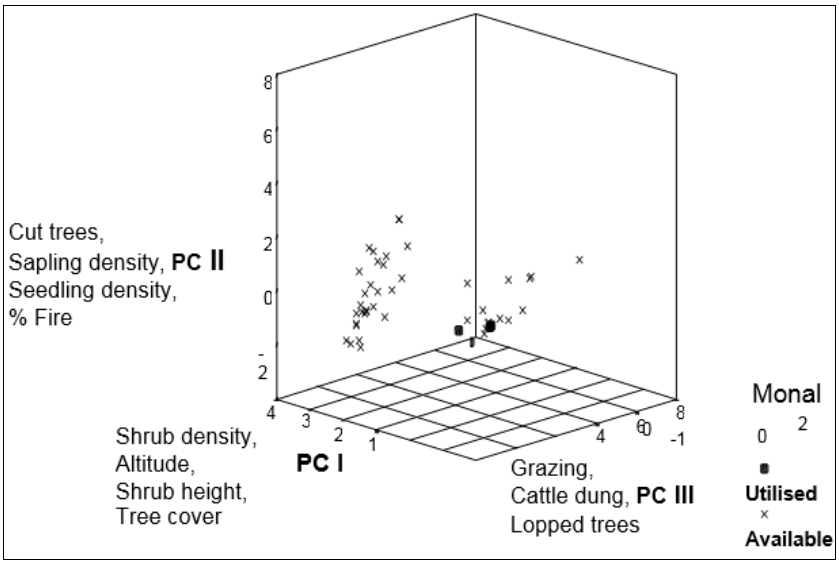

Fig 1: Ordination of available and utilized plots of Monal in surveyed sites of Garhwal Himalayas

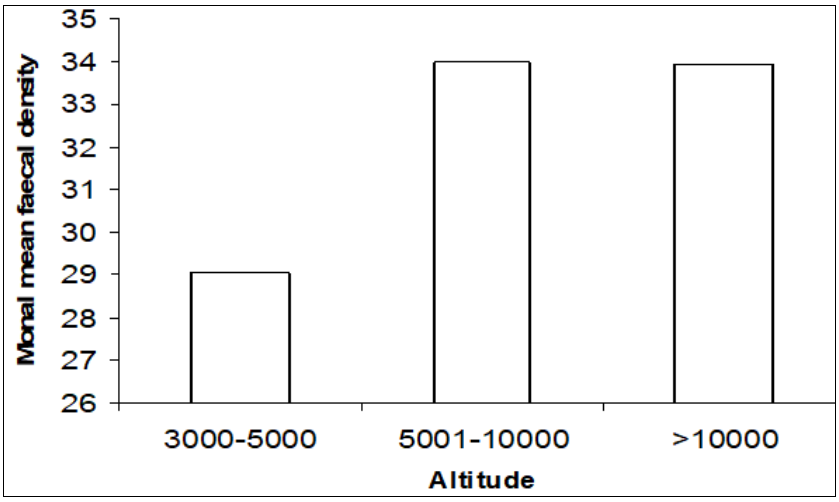

Fig 2: Mean fecal density/ha of Monal at different altitudinal zones

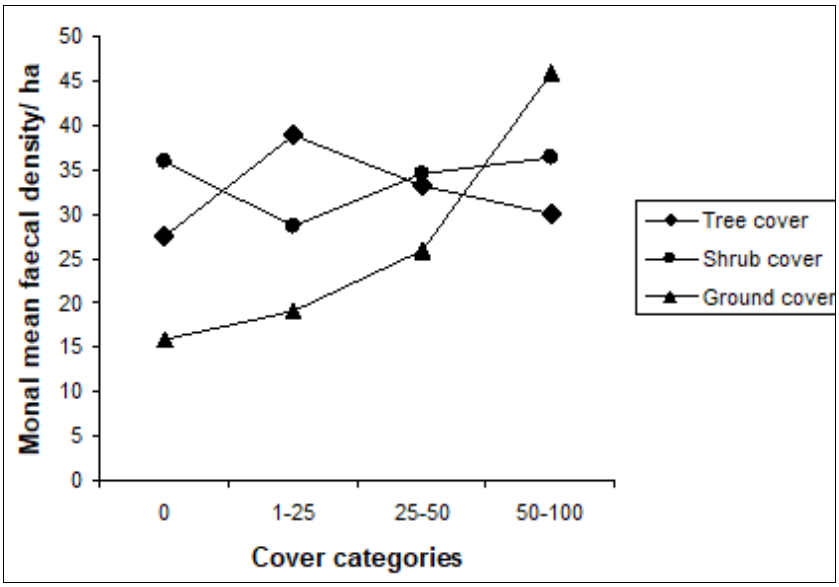

Fig 3: Mean fecal density/ha of Monal at different tree, shrub and herb cover categories

