Status, distribution, and threats of Himalayan Monal (*Lophophorus impejanus*) in Sagarmatha National Park

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This study was conducted to assess the population status, distribution, and threats of Himalayan Monal *(Lophophorus impejanus)* in Sagarmatha National Park from February to June 2022. The study area was divided into five blocks- Namche, Furte, Syangboche, Mislung, and Kyangjuma. Population was estimated by using the line transect method. Bird survey was conducted two times in each transect during the study period. Similarly, bird distribution was determined by direct evidences such as bird sightings, ground scratching marks of the birds, their feathers and fecal matter, and indirect evidences such as information from the locals and park staff. The Digital Elevation Model (DEM) was used in the feature digitization of slope, aspect, and elevation to show the bird distribution. A semi-structured questionnaire survey was conducted to assess the threats. Altogether, 67 Himalayan Monal birds consisting of 48 male and 19 female individuals were recorded. The pheasants were distributed in all the blocks, preferably in the pure pine forests with different aspects and slopes within 3250 m and 4021 m altitude above the mean sea level. The overall population density was found to be 4.69 birds/km^2. The highest density (7.26 birds/km^2) was recorded in the Namche Block, followed by the Furte Block (7.05 birds/km^2). Habitat degradation, free-ranging dogs, and human disturbance were the major threats to Himalayan Monal.

Keywords: Degradation, elevation, habitat, and population density

Himalayan Monal (*Lophophorus impejanus*), commonly known as 'Danphe,' is the national bird of Nepal and the state bird of Uttarakhand State of India. The species belongs to the family 'Phasianidae' under the order 'Galliformes' of birds and is native to Afghanistan, Pakistan, India, Bhutan, China (Mainland), Nepal, and Myanmar (Birdlife International, 2022). It is a highly recognized pheasant species in the western Himalaya due to its striking sexual dimorphism (Ramesh *et al*., 1999; Ramesh, 2003). Long crest and metallic blue, copper, purple and green plumage are observed in adult males, whereas females have a more subdued appearance with brownish-black feathers (Figure 1). The species feeds on grass and flower seeds, berries, shoots, tubers, insects and grubs, mainly by digging with its strong bill, and can dig deep in snow if necessary (Ali & Ripley, 1987).

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Figure 1: Himalayan Monals (one with sparking colors being male and another with non-sparking color being female) sighted in the SNP during field survey

The species prefers the oak-conifer forests in upper-temperate regions and oak forests in sub-alpine regions, combined with steep, grassy and open rocky slopes, cliffs and alpine meadows between 2400–4500 m elevation, mostly concentrating in a narrow belt between 2700–3700 m (Grimmett *et al*., 1998). The species has been recorded near the tree line of oak forests between 2600–3200 m in Azad Jammu and Kashmir (Ahmed *et al*., 1999; Qureshi *et al*., 1999; Sabir *et al*., 1999). Moreover, the species has been recorded between 2620–3350 m and 2000–2800 m during summer and winter respectively in the Great Himalayan National Park of India (Ramesh *et al*., 1999). However, the distribution is wider (2700–4000 m) for Pakistan (Mirza, 1978; Roberts, 1991). In Nepal, the pheasant is common in high-altitude protected areas and can be observed between 3300–4570 m in summer and down to 2500 m in winter (Grimmett *et al*., 2016). It is mainly found in rocky forests, dispersed with steep slopes, cliffs and alpine meadows between 3800–4000 m in Tibet, China (Xiaochun et al., 2011).

The legal status of Himalayan Monal in Nepal is 'Protected' (Appendix I) under the National Parks and Wildlife Conservation Act 1973 and 'Appendix I' in CITES law (DNPWC and BCN, 2018). It has been nationally assessed as 'Near threatened' and globally as 'Least Concern' (DNPWC, 2022). The global population size of Himalayan Monal has not been quantified (Birdlife International, 2022). However, in Nepal, its population is estimated to be between 3500–5000 (Inskipp *et al*., 2016). The population of Himalayan Monal is declining throughout its distribution range because of various anthropogenic threats such as poaching, habitat destruction, livestock grazing, mushroom collection, egg stealing, fire and predation by domestic dogs (Ramesh *et al*., 1999). In Nepal, the species is seriously threatened due to pressure from hunting, trapping for food and live trapping for cage bird trade (Inskipp *et al*., 2016). Moreover, climate and land cover changes are likely to impact the habitat of Himalayan Monal by 2050 in the Gandaki River Basin (Rai *et al*., 2020). There has been relatively limited research on Himalayan Monal in Nepal though it is the national bird and the information is not sufficient to ensure the long-term conservation of the species in its natural habitat. Sagarmatha National Park (SNP) is the potential site for this species, but the information on its distribution pattern and conservation threats is missing due to the lack of scientific research and proper regular monitoring. Thus, this study was conducted to assess the population status, distribution, and threats of Himalayan Monal in the SNP.

