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Habitat Suitability Modelling of Kalij Pheasant (*Lophura leucomelanos*) in Mirpur Division, Azad Jammu and Kashmir, Pakistan

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MF, ZA and FA conceived the idea and designed the study. MF collected the field data and wrote the article. RA and IUZ helped in mapping. MMS reviewed the article.

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Habitat suitability, Kalij pheasant, MaxEnt, modelling, Azad Jammu and Kashmir

ABSTRACT

Kalij pheasant *Lophura leucomelanos* is habitat indicator and the information about its habitat characteristics and suitability is lacking. In the current study, presence of kalij pheasant was recorded from 166 sites of Mirpur Division Azad Jammu and Kashmir, Pakistan. The maximum abundance was recorded at Gaian site (2.33/ha). Estimation of Habitat Suitability Index (HSI) from 166 sites revealed that ten sites fell under the category of highly suitable habitat based on parameters including water, food, vegetation, disturbance, hunting and predation pressure. Kalij pheasant was distributed between 381-1689m (asl) elevation. Species presence data along with GIS database were used to model the habitat suitability of kalij pheasant through MaxEnt software, version 3.4.4. The model showed an average Area Under the Curve value (AUC) (0.802), showing the model precision for suitable habitat mapping. The analysis for the contribution of environmental variables through Jackknife test showed that temperature was the prime environmental variable. Results revealed that out of total, 4388 km^2, 406.03 km^2 area was calculated to be highly suitable for kalij pheasant. Identification of hotspots and potential habitats for kalij pheasant can be considered as an important initiative to conserve the species.

INTRODUCTION

Galliformes are an important avian group and are useful indicators of environmental quality due to living in forests (Fuller and Garson, 2000). Kalij pheasants are native to South Asia, distributed from the Indus River of Pakistan in the Western Himalayas, Northern India, Nepal, Bhutan, Sikkim, Assam, South through Burma to Western Thailand and introduced to United States (Robert, 1991; McGowan and Panchen, 1994; Johnsgard, 1999; BirdLife International, 2016). Mostly they are sedentary from 400-3600m elevation in forested foothills and mountainous areas along with woodland roads, at the edges of forest clearings and brushy ravines, but during winter may move to lower elevations travelling to large distances (Bohl, 1971; Ali and Ripley, 1983).

The information about the distribution of species is vital for ecologists (Guisan and Thuiller, 2005). Density and abundance data are necessary for monitoring the population and implementation for conservation management (Conroy and Noon, 1996). Habitat Suitability Modelling techniques are helpful in locational records of species that predict the potential distribution to manage conservation issues (Guisan and Zimmerman, 2000). Mapping of potentially suitable habitat is vital for monitoring and restoration of species whose native population is declining (Hirzel *et al*., 2001). Furthermore, management of species native habitat and their conservation is also important (Elith and Leathwick, 2009). Sometimes important data related to species distribution and their status are insufficient that leads to the difficulty in habitat modelling (Kinnaird *et al*., 2003). Therefore, accurate modelling of geographic distribution of species is fundamental in ecology and conservation (Hirzel *et al*., 2002; Zaniewski *et al*., 2002).

The geographic distribution is obtained by mapping

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the particular area where all necessary requirements for species are met (Elith *et al*., 2006). These models can help in identifying previously existed populations, determining their sites for reintroduction, selection, and management of protected areas depending on data quality (Graham *et al*., 2004). These models statistically relate field observation to produce spatial prediction which indicates the suitability of different locations of species for exploring the required resources, assessing the ecological impact of different factors, human-wildlife conflict, threats, conservation planning, and priorities of species (Hirzel *et al*., 2001; Le Lay *et al*., 2001; Scott *et al*., 2002; Guisan and Thuiller, 2005; Smeraldo *et al*., 2017). MaxEnt estimates uniform distribution of an area in which the expected value of each environmental variable under this distribution matches its empirical average (Phillips *et al*., 2006).