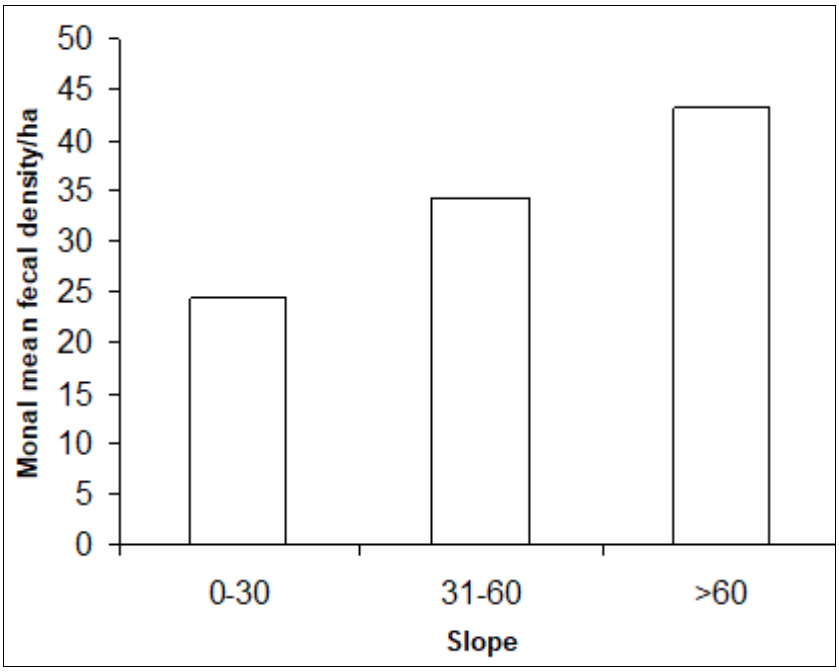

Fig 4: Mean fecal density/ha of Monal at different slope categories

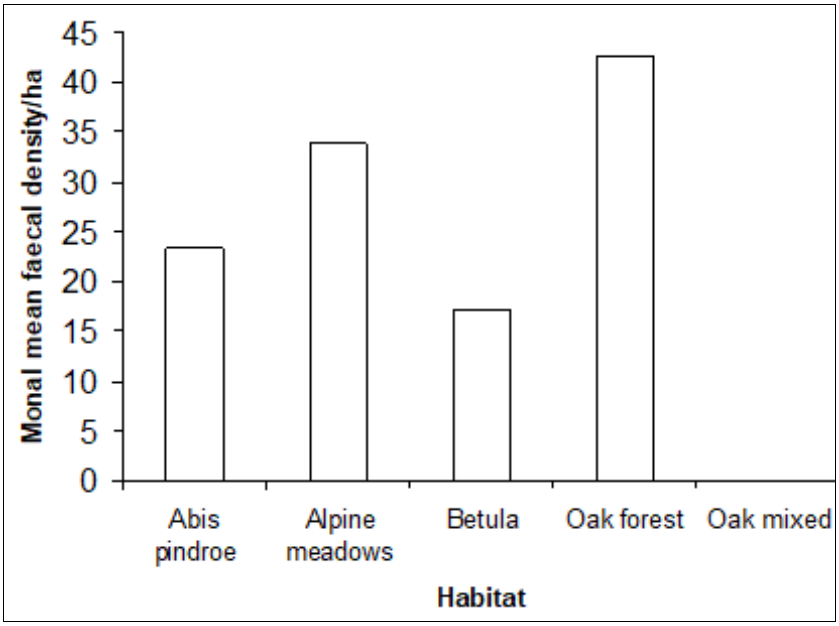

Fig 5: Mean fecal density/ha of Monal in different habitats at surveyed sites of Garhwal Himalayas

Table 2: Principal component analysis of fecal group of Monal in different surveyed sites in Garhwal Himalayas

