

IMPACT OF HABITAT QUALITIES ON THE BREEDING ACTIVITIES OF HIMALAYAN GRIFFONS (*GYPSS HIMALAYENSIS* HUME, 1869): A CASE STUDY FROM AZAD JAMMU AND KASHMIR, PAKISTAN

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ABSTRACT

Global declining populations of Himalayan Griffon (*Gyps himalayensis*) in South Asia have arisen the alarming situation, which highlighted the need to explore the current status of this vulture in the region. Breeding biology and ecology of Himalayan Griffon (HG) is little known globally. This study assessed the habitat utilization of HG in Hattian and Muzaffarabad districts of Azad Jammu and Kashmir, Pakistan with special reference to its relationship with breeding activities. Thus, four breeding colonies located at Sarli Sacha, Chumm, Talgran and Nardajian were monitored during 2005, 2007-2010 to assess the habitat preferences. The maximum (70%) nests were placed in open rocky area in Sarli Sacha and minimum (30%) in Talgran. Most (60-98%) of the nesting cliffs were facing towards the eastern aspect, except Talgran, which showed 70% southern exposure. Overall cliffs facing east direction showed positive correlation with number of active nests ($r= 0.80$) and occupied nests ($r= 0.69$). Positive correlation was also recorded between percentage of rocky area of cliffs with mean number of active nests ($r= 0.79$) and occupied nests ($r= 0.89$) in all study sites. There was negative correlation of percentage of cultivation ($r= -0.70$) and rural development ($r= -0.95$) with mean nesting site population.

Keywords: Himalayan Griffon, Breeding, Habitat, Pakistan.

INTRODUCTION

Vultures are the most successful scavengers and they dispose of carcasses and other organic wastes, providing a free of cost and very effective sanitation services in the natural ecosystems. They govern cleaning services and protect the health of humans, domestic and wild animals. Without their presence, the abundance of other scavengers, including some are well established disease reservoirs, increases substantially at carcasses (Prakash *et al.*, 2003; Pain *et al.*, 2003, 2008). Their functions are, however, now threatened due to sharp decline of more than 90% of their population throughout India as well as Pakistan (Prakash *et al.*, 2003; Gilbert *et al.*, 2004, 2006; Fakhar-i-Abbas *et al.*, 2013; Siddique and Khan, 2016). This is because that they have the slowest reproductive rates among birds, and their populations are particularly susceptible to high rates of mortality, whether by natural or human induced causes including shortage of food availability (Wynne-Edwards, 1955; Fakhar-i-Abbas *et al.*, 2013; Siddique and Khan, 2016).

Himalayan Griffon breeds usually between 4000 -8000 feet occurring up to 14000 feet in Tibet and to 10,000 feet in Gilgit (Baker, 1935). The nests are constructed in the cliff ledges and abandoned caves. They nest in colonies by selecting hollows or sheltered ledges and their nests are quite bulky stick structures placed on

inaccessible cliffs comprising a nest colony of not more than six nests. Himalayan Griffon choose inaccessible cliffs and precipices on the ledges of which they nest in company, though the nest are well separated and probably do not number four or five in one locality (Bates and Lowther, 1952). Sometime, old nest of Lammergeier (*Gypaetus barbatus*) is used, singly or few pairs scattered on same cliff face (Baker, 1935, Lees and Christie, 2001).

Himalayan Griffon inhabits and breeds in temperate grassland and rocky areas between 600-4500m and soaring birds have been seen as high as 5000. In winter, non-breeding birds haunt along the main valleys as low as 175 m, ascending in summer in highest alpine slopes, where nomadic sheep and goat flocks are more likely to provide food (Roberts, 1991; Lees and Christie, 2001; Li and Kasorndorkbua, 2008).

Himalayan Griffon is entirely a cliff builder, sometime selecting unapproachable sites on ledges on sheer precipices, unclimbable and with over hanging crests (Baker, 1935). Nesting sites are usually selected in very high inaccessible and steep cliffs with suitable ledges on the elevated parts of valleys around villages (Thakur, 2014). Cliff ledges and abundant caves are used as the nesting habitat of Himalayan Griffon (Suwal, 2003; Li and Kasorndorkbua, 2008).

Vultures have always been considered important due to their vital roles in ecology, tradition and aesthetics in the Subcontinent (Virani *et al.*, 2002). They are the

natural cleaners of the ecosystem by eating flesh from carcasses (Lerner and Mindell, 2005). Thus they help to maintain the sanitation of the area inhabited by the human population and play a vital role in controlling outbreak of epidemics and keeping the environment clean (Virani *et al.*, 2002; Gautam *et al.*, 2003). These crucial functions of vultures are now threatened due to the sharply declining populations of *Gyps* vultures as since the early 1990s, more than 92% of their populations have already diminished in the various parts of the Indian subcontinent (Prakash *et al.*, 2003; Green *et al.*, 2004; Gilbert *et al.*, 2004, 2006). Habitat availability and quality play a critical role in the existence and reproduction of a species in an area and accordingly the study of these aspects are extremely important to understand the significant impact on their population (Flint *et al.*, 1984).

However, these aspects of the vulture population living in Azad Jammu and Kashmir (AJK) have never been studied. Personal observations in AJK indicate that the Himalayan Griffons once seen very frequently are nowadays encountered very rarely. The current study tried to investigate the habitat utilization of the Griffon vultures with special reference to its relationship with the breeding activities in AJK.

MATERIALS AND METHODS

Study area: Himalayan Griffon is one of the vulture species found in AJK. Six active colonies were found to exist in the northern parts of AJK. However, only four colonies were selected to for the current study as other two colonies were located in very remote and inaccessible areas.

Four vulture colonies monitored during 2005-2010 were Nardajian, Chhum (located in Jhelum Valley), Talgran and Sarli Sacha (in Neelum Valley (Fig. 1). All these colonies were named after the names of the nearby villages. The first colony (Nardajian colony, 34°12'13.41N, 73°50'35.80E; 2180m above sea level, asl.) was established on a steep rock at a height of 500m from Nardajian Village. The second colony (Chhum colony, 34°12'43.32N, 73°56'17.88E; 2090m asl.) was situated at about 3km away from Nardajian near Chhum village. Both colonies were located at 20-23 km away from Chinari, a famous town on Srinagar Muzaffarabad Highway. This colony was present at a steep slope of 1000m radius, 700m higher from the Chhum village.