Material and methods

Study area

Sagarmatha National Park is situated in the north-eastern mountain region of Nepal, covering an area of 1148 km^2 in the Solukhumbu District

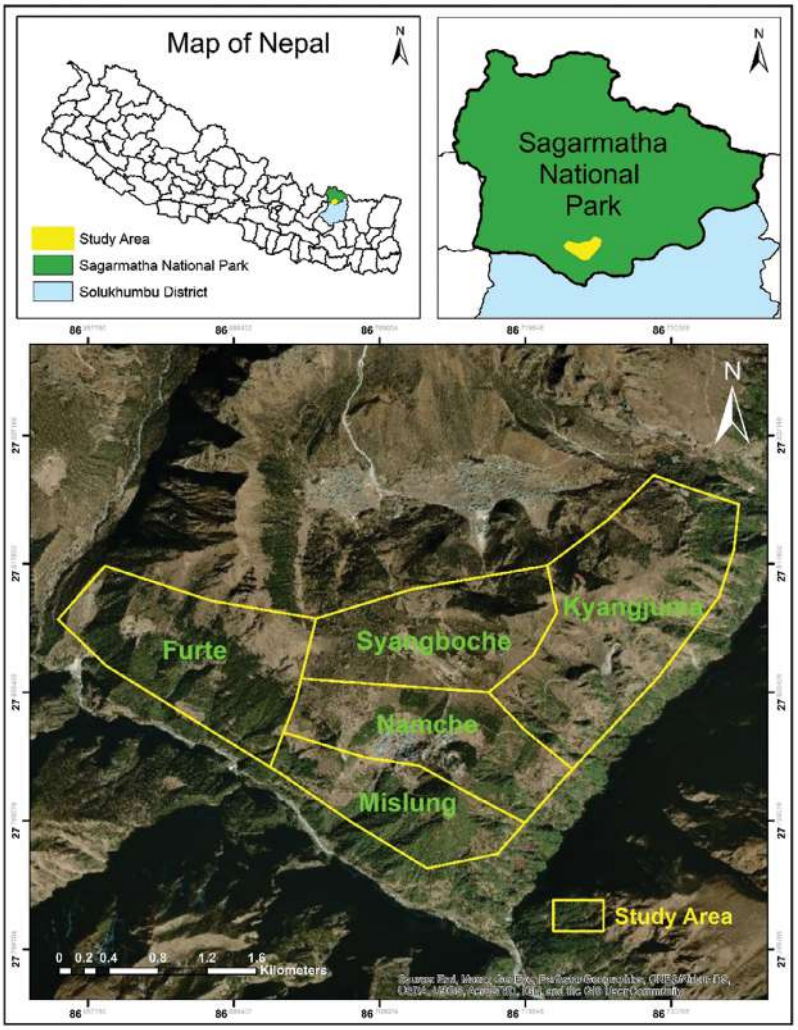

Figure 2: Map showing the location of the study area with different blocks

(Figure 2). The park elevation spans from 2845 m at Monju to 8848.86 m at the summit of Mount Everest between 27°45'–28°07' N and 86°28'–87°07' E. The core area of the park covers Ward 4 and 5 of Khumbu Pasanglhamu Rural Municipality. The park has been inscribed as a 'World Heritage site' by the UNESCO for its diversified aesthetic, scientific, and cultural values. The park is rich in biodiversity and is home to several rare species, such as Snow Leopard (*Panthera uncia*), Musk Deer (*Moschus chrysogaster*), Red Panda (*Ailurus fulgens*), Himalayan Monal, and many more. It is a well-known destination for mountain tourism, with over 2500 Sherpa people living within the region (UNESCO, 2022). Pine and hemlock forests cover lower altitude of the national park, whereas high altitude tree species include juniper, fir, birch, and rhododendron. *Pinus wallichiana*, *Betula utilis*, *Juniperus recurva*, *Abies spectabilis*, *Rhododendron arboretum*, and *Tsuga dumosa* are the dominant tree species. The park exhibits a temperate to arctic climate: generally moist and cool summer and cold, dry, and snowy winter. This research was concentrated within the core area (3111–4021 m altitude) of the national park since Himalayan Monal is commonly found within 3300–4570 m altitude in the protected areas of Nepal (Grimmett *et al*., 2016).