Kalij pheasant *Lophura leucomelanos* is Least Concern (Birdlife, 2021) and falls under Appendix III of CITES. Azad Jammu and Kashmir Wildlife Act (2015) kept kalij under schedule III and protected species (AJ and K Wildlife Act, 2015). In Pakistan, due to the limited habitat, population of kalij pheasant is plummeting alarmingly (Nawaz *et al*., 2000). Kalij pheasant has not been extensively studied in their natural habitat and their population is decreasing (Andleeb *et al*., 2012; Birdlife International, 2021; Furqan and Ali, 2022). There is a lack of in-depth research about their habitat, geographical distribution, hence scientific efforts were needed to elaborate the ecological data of kalij pheasant.

MATERIALS AND METHODS

Study area

The current research was conducted in Mirpur Division having three districts i.e., Mirpur, Bhimber, and Kotli (Fig. 1). Mirpur Division is situated in the South-eastern part of the State of Azad Jammu and Kashmir (AJ and K), Pakistan. It is bordered by Rawlakot District in the North, Jhelum in the South, Indian Administered Kashmir in the East and Rawalpindi in its West. The study area covers an area of 4,388 km^2, elevation ranges between 270 m –2000 m above sea level (asl). Mirpur district is located (33°1480'N, 73°7437' E) in the southern part of AJ and K covers an area of 1010 km^2. Topographically this region is plain, with scattered small hills and nullahs.

District Kotli has an area of 1862 km^2, located (33°5008'N, 73°9007' E) and mostly hilly areas with small, scattered plains. Protected areas Pir Lasura and Poonch River Mahsheer National Parks are located in this territory having the diversity of animals and plants. District Bhimber is located (32°9753'N, 74°0858'E) and covers an area of 1516 km^2. This region is plain with cultivated land, hills and nullahs also present.

Distribution

Distribution of kalij was determined by conducting 254 extensive surveys, data on direct (sightings and camera trapping) and indirect (calls, fecal pellets, feathers, local knowledge) evidence of species occurrence were gathered based on the systematic trail, sampling and opportunistic searches carried in the study area from April 2020 to March 2021. Data were collected on the following parameters during the monitoring: starting time, end time, habitat type, total distance covered. Geographical coordinates and elevation were recorded using the Garmin e-Trex GPS navigator. Secondary data were also collected through interviews with local people in the villages and surrounding areas.

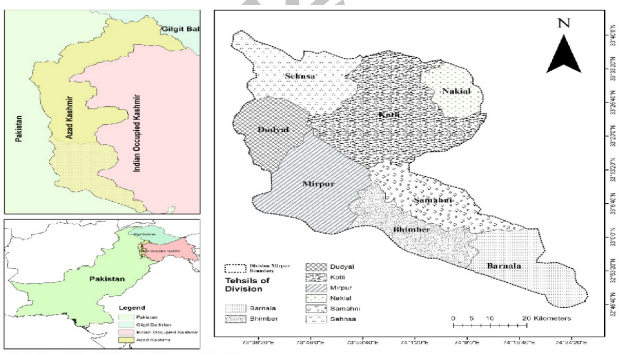

Fig. 1. Map of Mirpur Division Azad Jammu and Kashmir.

Distance sampling

Line transect method was used following distance sampling technique to estimate the population density (Buckland *et al*., 2001).

Ecogeographical variables

During field visit different ecogeographical variables were also recorded, that included distance to the water source, distance to human settlement, distance to agricultural land, distance to road and distance to forest. The distance was measured using Google Earth Pro software.

Habitat suitability index HSI of each locality was calculated by adding the score of each variable of a specific locality by using the following formula:

$$HSI=(SI_1+SI_2+SI_3+SI_4+SI_5+SI_6+SI_7+SI_8)/8$$

While Suitability Index (SI) values indicate the availability, accessibility and impact of different habitat variables including water, food, vegetation cover, cultivation, human settlement, as compared to the actual requirements of kalij pheasant as per literature. SI values of disturbance, hunting pressure, predation pressure were based on the primary and secondary data of each locality,

and HSI score ranged from 0.0–1.0 (least suitable to highly suitable habitat) (Ortigosa *et al*., 2000) (Table I).