The third colony i.e., Talgran colony (34°27'49.41N, 73°27'32.03E, 1670 m asl.) was located in Neelum Valley near the western boundary of Machiara National Park (MNP), at a distance of about 3km from Talgran village and 5km from Batal village on Kahori-Saidpur road. The 4th colony was Sarli Sacha colony (34°30'51.80N, 73°39'23.43E, 2724 m asl.), located at a

distance of 500m from Sarli Sacha village inside the south-eastern boundary of MNP.

Breeding biology: A total of 187 visits was conducted in five years (2005, 2007-2010) to collect the data on breeding biology of Himalayan griffon in four vulture colonies (i.e., Talgran, Sarli Sacha, Nardajian and Chhum). On average, each colony was visited twice a month to check the status and number of vulture present in each colony. All observations were taken at the distance of 100-300m from the breeding cliffs. Focal scan sampling method was used to monitor the breeding status and breeding behavior of breeding population of each colony (Acharya *et al.*, 2009; Postupalsky, 1974). During each visit, five minutes were fixed to observe the breeding status of each nest in each colony. All observations were recorded from 8.00-11.00a.m. in the morning. Nests were identified by the presence of the nesting material and white past (excreta) below the nest or by the presence of the incubating vulture in the nest. All the identified nests were marked (numbered) in a sequence by some identification marks. Confirmation of active (occupied) and inactive (unoccupied) nest was based on the criteria laid down by Postupalsky (1974). An active breeding pair was defined as one that laid an egg, and non-breeding pair was one that occupied the nest at least for three week visits, but did not laid an egg. Breeding success was calculated as the number of fledglings divided by the number of breeding pairs. Productivity was defined as the number of fledglings divided by the total number of pairs (breeding and non-breeding). On each visit, a nest was considered occupied by a pair when two adult vultures were observed at the nest, one standing and one incubating or one incubating adult was present or one adult with chick or a young chick alone was present in the nest.

The vulture colonies and different nests were carefully observed using binoculars (Canon 30×50) and spotting scope (Bushnell, 800×70 mm) from a suitable distance (100-300m) in front of each colony. All colonies were located on inaccessible cliffs. Data were collected during each breeding season for each colony (from February to September). The breeding cycle of Himalayan Griffon started in December and ended in August/September.

The data on commencement of incubation was determined by the median day between the last visit with an empty nest or a standing adult and the first visit with the incubating bird. The hatching date was determined by the median day between the last visit with an incubating adult and the first visit with adult and chick. Similarly, the fledging date was determined by the median day between the last visit to the nest with young present and the first visit to the nest when it was empty (Puente, 2005).

Observations for first two months (December, January) of breeding cycle were not taken since colonies were located on higher altitudes and area was completely covered with snow during these two months. Some additional visits were made to find out the status of non-breeding population, availability of carcasses and ethnovulture relationship. The status of pairs was considered as 'breeding pairs' on the basis of their behavioral patterns such as site selection, observing the two adults, one in sitting in the nest and the other, if present, near by the nesting site. A colony was considered as active, if it was occupied by at least an active egg (Xirouchakis and Mylonas, 2005).

Habitat: To collect the information about the different habitat variables and their relationship with breeding parameters, all 4 colonies and their habitats were regularly monitored during 2005-2010. The investigated parameters were broadly categorized as geomorphologic, anthropogenic, food availability and intraspecific variables.

Location, aspect and elevation of each colony/cliff above sea level were recorded using GPS device (Garmin *Etrax* 30), while the height (from the base) and cliff width were measured with the help of clinometer and measuring tape respectively. Rock exposure was determined by compass. Other geomorphic variables like percentage of rocky area, nest coverage by shelter and general pattern of vegetation were recorded using binoculars and telescope from the selected observation points at average distance of 500m from the parallel accessible hill/cliff opposite to each inaccessible colony at about the similar elevation/height (Borello and Borellow, 1993). Photographs were taken with zoom camera (Nikon, D3100) and later on analyzed.

The anthropogenic variables i.e., percentage of pastures, vegetation cover, rural development, availability of water sources, human settlements, cultivation status and availability of roads within the 5km radius of breeding colonies were recorded with the help of binoculars and telescope from the observation points selected on the top of the valleys covering the radius of 5km from the vulture colonies.

To assess the status of the variables related to food availability, surveys were carried out in the villages within 5-10 km radius around vulture colony. During these surveys, numbers of livestock (including sedentary and migratory) and rubbish dumps were recorded through questionnaire (n=118 households) and field surveys during each breeding season of the study period. The collected data were extrapolated to all villages to estimate total available livestock population according to the total households of district Muzaffarabad and Hattian where vulture colonies were present.

Statistical analysis: Statistical tests including mean, standard error of mean, correlation, regression, One-way

and Two-way Analysis of Variance followed by LSD were performed with the help of MS Excel 2010 and SPSS (ver.16).

RESULTS AND DISCUSSION

Breeding biology: Nest status: During the course of five years' study, a total of 98 nests were found occupied by the vultures, out of which 75 were active and 23 inactive. Among the active nests, 61 successfully fledged, while the remaining 14 failed (n=9) or destroyed (n=5). The maximum number of active nests or breeding pairs was recorded at Chhum (4.4 ± 2.30) and Sarli Sacha (4.4 ± 2.88) while minimum at Talgran (2.2 ± 1.30) study site (Table 1).

A continuous decline was recorded in occupied and active nests in first three years, while a gradual increase in breeding pairs was recorded in subsequent years (n=15). Evidently, a maximum of 30 occupied nests (7.50 ± 2.52) were observed in year one whereas minimum of 14 (3.50 ± 1.91) were seen in year three. Overall, there had been 40% @6.66% p.a. decline in active nests and 33.33% @5.5% p.a. in occupied nests recorded (Fig. 2).