Data collection

A preliminary survey was carried out in February 2022 to select the sites for transects. The sites were selected by interacting with local people, park staff, and bird watchers. The entire potential habitat was divided into five different blocks *viz.* i) Namche Block, ii) Furte Block, iii) Syangboche Block, iv) Mislung Block, and v) Kyangjuma Block (Figure 2). Altogether, ten transects (T1, T2, T3, T4, T5, T6, T7, T8, T9 and T10), two in each block, were laid. The status and distribution of Himalayan Monal were determined using line transect and direct observation. Line transect method is reliable for estimating Himalayan Monal population because of the method's accuracy and efficiency (Selvan *et al*., 2013). Moreover, a number of researchers such as Ramesh (2003), Miller (2010), and Ahmad et al. (2019) have used this method in their studies. Ten transects, each 1.5 km long, were monitored two times (in March and May) during the study period in 2022. All the pheasants observed within 200 m on either side of the transects were recorded. Observations were carried out using binoculars and cameras in the morning and evening. The number, gender, and GPS locations of the observed Himalayan

Monals were recorded for their population status. Evidences like direct observations, calls, feathers, fresh ground scratches, fecal matter, and information from the local people, trekking guides and SNP staff were used for assessing the distribution of Himalayan Monal.

During the field survey, habitat types and composition data were also collected along the trails. Different habitat types were recognized in the study area by analyzing field survey data and through direct field observations based on vegetation structure and land use. The entire habitat was classified into four types- i) Pure Pine Forest, ii) Mixed Pine Forest, iii) Rangeland, and v) Cultivated Land. The proportion of transect in each habitat type was not equal. Forty percent of the transects were traversed within Pure Pine Forest, 23% within Mixed Pine Forest, 17% within rangeland, and 20% within Cultivated Land. Threats to Himalayan Monal were assessed through direct field observation and a semi-structured questionnaire survey. Questionnaire survey was carried out with 50 respondents, including the local people, trekking guides, local government representatives, photographers, local conservationists, and park staff, to assess the threats and to understand the local people's opinion towards this avifauna. Besides, relevant data and information were also collected through literature review, which included several books, research articles, journals, and reports from concerned authorities.

Data analysis

The population density (PD) of Himalayan Monal was calculated by dividing the total number of the pheasants observed by the total area surveyed, i.e.,

PD = Total number of pheasants observed / Total area surveyed.

Similarly, the encounter rate (ER) was calculated by dividing the number of sightings or birds detected by the distance covered, i.e.,

ER = n / L,

where n = number of sightings or birds detected and L = distance covered (Caughley, 1977).

Likewise, the habitat preference rating index (HPI) was computed by dividing the percentage of the pheasants observed in each habitat type by the percentage of transect traversed in each habitat type, i.e.,

HPI = X / Y,

where X = percentage of the pheasants observed in each habitat type and Y = percentage of transect traversed in each habitat type (Mishra, 1982).

The distribution pattern of Himalayan Monal was calculated based on the variance-to-mean ratio (Odum, 1971), which is because the variance (S^2) is equal to the mean (X) in the Poisson Distribution. The ratio $S^2/X < 1$ indicates uniform distribution; the ratio $S^2/X = 1$ indicates random distribution; and $S^2/X > 1$ indicates clumped distribution.

Furthermore, the distribution of the Himalayan Monal within the study area was analyzed by using χ^2 tests (Chi-squared test) at a 5 % level of significance:

$$\chi^2 = \frac{\sum(O-E)^2}{E},$$

where, O= Observed value and E= Expected value.

Digital Elevation Model (DEM) was used in feature digitization of the slope, aspect, and elevation to show the distribution of Himalayan Monal in the study area. Digital data were downloaded from the USGS Earth Explorer's SRTM 1 ARC-Second Global feature. Slope was categorized as 0–10º, 10–20º, 20–30º, 30–40º, 50–60º, and 60–70º. The aspect was categorized as North, East, South and West. Elevation range was categorized into 3100–3250 m, 3250–3400 m, 3400–3550 m, 3550–3700 m, 3700–3850 m, and 3850–4021 m.

Results

Himalayan Monal was distributed in all five blocks with an area of 7.14 km^2 ranging from 3111 m to 4021 m above the mean sea level (msl).