Table I. Habitat suitability index score.

HSI Score	Category	Suitability
< 0.50	Poor	Least Suitable
0.50 - 0.59	Below average	
0.60 - 0.69	Average	Less Suitable
0.70 - 0.79	Good	Moderately suitable
> 0.8	Excellent	Highly suitable

MaxEnt modelling

Species presence data along with GIS (geographical information system) database was used to model the habitat suitability of kalij pheasant through MaxEnt (Maximum Entropy Modelling) software, version 3.4.4. By using presence data environmental layers were formed and calculated the probability of occurrence of species (Elith *et al*., 2011). Furthermore, area based on habitat suitability was also calculated using MaxEnt output.

Elevation data were obtained from Earth Resources Observation and Science through Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global data set and land cover from Global Land Cover Characterization (GLCC) US geological survey (EROS, 2017). A slope dataset was developed using spatial analyst of ArcGIS using SRTM one Arc Second global DEM. Precipitation and temperature data of 1km spatial resolution from world climate surface for global land area (Fick and Hijmans, 2017). The importance of the environmental variables was evaluated by Jackknife test (Phillips *et al*., 2006).

RESULTS

Species presence data

Kalij pheasant was distributed in different areas of Mirpur Division and their presence was recorded from 166 sites of the study area. We have directly observed 104 kalij pheasant including (Juvenile (15), Male (48), Female (41)) from 51 sites. Maximum (7) kalij pheasants were sighted at Gaian (Male (4), Female (3)) and Pona Knad (Juvenile (4), Male (1), female (2)) while minimum (1) in Kathar, Jair dhara. Pir Klinger, Pir Lasura, Glater palian, Sair mandi, Burjan, Sahar, Chowki mong, Dabsi, and Sohana. Indirect evidence (Fecal (262), Calls (51), Feathers (325) and Footprints (2)). Four kalij pheasants (Male (02), Female (02)) were captured in camera traps from Durjan District Mirpur. The distribution of kalij pheasant was maximum (68.95%) in the range of 501m-1000m (Table II).

Table II. Percent occurrence frequency of Kalij pheasant related to environmental variables.

Environmental variables	Description	Categories	Direct sighted	Indirect evidence				Total indirect	Total	PO (%)
				Fecal	Calls	Feathers	Footprint			
Topographic	Elevation	Below 500m	7	21	1	26	0	48	55	7.39
		501m-1000m	69	195	34	213	2	444	513	68.95
		1001m and above	28	46	16	86	0	148	176	23.65
	Slope	Below 30	6	16	3	21	0	40	46	6.18
		30-45	95	232	47	290	2	571	666	89.51
		Above 45	3	14	1	14	0	29	32	4.3
Land Cover	Distance from agriculture land	0m-200m	74	133	27	171	2	333	407	54.70
		201m-400m	8	80	9	78	0	167	175	23.52
		400m and above	22	49	15	76	0	140	162	21.77
	Distance from forest	0m-50m	69	209	42	261	2	514	583	78.36
		51m-100m	17	26	6	17	0	49	66	8.87
		101m and above	18	27	3	47	0	77	95	12.77
	Distance from water source	0m-200m	69	128	26	184	2	340	409	54.97
		201m-400m	32	113	22	118	0	253	285	38.31
		401m and above	3	21	3	23	0	47	50	6.72
Anthropogenic	Distance from road	0m-200m	42	117	26	128	0	271	313	42.07
		201m-400m	29	66	14	101	2	183	212	28.49
		401m and above	33	79	11	96	0	186	219	29.43
	Distance from human settlement	0m-200m	60	115	28	142	2	287	347	46.64
		201m-400m	33	99	14	106	0	219	252	33.87
		401m and above	11	48	9	77	0	134	145	19.48

Population density

The maximum population density (2.33/ha) of kalij pheasant was recorded from Gaian followed by Glater palian (1.67/ha), Kanad (1.33/ha), Jair (0.89/ha, 0.86/ha), while minimum (0.1/ha) from Maskeen Pur and Gwand localities respectively.