A maximum of 94.4% pair laying was observed in yr 2 while minimum of 62.50% in yr 3. Accordingly, there was an overall decline of 10% @2% p.a. during the study period (Fig. 3).

Collectively, during the course of five years' study, Sarli Sacha site was the most successful site as all the laid eggs (4.4 ± 2.88) were successfully hatched (4.4 ± 2.88) and fledged (4.4 ± 2.88) indicating zero mortality. However, the numbers of eggs laid at one site were the highest in Chhum (4.6 ± 2.41) (Table 2).

Declining status of nests of HG have also been reported from several parts of its distribution. Acharya *et al.* (2009) reported a decline of 84% in active nests from 2002 to 2005 in Mustang, Nepal, probably due to the use of veterinary drug, diclofenac. There are also reports of 100% nest decline in HG during 2002-2004 in Ghemi area, 75% decline in Goysar area of Upper Mastang, Nepal and a smaller decline of 27% at Chungshi area during 2004-2005. However, Thakur (2014) recently reported an increase in occupied nests from 49 to 69 during three breeding years (2010-2012) of HG in Himachal Pradesh, India.

Habitat utilization: The spatial distribution of Himalayan Griffon in four sites was analyzed and correlated with habitat variables of nesting sites (cliffs) within 5km radius from the nesting sites. The habitat variables (n=37) are related to geography and geomorphology (n=13), Anthropogenic disturbances to vulture (n=9), food (n=9), and intra-specific (n=2) variables.

Habitat quality is responsible in controlling the raptor populations and determines the specific settlement

pattern of the species (Newton, 1998). It is essential to investigate the factors which limit the population of vulture as well as describe its habitat in terms of changes in land use and human related pressure in a quantitative fashion. Keeping in view the above literature, the habitat variables were categorized in the following habitat variables as discussed below:

Geographic variables: Among geographic variables, 50-55% of nests were placed in open rocky sites in Nardajian and Chhum and 30-70% in Sarli Sacha and Talgran (Table 3). The maximum (70%) in Sarli Sacha and minimum (30%) in Talgran sites mean nests were covered with shelter of overhanging rocks. The maximum mean nests were placed in open ledges of rocks in Talgran (70%) and minimum in Sarli Sacha site (30%). A consistent trend of mean nests placed on open surface of rocks with mean numbers of active nests was recorded in Nardajian and Chhum sites (Fig. 4).

Most (60-98%) of the cliffs in study sites showed eastern exposure except Talgran which showed Southern (70%) and Western (30%) exposures (Table 3). The eastern face of the cliffs in all sites showed a consistent trend with mean numbers of active and occupied nests present at all sites while other aspects (southern and western) showed irregular pattern with mean numbers of both types of nests (Fig. 5).

The eastern face of the cliff in all four sites showed a positive correlation with mean numbers of active ($r=0.80$) and occupied nests ($r=0.69$), while western and southern exposure showed negative correlations with these two breeding parameters (Table 4). The maximum (65%) of rocky area in cliff was recorded at Sarli Sacha and minimum (40%) at Talgran. The maximum (60%) vegetation cover was recorded at Talgran while the minimum (35%) at Sarli Sacha (Table 3). Excluding Talgran, mean numbers of active nests showed a consistent pattern of fluctuations with both habitat variables (Fig. 6).

Overall a positive correlation was recorded between percentage of rocky area with mean numbers of active ($r=0.79$) and occupied nests ($r=0.89$) at all four sites (Table 4). Similarly, a strong negative correlation of percentage of rocky area in cliff was recorded with both these breeding parameters. A consistent trend in cliff height (m) above the ground and mean numbers of active and occupied nests was recorded at all four breeding sites of the study area (Fig. 7).

There was a strong positive correlation ($r=0.93$) between the percentage of rocky area in cliff and cliff elevation and strong negative correlation ($r=-0.93$) between percentage of vegetative cover in cliff and cliff elevation. Cliff elevation, cliff heights above ground and cliff lengths were positively correlated with breeding parameters (active nests, occupied nests, numbers of fledglings and population). Similarly, a strong positive

correlation was recorded between eastern exposure of cliffs and percentage of rocky area at all studies cliffs (Table 4). The other intra-geographic variables showed little impact on population and breeding parameters of vultures in different study sites.

The selection of cliff for nesting site was based on presence of small rocks which provided shelter to the active nests, since the number of occupied nests was strongly correlated to the mean nest covered by the shelters ($r=0.94$). In another study in Herzegovina, 31% of the population of nests of *Gyps fulvus* was present in caves and 36.1% in half caves (Marinkovic *et al.*, 2012). Cliffs at Sarli Sacha and Talgran were mainly made up of limestone rocks, while at Nardajian and Chhum sites they were composed of dolomite rocks. The Eurasian griffon has nested in Herzegovina on dolomite and limestone rocks (Talsky, 1882; Reiser, 1939). *Gyps fulvus*, a closely related species to HG, prefers 92% limestone of nesting sites in Balkans (Marinkovic, 1999), 74% on the Iberian Peninsula (Donazar, 1993) and 60% of rocky area made up of dolomite and limestone in Crete, Greece (Xirouchakis and Mylonas, 2005). Liberatori and Penteriani (2001) also recorded higher percentage of nests covered by shelters in rocky areas in Egyptian vulture colonies at Italian peninsula.

About 60-98% of the current study site cliffs were on the eastern exposures except the Talgran (70% western). Overall eastern face of the cliff in all four sites showed the positive correlation ($r=0.80$) with mean number of active and occupied nests. According to Donazar *et al.* (1989), the role of cliff in nest site selection process by species is very important. A strong association of active nests with eastern exposures in majority of study sites was probably to absorb maximum heat from the sun or it may be the specific characteristic of this species, as in case of Egyptian vultures, where the strong association of mean number of active and occupied nests with south facing slopes was reported as a typical preference of the species (Canut *et al.*, 1988; Grubac, 1989; Carlon, 1992; Mundy *et al.*, 1992; Vlachos *et al.*, 1998; Liberatori and Penteriani, 2001).