Twenty surveys were conducted in five blocks within the study area. During the study period, 67 Himalayan Monals were sighted in all the blocks, with 48 male and 19 female individuals (Table 1). The overall population density was 4.69 birds/ $km^{2,}$ with the highest population density in the Namche Block and the lowest in the Syangboche Block (Table 2). Similarly, the overall encounter rate was 2.33 birds/km, the highest (encounter rate) in the Furte Block and the lowest in the Syangboche Block (Figure 3). *Pinus wallichiana* was the dominant tree species in the Furte and Mislung Blocks, while *P. wallichiana*, *Abies spectabilis,* and *Juniperus recurva* were the major tree species noticed in the Namche Block. The study area consists of steep, rocky and open grassy slopes.

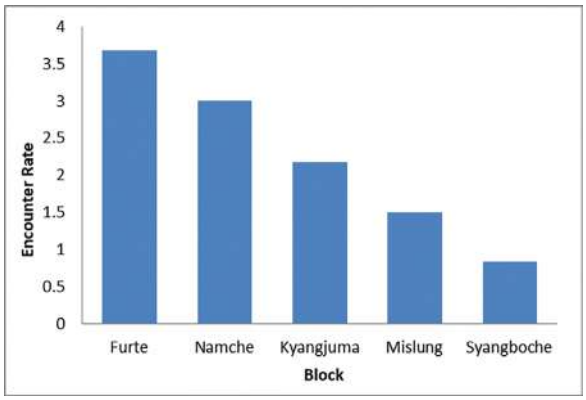

Figure 3: Encounter rate of Himalayan Monal in different blocks.

Table 1: Estimated population of Himalayan Monal in different blocks

Block	Transect	No. of Himalayan Monal encountered			
		March		May	
		Male	Female	Male	Female
Namche	T1	4	3	3	1
	T2	3	1	2	1
Furte	T3	6	3	4	2
	T4	3	1	3	0
Syangboche	T5	2	0	1	0
	T6	1	0	1	0
Mislung	T7	3	1	3	0
	T8	1	0	1	0
Kyangjuma	T9	3	2	1	2
	T10	2	1	1	1
Total		28	12	20	7
Grand Total		**67 (48 Male and 19 Female)**			

Source: Field study, 2022.

Table 2: Block-wise population density of Himalayan Monal

Block	Himalayan Monal encountered	Mean population	Total area of the Block (km^2)	Population density (birds/km^2)
Namche	18	9	1.24	7.26
Furte	22	11	1.56	7.05
Syangboche	5	2.5	1.29	1.94
Mislung	9	4.5	0.93	4.84
Kyangjuma	13	6.5	2.12	3.07
Total	67	33.5	7.14	4.69

Source: Field study, 2022.