Ecogeographical variables

Evidence from the field showed that 89.51% kalij pheasants preferred 30°-45° slope while 6.18% were found below 30°. Only 4.3% were found at steep slopes above 45°. About 54.70% kalij were recorded near 0-200m the agriculture land followed by areas 201m-400m away from agriculture land (23.52%) and the lowest (21.77%) occurrence recorded in areas 401m and above (Table II).

Kalij pheasants were documented mostly (78.36%) near (0-50m) the forest and 8.87% (51-100m) and 12.76% away (101m and above) from forest, respectively. The activities of kalij pheasant were recorded highest (54.97%) nearest water source (0-200m), followed by sites (201-400m, 38.31%) (401m and above 6.72%) away from water source respectively. The occurrence of kalij was recorded highest (42.069%) near to road (0-200m), followed by 28.49% (201m-400m) and 29.43% (401m and above) respectively. The direct and indirect evidence showed that kalij pheasant occurs mostly (46.64%) near (0-200m) human settlements followed by (33.87%) at a distance of 201-400m and the lowest (19.49%) was recorded at 401m and above (Table II).

Kalij pheasant were sighted mostly (n=38) at 7am-8am, followed by (n=17, n=16, n=14) at 3pm-4pm, 4pm-5pm and 5pm-6pm respectively. Direct sighting was average (n=7) at 5am-6am and 8am-9am while minimum (n=3) at 6pm-7pm (Fig. 2).

Fig. 2. Activity pattern of kalij pheasant in study area.

Habitat suitability index

The habitat suitability index based upon availability of water, food, vegetation cover, cultivation, human settlement, hunting, predation pressure, disturbance from 166 study sites showed that ten sites fell into the criteria of highly suitable (Table III) followed by moderately suitable (n=63), less suitable (n=75) and least suitable (n=18) was recorded (Fig. 3). Highly suitable sites included Gaian (02 sites), Pir Lasura (02 sites), Sohana, Majhan, Dabsi, Chapar, Chameri, and Thalarajwali.

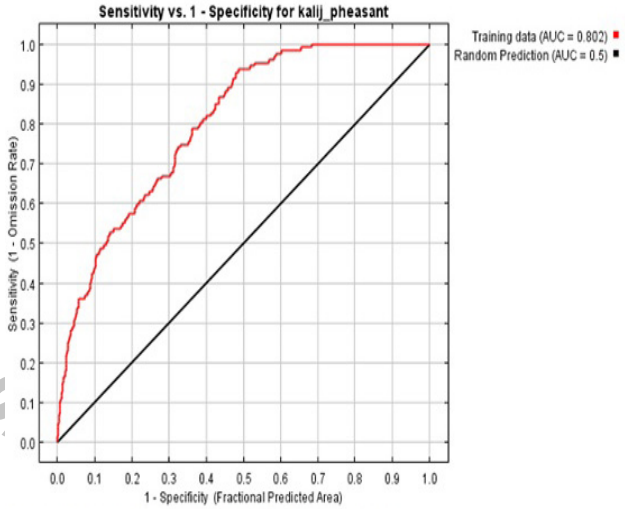

Fig. 3. AUC sensitivity and specificity for kalij pheasant.

Table III. Habitat Suitability Index value of highly suitable sites.

Study site	Elevation(m)	Direct sighting	Indirect evidence	Camera trapping	HSI
Gaian	621	-	+	+	0.8181
Gaian 1	565	+	+	-	0.8171
Pir Lasura	1435	-	+	-	0.8095
Pir Lasura 1	1689	+	+	+	0.8095
Sohana	1137	+	+	+	0.8076
Majhan	1483	+	+	-	0.8062
Dabsi	1484	-	+	-	0.8033
Chapar	981	-	+	-	0.8021
Chameri	913	-	+	+	0.8021
Thalarajwali	558	+	+	-	0.8007

Environmental variables and MaxEnt modelling

Elevation of study area varies from Mirpur to Bhimber lower altitude towards higher altitude of district Kotli. Land cover is shown by low and high values of land cover.