A sufficient amount of heat is necessary during the incubation period to give maximum output in terms of fledged chicks as evident in our Sarli Sacha site, where the breeding success was 100%.

The vegetation cover of the cliffs was strongly negatively correlated with the active ($r=-0.79$) and occupied ($r=-0.89$) nests suggesting that the rock selection and breeding activities of vultures might also be influenced by the vegetation cover. The larger the vegetation covers in cliffs, the smaller the breeding output, as was observed in less productive colonies (Talgran and Nardajian), where vegetation cover was 60% while in Sarli Sacha, the most productive nesting site, it was only 35% (Table 3).

The selection of cliffs, with reference to elevation above sea level, height above the ground and cliff length, was strongly associated with the breeding output of the vulture in the study area. All these cliff characteristics were strongly positively correlated to the occupied nests and numbers of young fledglings (Table 4). Similarly, there was a strong positive correlation ($r=0.93$) between the percentage of rocky area and cliff elevation. All of these parameters made the cliff inaccessible to human and other predators.

Anthropogenic variables: The effects of anthropogenic parameters within a radius of 5km from the breeding cliffs on the population of vultures were analyzed at all study sites. Maximum pasturelands were observed at Sarli Sacha (40%) and minimum at Chhum (15%), while maximum (80%) of vegetation cover at Chhum and minimum (30%) at Sarli Sacha was recorded. A maximum (30%) of rocky area around 5km of breeding cliff at Talgran and minimum (5%) at Sarli Sacha was recorded. Maximum (27%) area was under rural development at Talgran and minimum (5%) area at Chhum. Talgran site had maximum (50%) area under cultivation while minimum (20%) at Chhum. Maximum human settlements in terms of households were found at Talgran ($n=900$) while minimum ($n=500$) was recorded at Chhum. The percentage of cultivation around Nardajian and Talgran negatively affect the vulture population at two sites (Fig. 8).

The number of households, rural development and vegetation cover around study sites showed negative correlation with mean population (Table 5). Other anthropogenic variables like distance to paved, un-paved roads from the breeding cliffs and distance to nearest village from the cliff showed little impacts on the population dynamics of the vultures in different sites.

During study period, nine anthropogenic variables were investigated with reference to their association with vulture population and breeding parameters. A strong negative correlation of rural development (within the 5km radius of nesting cliffs) with mean numbers of active nests ($r=-0.88$), occupied ($r=-0.86$) nests and population ($r=-0.95$) revealed the negative impacts of human population near vulture colonies. Both productive sites i.e. Sarli Sacha and Chhum, have only one village each within radius of 5km of nesting site, while our two other sites i.e., Talgran and Nardajian have 5 and 4 villages respectively. Similarly, a strong negative correlation between percentage of cultivation with mean numbers of active ($r=-0.95$) and occupied ($r=-0.79$) nests, suggests that the agricultural practices might have strong negative impacts on the breeding process and population of HG in the study area (Table 5). Low productive colonies (i.e., Talgran and Nardajian) have much anthropogenic pressure (in terms of human settlements and activities) as compared to

productive colonies i.e. Sarli Sacha and Chhum. According to Liberatori and Penteriani (2001), habitat modification by human was the main factor in population change of Egyptian vulture in Italy. In the study area, habitat modifications through agricultural activities, noise, summer grass cutting for winter fodder collection for their cattle, and collection of medicinal plants were major activities around the vulture colonies. Land use changes can decrease the carrying capacity of nesting habitat, although food availability is not always deterministic factor in population growth of raptors (Xirouchakis and Mylonas, 2005).

Food variables: All vulture sites were explored at Muzaffarabad and Hattian districts of Azad Jammu and Kashmir. Vultures were found soaring in the vicinity of these districts. The available livestock population in these areas constituted a major food source of vultures. Based on livestock survey of randomly selected 118 households, a total of about 1853750 livestock heads were estimated in year one which showed 75.31% decline up to the year five ($n=457610$) with 12.5% annual decline (Table 6).

This sharp decline of 75.31% (averaging @12.5% per annum) in livestock population during five years following Kashmir earthquake disaster of 2005 resulted in severe shortage of food for HG due to sudden livestock population crash. In the wake of natural disaster, the agro-pastoral system (nomadic grazing in open pastures) sharply decreased and replaced by stall feeding. There was a positive correlation ($r=0.70$) between numbers of active nests and the numbers of livestock within 5km radius of the colonies. Parra and Telleria (2004) also recorded that changes in the number of breeding pairs of *Gyps fulvus* in Spain was positively correlated to changes in livestock abundance during 1989-1999, supporting functional relationship between food availability and vulture abundance.

There are some evidences that the food limitation is a potentially emerging factor for the Asian vulture crisis, because, the shift and increase in livestock utilization by human has resulted into decline in carcasses. Hence, the availability of carcasses decreased from 2002 ($n=17$) to 2005 ($n=0$) and none of the carcasses could ever be recorded in the years thereafter (Fakhar-i-Abbas *et al.*, 2013). Chao *et al.* (2013) also reported that population of HG showed slightly decreasing trends at Drigung Thel Monastery, Tibet, China from year 2009 to 2012 ($n=250-200$) due to decreasing trend of celestial burials in Tibet. Evidently, the decline in vulture population corresponds to decreasing food availability in the area.

In study area, the availability of food, natural disaster and human related variables were the major factors contributing to the variation in breeding activities. The ethno-vulture surveys carried out during the study did not report any vulture mortality in the life time of

respondents; though, there was a little use of veterinary drugs by the local livestock grazers in the area. The plausible explanation in decline of breeding activities in the first three years of the present study, may correspond to the massive earthquake struck the study area in 2005, which resulted in the loss of some 70,000 humans as well substantial number of livestock. Therefore, a sudden decline in food base resulted in availability of poor food supply for HG during the early three years. But the increase in livestock population in the last two years of study reflects a positive correlation for an increase in both active ($r=0.70$) and occupied nests ($r=0.44$) during this period (Fig. 2). Evidently, an increased food supply,

provided by the livestock is an indicator of increased breeding activity in HG and vice versa.