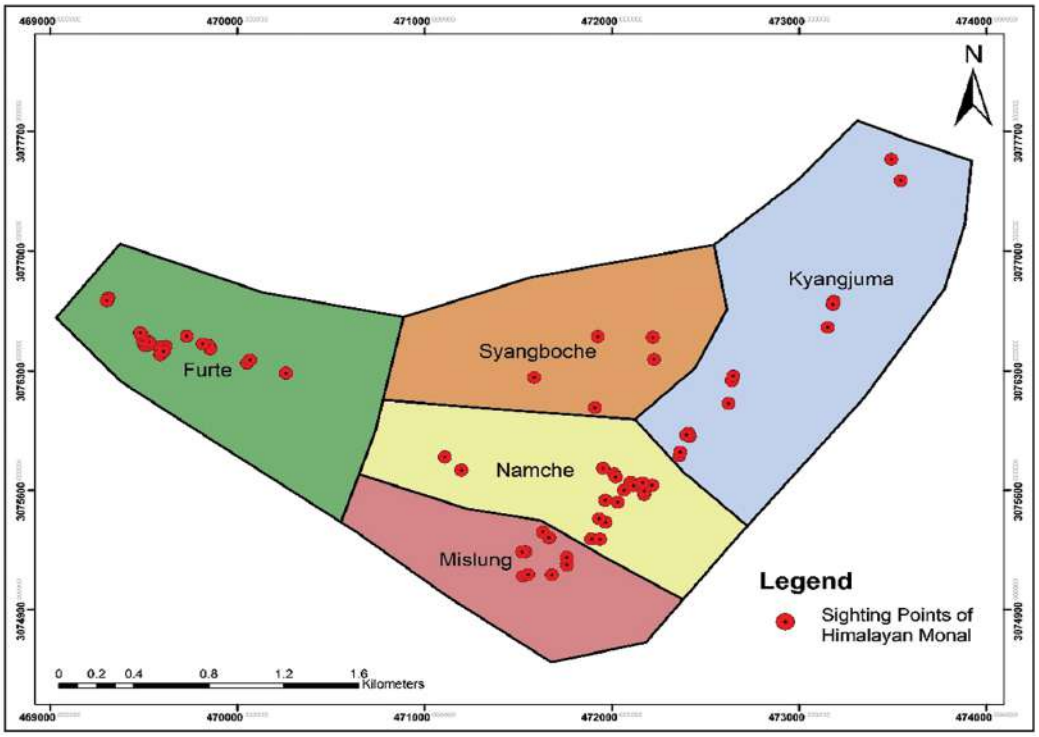

Figure 4: Distribution of Himalayan Monal in different blocks

Distribution pattern

Block-wise distribution

The distribution of Himalayan Monal showed a clumped pattern ($S^2/X=2.76$) with the highest proportion (33%) in the Furte Block and the lowest proportion (8%) in the Syangboche Block (Figure 4). The Himalayan Monals encountered were not uniformly distributed ($\chi^2=13.821$, df=4, $p<0.05$) in different blocks within the study area.

Habitat-wise distribution`

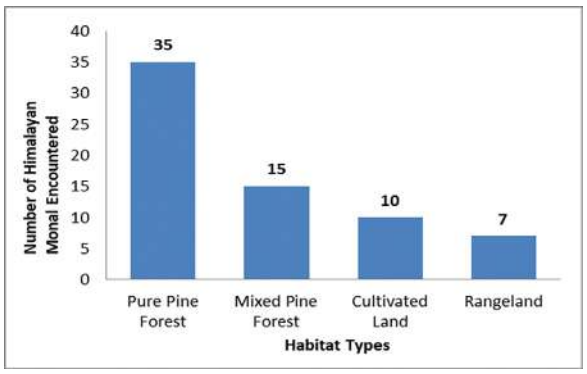

Figure 5: Distribution of Himalayan Monal in different habitat types

The number of the Himalayan Monal sighted varied as per the habitat types. A maximum of 35 individuals were recorded in pure pine forest, and only seven were recorded in rangeland (Figure 5). The distribution of Himalayan Monal was not uniform in different habitat types ($\chi^2=28.462$; df=3, $p<0.05$).

Habitat Preference Rating Index (HPI)

The Habitat Preference Rating Index indicated that the highest preference of the Himalayan Monal within the study area was towards the Pure Pine Forest (Table 3).

Table 3: Habitat Preference Rating Index

Habitat Types	Himalayan Monal encountered	X	Y	HPI (X/Y)
Pure Pine Forest	35	52	40	1.30
Mixed Pine Forest	15	22	23	0.96
Rangeland	7	11	17	0.65
Cultivated Land	10	15	20	0.75

Note: X = Percentage of Himalayan Monal observed in each habitat type and

Y = Percentage of transect traversed in each habitat type.