Precipitation and temperature also fluctuated throughout the areas (Fig. 4). The AUC value obtained from MaxEnt modelling was 0.802 which was predicted for the suitable habitat of kalij pheasant for an altitudinal range of 381m to 1689m from Mirpur Division AJ and K as shown in Receiver Operating Curve (ROC) (Fig. 3). A high value of AUC validates the model accuracy. The model generated for the predicted distribution of kalij pheasant reveals that warmer colours show areas with better predicted conditions. White dots show the presence locations used for training, while violet dots show test locations (Fig. 4). Analysis of each environmental variable's contribution during modelling revealed that temperature emerged as a significant contributor with 82.3% (Fig. 5) that influenced the spatial distribution of kalij pheasant in Mirpur Division AJandK. Similarly, in the Jackknife test, temperature was found to be the prime environmental variable (Fig. 6).

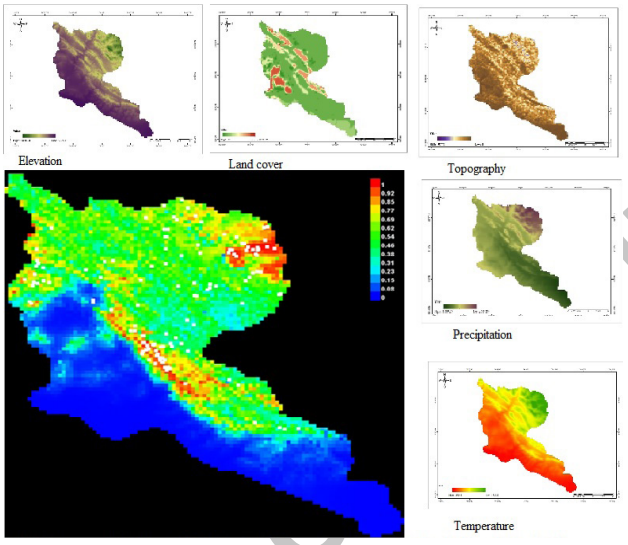

Fig. 4. Environment variables and distribution of pheasant through MaxEnt Modelling in Mirpur division AJ and K.

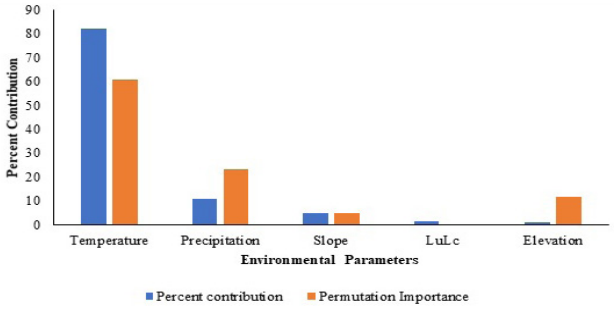

Fig. 5. Environmental variables contribution in habitat suitability.

Suitable area for the kalij pheasant

The area predicted for the suitability of kalij pheasant can be divided into three categories i.e., highly suitable (>85%), moderately suitable (71–85%), least suitable (51–70%). The model identified the highly suitable (406.03km^2), moderately suitable (626.13 km^2) and least suitable (1302.18Km^2) area, respectively from the total area (4388Km^2) for kalij pheasant (Singh *et al*., 2020).

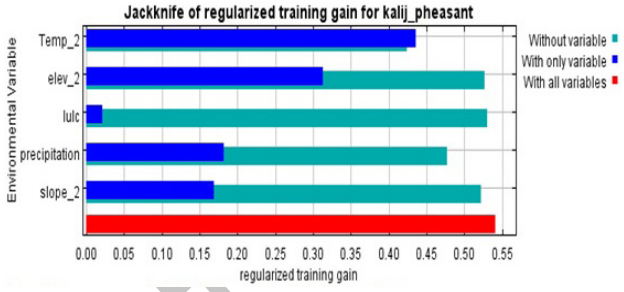

Fig. 6. Importance of variable through Jackknife for kalij pheasant.