However, in case of wildlife population fluctuations, some environmental factors may indirectly guarantee for healthy food supply. For example, Mduma *et al.* (1999) recorded the inverse relationship between the number of occupied /active nests and rainfall, which could be related to high availability of food for scavengers. Apparently, Pain *et al.* (2008) also reported the same situation elsewhere in case of other *Gyps* species, while in case of current study, the HG relies substantially on human led livestock fluctuations rather than wildlife of the area.

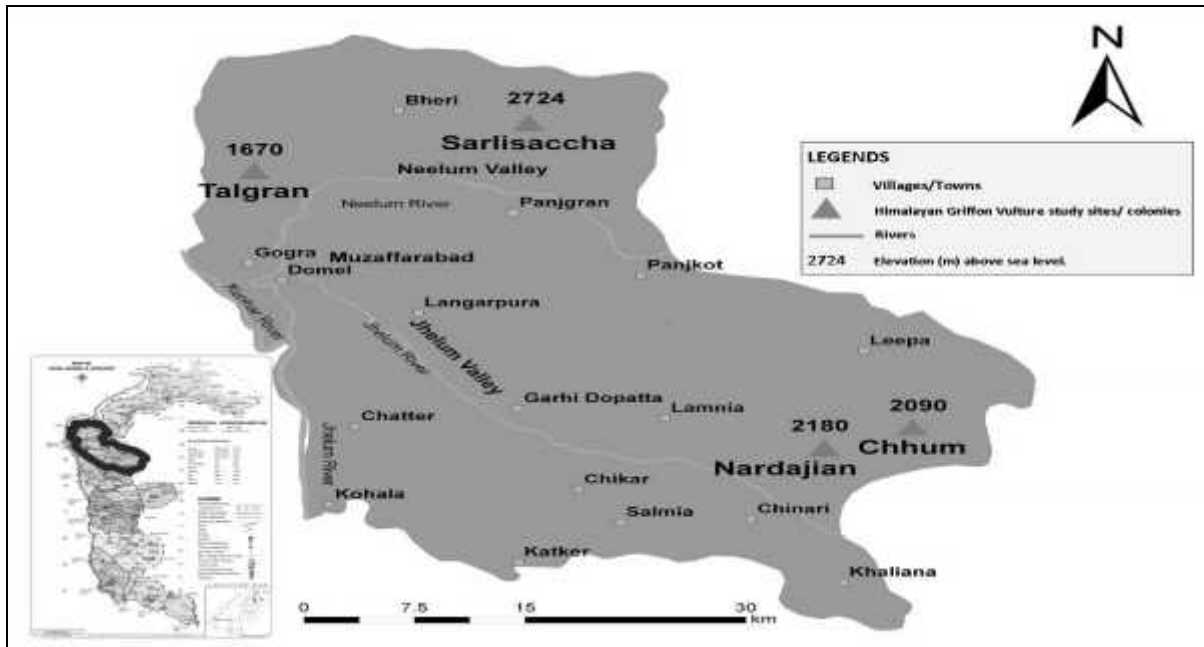


Fig.1: Location/Distribution of Himalayan Griffon colonies in AJK during 2005-2010.

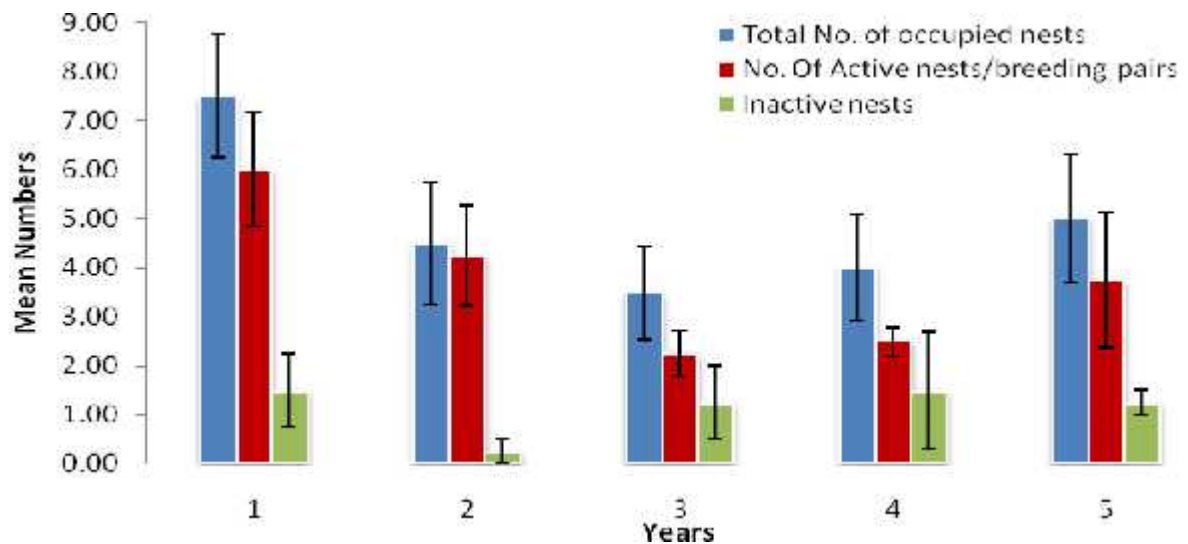


Fig. 2: Overall nests' status (mean±SEM) of Himalayan Griffions in study area.