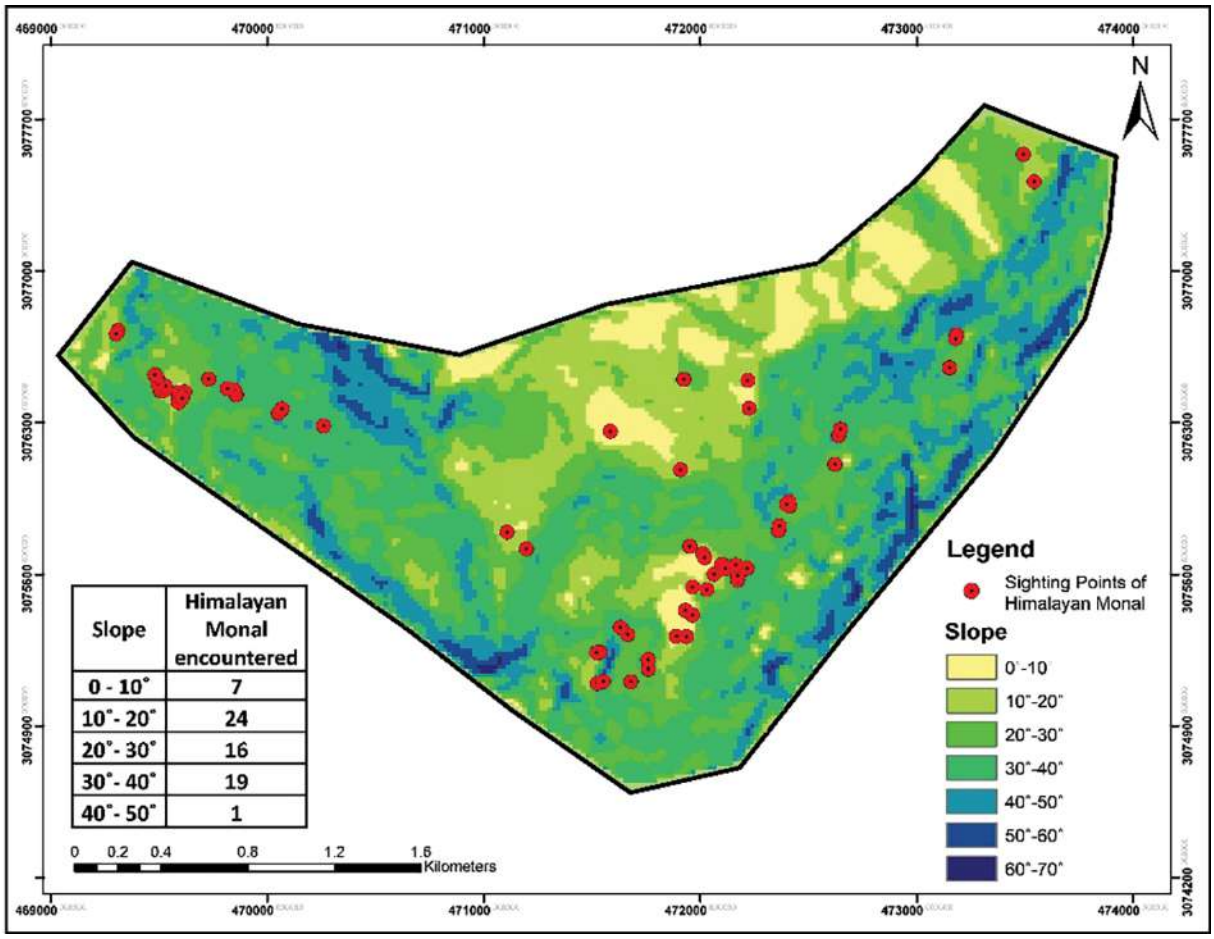

Figure 6: Distribution of Himalayan Monal in terms of different slopes

Digital Elevation Model (DEM)

Slope

Himalayan Monals were recorded at different slopes; a maximum of 24 individuals recorded between 10–20º slope followed by 19 between 30–40º slope and 16 between 20–30º slope. Similarly, seven individuals were recorded between 0–10º slope and just one individual between 40–50º slope (Figure 6). However, the difference was statistically significant, and Himalayan Monals were not uniformly distributed through the range of slopes between 0-50º (χ^2=25.761, df=4, $p<0.05$).

Aspect

Himalayan Monals were encountered in all aspects of the study area. A total of 23 individuals (maximum) were observed on the northern aspect, 15 individuals both on the eastern and western aspects and 14 (minimum) individuals on the southern aspect (Figure 7). Himalayan Monal was found to have preferred the eastern aspect in the Kyangjuma Block with steep rocky slopes and the northern aspect in the Syangboche Block with open grassy slopes. Similarly, the northern aspect was preferred in the Mislung Block, where the dominant tree species was *Pinus wallichiana*. Likewise, the northern and western aspects were preferred in both the Furte and Namche Blocks. However, the difference was found to be statistically non-significant, so the pheasants were uniformly distributed on all aspects (χ^2=3.149, df=3, $p>0.05$).