DISCUSSION

Pheasants are considered bioindicators of the quality of an environment. Kalij pheasant are distributed in Pakistan in the eastern Himalayas, Northern India, Nepal, Bhutan, Sikkim, Assam, South through Burma to Western Thailand. Kalij pheasant was confirmed in protected areas of Mizoram, India by Lalthanzara *et al*. (2011) and suggested that they are resident and present in many parts of the state. Sailo *et al*. (2013) also carried out a study in Mizoram, India to find out the spatial distribution of pheasants and reported kalij pheasant from all study sites. Sathyakumar *et al*. (1993) studied the habitat use and density estimate by kalij in the Kedarnath Wildlife Sanctuary. They found that kalij was present commonly in eastern Himalaya in low canopy and grass cover, while tree density and cover of shrubs was high. They preferred mostly moderate grass, shrub and tree cover in the western Himalayas. Yadav *et al*. (2019) reported the first time kalij pheasant from Banke National Park south-west Nepal and suggested that the density of kalij pheasant was low and localized to specific areas. Shafiq and Saqib (2011) reported the distribution of kalij pheasant from Kaghan Valley, Pakistan (Haq, 2012) from Battagram Khyber Pakhtun Khwa, Chandio *et al*. (2019) from Margalla Hills National Park. Previous study reported the distribution of kalij pheasant from different areas of AJandK including Awan *et al*. (2012) from Salkhala Game Reserve Neelum valley, Faiz *et al*. (2015) from Tolipir National Park, Khalid *et al*. (2017) from Rawlakot city and its surrounding. Akrim *et*

al. (2018) reported kalij pheasant from Pir Lasura National Park district Kotli AJ and K and we also confirmed their distribution from other districts of Mirpur Division by camera trapping, direct and indirect evidence.

During the study, it was noted that kalij pheasant was distributed at an elevation range of 381-1689m asl from different patches of the study area. Kalij pheasant is mostly sedentary from 600-3400 m elevation in forested foothills and mountainous areas along with woodland roads (Bohl, 1971; Delacour, 1977). The altitudinal range recorded from Nepal was 245-3700m (Inskipp *et al*., 2016). Delacour (1977) found kalij in evergreen and deciduous forests up to 3,300 m elevation. Our results are in line with Kukreti (2015) who studied the distribution, habitat ecology of Kalij in Garhwal, Himalayas, India and sighted the kalij between 700m-2000m altitude and habitat of subtropical deciduous forest, mixed pine and broad leaved temperate forest.

Kalij pheasants were often seen in the vicinity of water, which they correspondingly visit recurrently. Dohling and Sathyakumar (2011) reported the presence of kalij pheasant in Nongkhyllem Wildlife Sanctuary, Meghalaya, India nearby water and moist habitat. They feed in dense grounds at dawn and again at later evening. They take rest during the day, routinely on the ground under dense bushes. The activity of kalij pheasant at night was also noted which is in line with the study of Bump and Bohl (1961) who stated that they roosted on trees of 20-40 feet of height at night for rest and used same tree except when they were disturbed.

Although these pheasants are shy but still, we sighted 104 kalij pheasants directly and maximum abundance (2.33/ha) was recorded from the Gaian locality. Pheasant habitat depends on vegetation and forested area which may differ from open to closed cover with rise of shrub cover. Kalij pheasants were scattered in the closed cover forest with small fractions of shrub, grass and herb density. Similar findings were reported by Hussain and Sultana (2013) who studied the ecological habitat variables among pheasant species of the Himalayas and noted that altitude was an important factor that distinguished the segregation of species. Kukreti (2015) observed 685 kalij pheasants in 228 sightings. Selvan *et al*. (2013) recorded the density (6.7/km^2) of kalij pheasant from eastern Himalayas of Arunachal Pradesh, India. Hussain *et al*. (2001) sighted 67 groups of kalij in Kumaon Himalayas, India and described that kalij pheasants were linked with plant cover having medium tree cover and tall shrub layer of the forested area at lower altitude. Dohling and Sathyakumar (2011) observed 2.85 birds/km^2 from Nongkhyllem Wildlife Sanctuary, Meghalaya, India. Habitat provides basic necessities to all animals which include food, shelter and water depends on particular habitat where species have existed and fulfil its needs (White and Garrot, 1990).