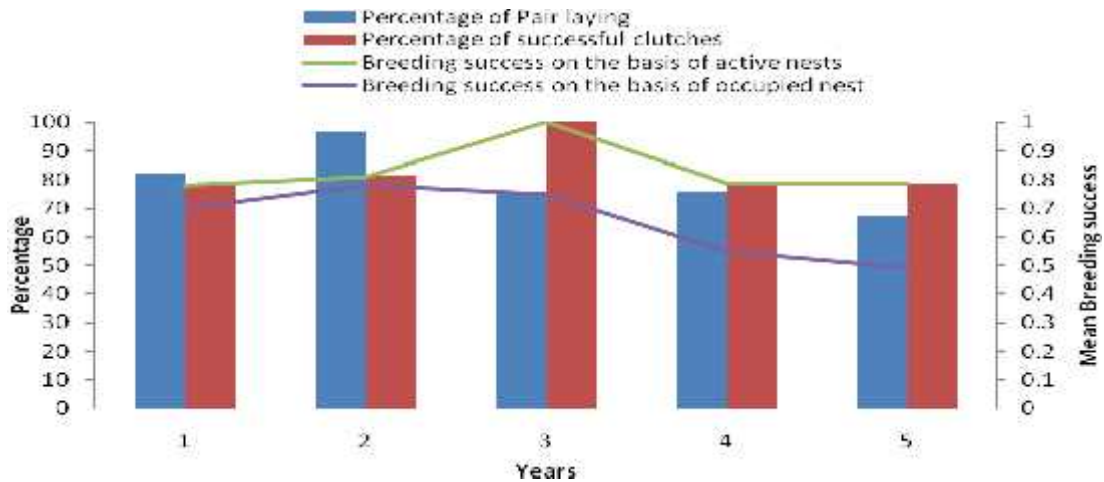


Fig. 3: Annual breeding activities status of Himalayan Griffions in study area.

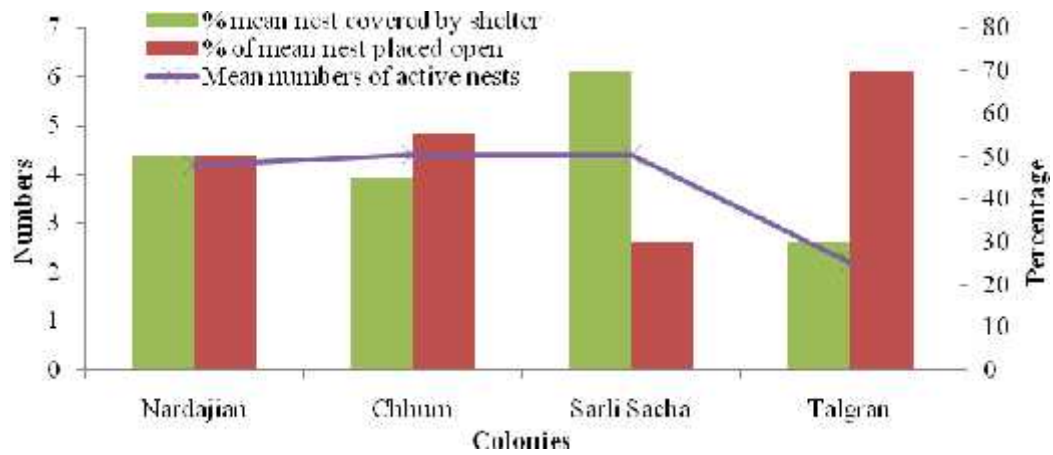


Fig. 4: Relationship between mean numbers of active nests and nest cover in different vulture sites during study period.

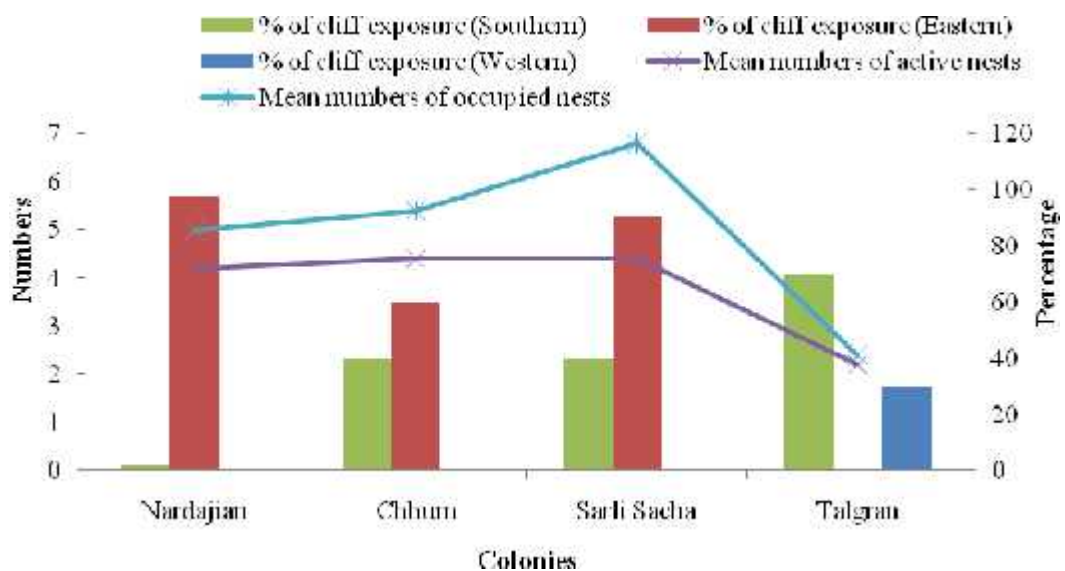


Fig. 5: Relationship between mean number of nests and cliff exposure during study period.

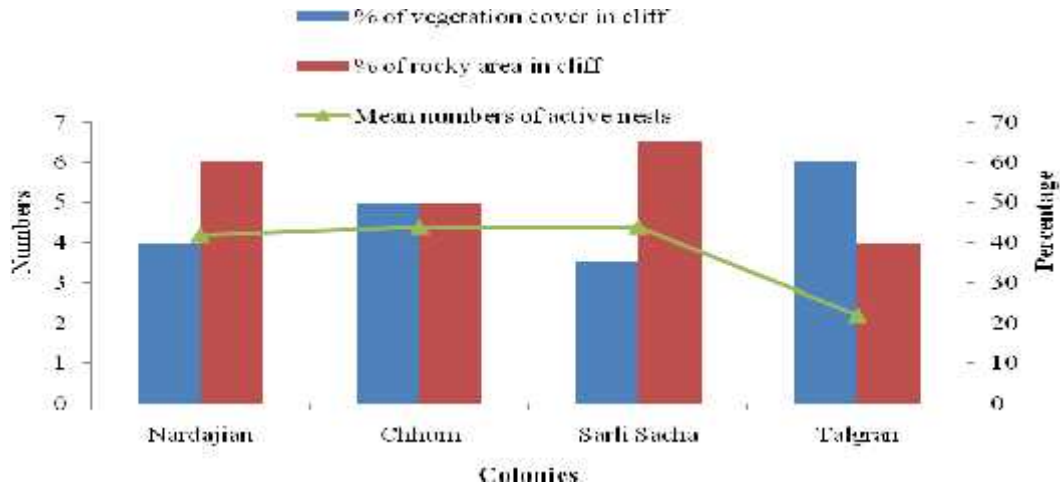


Fig. 6: Relationship among mean numbers of active nests, vegetation cover and rocky area during study period.