Variables	PC I	PCII	PCIII
Altitude	0.927	0.305	0.0846
Slope	0.463	0.091	-0.068
%Tree cover	0.844	0.147	0.019
Tree density	0.908	0.326	-0.088
Seedling density	0.437	0.631	-0.139
Sapling density	0.447	-0.661	-0.175
%Shrub cover	0.227	0.280	-0.236
Shrub height	0.910	0.035	-0.062
Shrub density	0.934	0.096	-0.076
Herb density	0.829	0.298	-0.019
%Grass cover	0.338	0.082	0.026
Grass density	0.610	0.381	-0.087
Grass diversity	-0.208	0.052	-0.054
%Rock	0.0054	0.068	0.025
%Littre	0.639	0.0009	-0.178
%Grass	-0.0139	-0.078	0.012

%Herb	0.165	0.066	0.0524
%Bare ground	-0.007	0.178	0.116
Tree cut	0.284	0.664	0.218
Tree lopping	-0.143	0.135	0.714
No of Cattle dung	-0.091	0.77	-0.075
%Grazing	-0.038	0.845	-0.112
% Fire	0.465	0.567	-0.079
Distance from nearest human habitation	0.830	0.338	-0.143
Percent variation	30.94	9.8	8.7
Percent Cumulative variation	30.94	40.76	49.46

Threats or Disturbance Factor for Monal in Different Surveyed Sites: Among the different disturbance factor the table 3 shows that the tree lopping as well as tree cutting was found to be maximum in Mulakhark (1.9±.8226 and 1.0±0.25 respectively), No of cattle dung was found maximum in Tungnath (1.33±.45) and proportion of grazing was recorded maximum in Mulakhark (28±11.13). Effect of forest fire was recorded from two sites only i.e. Himtoli and Mulakhark and maximum was recorded from Himtoli (26.5±4.2).

Table 3: Disturbance factor at different surveyed sites of Garhwal Himalayas

Habitat	Tungnath	Saukhark	Madhmaheshwer	Bansinarayan
Lopped trees	0	0	0.16±0.08	0.03±0.03
Tree cutting	0	0.07±0.05	.22±0.077	.3±.15
Cattle dung	1.33±.45	0	0.36±0.12	0.13±0.13
Fire	0	0	0	0
%Grazing	23.3±6.2	0	11.92±2.4	1.16±0.74

Discussion

Of the three species of Monal pheasants found in India, the Himalayan Monal is distributed from the west to east of the Himalayan range. The Himalayan Monal or the Monal Pheasant as it is more commonly called is among all the Himalayan pheasants, the bird with undoubted Himalayan credentials. It is rightly called the Himalayan Monal in view of its widespread distribution across the Himalayas from Afghanistan and Pakistan in the west to Arunachal Pradesh in the east within India, besides being found in Tibet, China, Bhutan, Nepal and Myanmar (Ali & Ripley 1987) [1].

This survey was conducted from East to west at the altitudinal range from 2500m to 4000m in protected and non-protected areas. The maximum sighting was recorded from Bansinarayan and Madh Maheshwer, while indirect evidences were recorded from all the sites though it was very less from the Tungnath and Mulakher, may be because of the high tourist pressure as these sites are the pilgrimage as well as the tourist attraction sites. However, the PCA results shows that they avoid the disturbance such as tree cutting, lopping, grazing and fire. Among the altitudinal range they prefer medium to higher altitude with high slopes and high tree cover. Beebe (1992); Hussain & Sultana (2013) [2, 10] also highlighted that habitat preference of the species is positively influence by the slope. It is quite plausible that Himalayan monal is preferring steeper slopes for roosting as a strategy to escape depredation by carnivores and also steeper slopes to avoid anthropogenic disturbances. The oak forest (*Quescus semicarpifolia)* very close to timebr lines and Alpine meadows are the most preferred habitat as they are mostly found near the timber lines with steep slopes and it was reported by Delacour (1977) [5] also. It has been observed that Himalayan monal exhibited with seasonal migration along with the altitudinal gradient Gaston & Garson (1981) [7] mostly distributed at altitudes between 2620 m and 3350 m in summer and between 2000 m and 2800 m in winter, with relative preference to the sub-alpine oak forest in spring and conifer, dominated forest during winter Ramesh 2003 [11].

Though Himalayan Monal is listed among the Least Concern species under IUCN 2022, but has been provided maximum protection as Schedule I of WPA 1972 considering the threats species is facing because of illegal poaching and habitat loss. The populations of this spectacular bird is declining throughout its distribution range because of different anthropogenic threats (Ramesh 2003) [11]. However, the different aspects of ecology of Himalayan Monal has not explored. This is the high time that we should further study the species in its distributional range to understand the ecology and biology of the species and assess the threats including the intensity of poaching. Recommendation are suggested to strengthen the protection of the existing protected areas, and more areas should be included for the better management of the species

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