During the study camera trapping and direct sighting showed that kalij pheasant were active mostly 4am-9am and 3pm-7pm in different seasons. Similar findings were reported by Selvan *et al*. (2013) from Arunachal Pradesh, India that the estimated activity pattern of kalij pheasant was 8.29hrs ± 0.18hrs starting before dawn till the evening. The highest number of kalij were seen between 7am-8am and 4pm-5pm which proved their activity pattern during the day.

The presence of pheasants is associated with suitable vegetation because they select small patches with regular edges. Herbaceous and bushy cover supply food and protection from predators and severe weather (Nelli *et al*., 2012). Kalij pheasant is adapted to different habitats like deciduous, evergreen, thickest forest, cultivated areas near to forest and water source (Sathyakumar and Sivakumar, 2007). The kalij pheasant was recorded highest (54.97%) nearest water source (0-200m), near (0-50m) to forest (78.36%), preferred (89.516%) slope (30^o-45^o) areas. It was also noted by Shuai *et al*. (2007) at Taihe Nature Reserve in China that habitat variables like vegetation cover, distance to roads and slope played important role in the selection of proper habitat and nests by common pheasant (*Phasianus colchicus*). Li *et al*. (2009) found that these variables affect the foraging habitat selection of common pheasants in Huanglong Mountains, China. Kalij pheasants were found mostly near to forest because they need food, dense cover and more sloping areas to hide from predators. Water availability was a key component of the habitat as they needed regularly as they were present nearest to water source.

The predicted omission rate is a straight line while our results are near to the predicted omission rate. The omission line lies below because training and test data are not independent. The Maxent model predicted that environmental variables affected the distribution of kalij pheasant. According to study areas, defined by environmental data AUC values were higher for species with narrow ranges. If AUC values of the model over 0.8 or 0.9, then model, is good or very good (Araujo *et al*., 2005) and our results showed the value of AUC (0.802) showing the model well. Song *et al*. (2020) also studied the habitat suitability of brown eared pheasant from two nature reserve of Beijing and Hebei, China. Both HSI score and MaxEnt model revealed that Gaian, Pir Lasura, Majhan, Dabsi, Chapar, Chameri and Thalarajwali are highly suitable sites for species providing all requirements. There is food and water scarcity in some seasons of the year and they migrate to other areas and even come to near human settlements in agriculture land which exposes them.

Habitat destruction, hunting and forest fire were recorded from different sites which affect badly their population and even remove them from some areas.

The study area has a large potential for suitable habitat of kalij pheasant. Due to population in patches, they should be introduced in other areas fulfilling the requirement of kalij and proper monitoring can increase their numbers. The protection of kalij from local communities and natural predators especially, during the breeding season is also vital for their survival. It was experienced from field visits many people were unaware about the ecological importance of the species.

CONCLUSION

Kalij pheasants have a patchy distribution in the study area. MaxEnt model was used to predict the species distribution by using species presence data and five environmental variables (slope, elevation, temperature, precipitation and land cover). The AUC value of model was 0.802 showing the good model performance. An area of 9.25% was found to be highly suitable habitat for kalij pheasant as per the model. Their suitable habitat was associated with food, water availability, dense cover, sloping areas, elevation, precipitation and temperature in the study area. The sites identified as highly suitable (Gaian, Pir Lasura, Majhan, Dabsi, Chapar, Chameri, and Thalarajwali) must be protected for conservation of kalij pheasant at present as well as in future. The current study can be considered as an initiative for the conservation and management of kalij pheasant in the identified hotspots of kalij pheasant.

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Statement of conflict of interest

The authors have declared no conflict of interest.

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