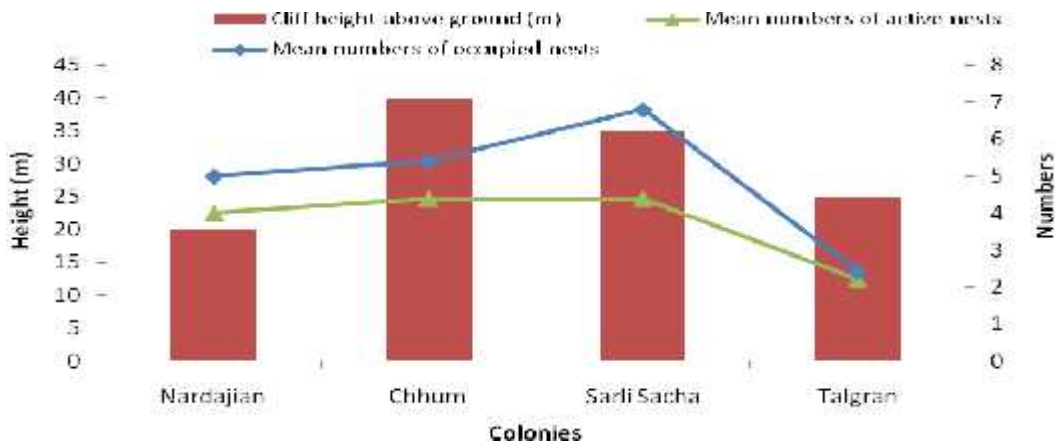


Fig. 7: Nesting trend along the cliff height (m) above the ground of different vulture sites of the study area during study period.

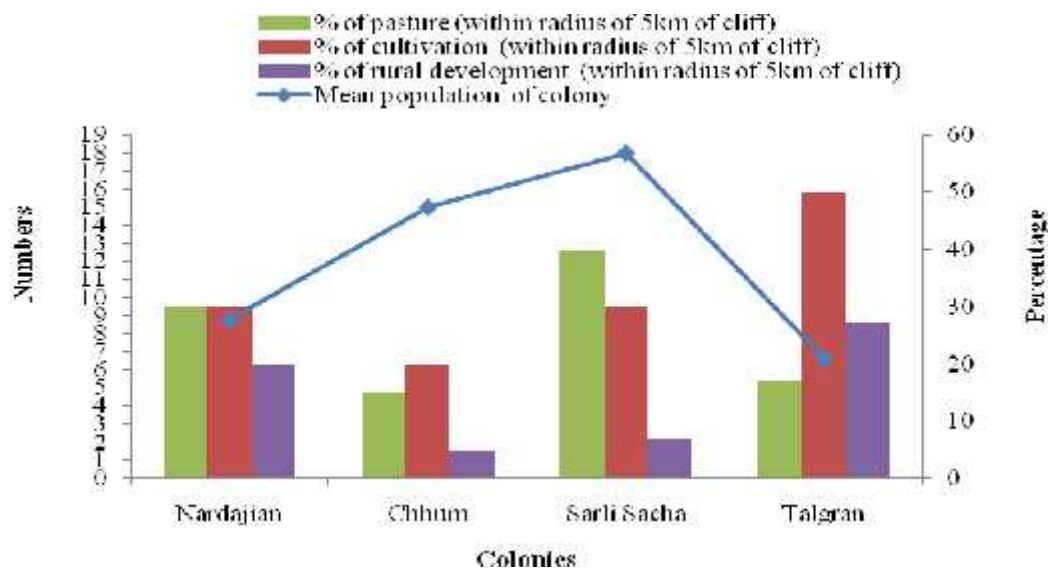


Fig. 8: Effects of anthropogenic factors on mean nesting site population of vulture sites.

Table 1. Summary of Himalayan Griffons nest status (mean±SEM) at four study sites.

Study Sites	Occupied Nests	Active Nests or Breeding pairs	Inactive nests	Failed nests	Successful nests or fledged
Nardajian	5.0±2.82	4.2±1.92	0.8±1.30	2.2±2.38	2.0±1.00
Chhum	5.4±1.67	4.4±2.30	1.0±1.22	0.2±0.44	4.2±1.92
Sarli Sacha	6.8±2.38	4.4±2.88	2.4±1.51	0.0±0.00	4.4±2.88
Talgran	2.4±1.14	2.2±1.30	0.2±0.44	0.4±0.54	1.8±1.30

Table 2. Summary of analysis of breeding activities (mean±SEM) of Himalayan Griffons documented during five years study period.

Study Sites	Nos. of Eggs Laid	Nos. of Eggs hatched	Nos. of Fledglings left the nest
Nardajian	3.8±1.48	2.0±1.00	1.8±1.10
Chhum	4.6±2.41	4.4±2.30	4.2±1.92
Sarli Sacha	4.4±2.88	4.4±2.88	4.4±2.88
Talgran	2.2±1.30	1.8±1.30	1.8±1.30

Table 3. Summary of population, habitat and breeding parameters of Himalayan Griffon at different study sites during 2005, 2007-2010.