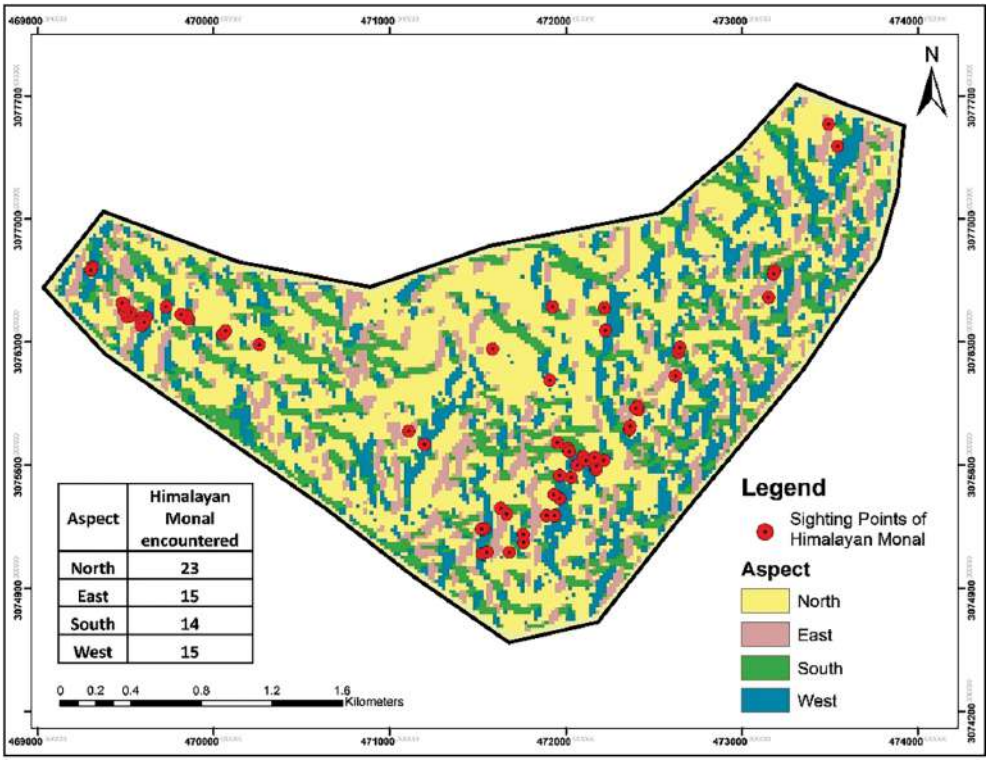

Figure 7: Distribution of Himalayan Monal in terms of different aspects

Elevation

Himalayan Monals were recorded at different altitudinal ranges. A total of 41 individuals (maximum) were recorded between 3400–3550 m altitude (Figure 8). Only one individual (least) was recorded between 3850–4021m altitude. The distribution of Himalayan Monal was not uniform in different elevations (χ^2=82.478, df=4, p<0.05).

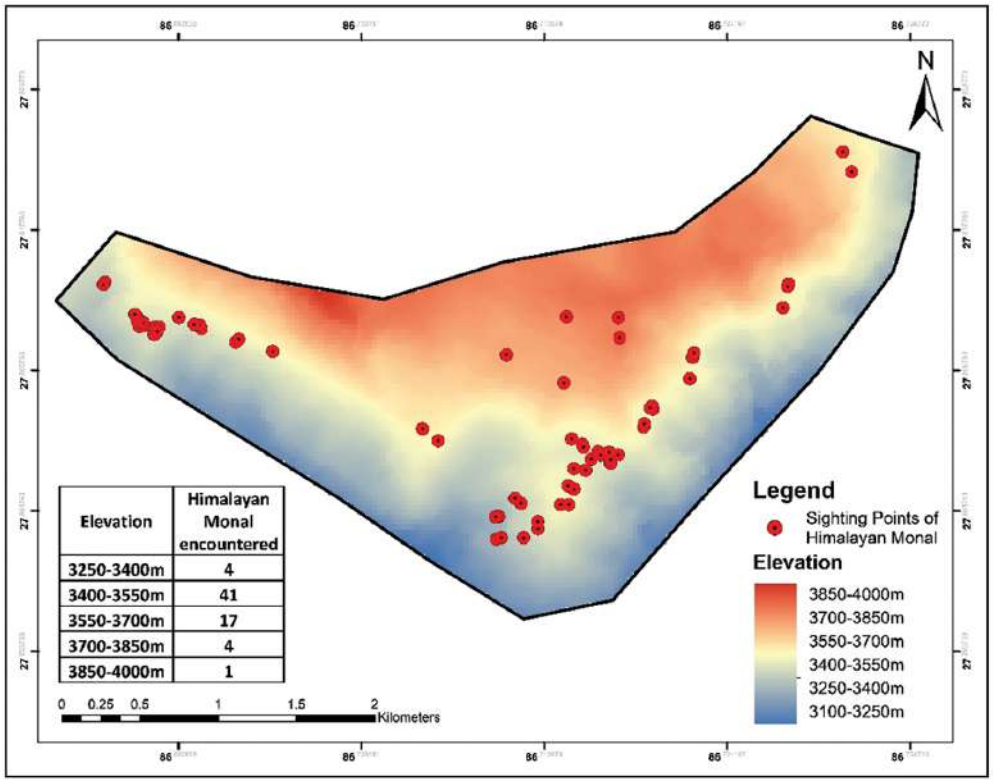

Figure 8: Distribution of Himalayan Monal within different elevations

Respondent's perception

All the respondents showed positive responses towards Himalayan Monal protection and conservation. Though the bird feeds on potato fields during potato cultivation and harvesting season, the local people were always positive towards its conservation and happy to see the national bird feeding on their cultivated lands.

Threats

Most respondents perceived habitat degradation as the main threat to Himalayan Monal, followed by free-ranging dogs, human disturbances, and poaching (Figure 9). Human disturbances included collection of mushrooms and medicinal plants, livestock grazing, and trekking routes in the habitats of Himalayan Monal.

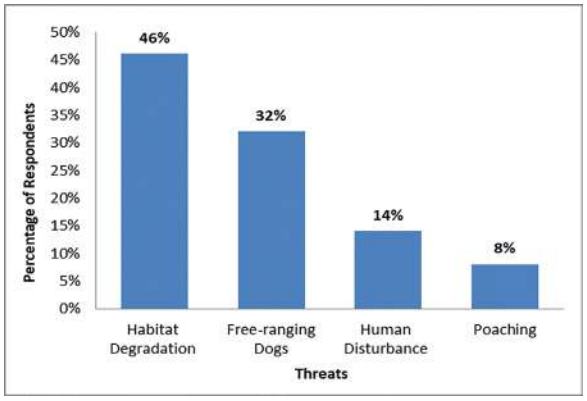

Figure 9: Perception of respondents regarding threats to Himalayan Monal

Discussion

Poudyal *et al*. (2013) sighted 51 Himalayan Monals in seven sites of Seti Khola forests inside the Annapurna Conservation Area. Similarly, another study conducted in seven different routes covering almost all the areas of Sagarmatha National Park and its buffer zone recorded 97 Himalayan Monals (SNP, 2016). This study recorded 67 individuals (48 male and 19 female). The population density in the study area was 4.69 birds/km^2, less than the reported density (5.63 birds/km^2) from the Salkhala Game Reserve of Pakistan (Ahmad *et al*., 2019). The variations might be due to different methods, time duration, season, and topographic features of the coverage area.

The distribution of Himalayan Monal was not uniform in the study area. The encounter rate was highest in the Furte Block because the block had suitable habitat conditions and low human interference. Generally, the species avoids human disturbances and altered land use (Sharief *et al*., 2022). According to Miller (2010), Himalayan Monal preferred broadleaf and conifer forests in India's Great Himalayan National Park. This study also showed more preference towards pure pine forest. According to Grimmett *et al*. (2016), Himalayan Monal is commonly found in the protected areas of Nepal between 3300–4570 m altitude. This study recorded maximum number of Himalayan Monals (58) between 3400–3700 m altitude. Himalayan Monals were encountered in all aspects; however, most of the species were recorded on the northern aspect with 10–40º steep, rocky and open grassy slopes, which is in line with the findings of Ahmad *et al*. (2019). Prefence of cliffs and huge rocks for roosting in northern and south-eastern slopes is common for Himalayan Monal. High cliffs and rocks protect the species from predators such as foxes and allow the easy gliding for the species (Rimlinger *et al*., 2000).

The DNPWC and DFSC (2018) stated that the Himalayan Monal faces the most significant threat of extinction due to poaching, habitat loss, and degradation. According to the respondents, habitat degradation, free-ranging dogs, and human disturbance were significant threats to Himalayan Monal. Poaching was found rare since the Sherpa community is against killing wildlife and is always focused on biodiversity conservation.

Conclusion

Himalayan Monal was distributed in all the blocks of the study area with different land use patterns (pure pine forest, mixed forest, cultivated land, and rangeland). However, the maximum number of the pheasants (35) was observed within the pure pine forests with different aspects and slopes between 3250 m and 4021 m above the mean sea level. Mushrooms and medicinal plant collection,

livestock grazing, free-ranging dogs, and trekking routes were reported to be the major factors leading to disturbance and degradation in the habitats of Himalayan Monal in the Sagarmatha National Park. Detail scientific research and long-term monitoring of Himalayan Monal should be prioritized along with improvement in patrolling by the Sagarmatha National Park Authority to control the over-exploitation of the natural habitats of this national bird species.

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