Habitat Parameters	Nardajian	Chhum	Sarli Sacha	Talgran
Coordinates	34°12'13.41N; 73°50'35.80E	34°12'43.32N; 73°56'17.88E	34°30'51.80N; 73°39'23.43E	34°27'49.41N; 73°27'32.03E
Cliff elevation (m.a.s.l.)	2180	2090	2724	1670
% Cliff slope	65	80	60	75
Cliff height above ground (m)	20	40	35	25
Cliff length (m)	30	50	70	30
% of pasture (within radius of 5km of cliff)	30	15	40	17
% of vegetation cover (within radius of 5km of cliff)	60	80	30	50
% of rocky area (within radius of 5km of cliff)	10	5	30	33
% of rocky area in cliff	60	50	65	40
% of vegetation cover in cliff	40	50	35	60
% of cultivation (within radius of 5km of cliff)	30	20	30	50
% of rural development (within radius of 5km of cliff)	20	5	7	27
Distance to water from cliff (m)	30	20	27	70
Distance to nearest village from cliff (m)	70	35	30	40
Distance to paved road from cliff (m)	130	200	300	250
Distance to unpaved road from cliff (m)	50	45	70	80
Dominant vegetation (within radius of 5km of cliff)	<i>Pinus wallichiana</i> , <i>Picea smithiana</i> , <i>Juglans regia</i> , <i>Plactranthus</i>	<i>Pinus wallichiana</i> , <i>Picea smithiana</i> , <i>Juglans regia</i> , <i>Plactranthus</i>	<i>Pinus wallichiana</i> , <i>Taxus wallichii</i> , <i>Plactranthus</i> <i>rugosus</i> , <i>Viburnum</i>	<i>Pinus wallichiana</i> , <i>Taxus wallichii</i> , <i>Plactranthus</i> <i>rugosus</i> , <i>Viburnum</i>

Habitat Parameters	Nardajian <i>rugosus, Vibernum glandiflorum</i>	Chhum <i>rugosus, Vibernum glandiflorum</i>	Sarli Sacha <i>glandiflorum</i>	Talgran <i>glandiflorum, Indigofera heterantha</i>
% of cliff exposure (Southern)	2	40	40	70
% of cliff exposure (Eastern)	98	60	90	0
% of cliff exposure (Western)	0	0	0	30
Total numbers of households within radius of 5km of cliff	700	500	800	900
Total numbers of livestock (within radius of 5km of cliff)	4900	3500	5600	6300
% mean sent covered by shelter	50	45	70	30
% of mean nest placed open	50	55	30	70
Distance to nearest breeding site (m)	3000	3000	10000	10000
Mean nest height from the ground of the cliff (m)	10	20	15	18
Numbers of rubbish damps (within radius of 5km of cliff)	2	3	4	2
Distance to nearest rubbish damp from cliff	70	35	30	40
numbers of roosting sites (within radius of 5km of cliff)	3	4	3	2
Types of predatory bird (within radius of 20km of cliff)	Golden eagle, ?Kite, Raven	Raven, Golden eagle, Common kestrel	Raven, Golden eagle, ?Kite	Raven, ?Kite
Types of predatory mammals (within radius of 20km of cliff)	Jackal, Feral dogs, Common leopard, Red fox, Indian mongoose	Jackal, Common leopard, Red fox, Palm civet	Jackal, Feral dogs, Common leopard, Red fox, Indian mongoose, Palm civet	Jackal, Feral dogs, Red fox, Indian mongoose
Numbers of migratory domestic ungulates (within radius of 10km of cliff)	3500	2500	4000	3500
Mean numbers of active nests	4.2	4.4	4.4	2.2
Mean numbers of occupied nests	5	5.4	6.8	2.4
Mean numbers of young fledged	2	4.2	4.4	1.8
Mean population of colony	8.8	15	18	6.6

Table 4. Correlation matrix between different geographic parameters within the habitat of Himalayan griffons during study period.

	Cliff elevation (m.a.s.l.)	% Cliff slope	Cliff height above ground (m)	Cliff length (m)	% of rocky area (within radius of 5km of cliff)	% of rocky area in cliff	% of vegetation cover in cliff	% of cliff exposure (Southern)	% of cliff exposure (Eastern)	% of cliff exposure (Western)	% mean nest covered by shelter	% of mean nest placed open	Mean nest height from the ground of the cliff (m)	Mean numbers of active nests	Mean numbers of occupied nests	Mean numbers of young fledged	Mean population of site
Cliff elevation (m.a.s.l.)	1.00																
% Cliff slope	-	1.00															
Cliff height above ground (m)	0.75	0.37	1.00														
Cliff length (m)	0.84	-0.38	0.76	1.00													
% of rocky area (within radius of 5km of cliff)	0.01	-0.35	-0.17	0.16	1.00												
% of rocky area in cliff	0.93	-0.82	0.08	0.59	-0.16	1.00											
% of vegetation cover in cliff	-	0.82	-0.08	-	0.16	-	1.00										
% of cliff exposure (Southern)	0.93	0.45	0.30	0.07	0.65	-	0.70	1.00									
% of cliff exposure (Eastern)	0.43	-0.44	0.07	0.14	-0.69	0.79	-0.79	-0.97	1.00								
% of cliff exposure (Western)	0.58	0.37	-0.37	-	0.64	-	0.83	0.77	-0.90	1.00							
% mean sent covered by shelter	0.76	-0.77	0.33	0.82	0.02	0.94	-0.94	-0.44	0.58	-0.76	1.00						
% of mean nest placed open	1.00	0.77	-0.33	-	-0.02	-	0.94	0.44	-0.58	0.76	-1.00	1.00					
Mean nest height from the ground of the cliff (m)	-	0.76	0.71	0.22	0.08	-	0.63	0.79	-0.67	0.34	-0.38	0.38	1.00				
Mean numbers of active nests	0.34	0.79	-0.31	0.52	0.65	-0.58	0.79	-0.79	-0.64	0.80	-0.98	0.78	-0.78	-0.19	1.00		
Mean numbers of occupied nests	0.95	-0.54	0.52	0.82	-0.28	0.89	-0.89	-0.51	0.69	-0.91	0.94	-0.94	-0.23	0.94	1.00		
Mean numbers of young fledged	0.67	-0.05	0.93	0.93	-0.12	0.42	-0.42	0.08	0.16	-0.58	0.65	-0.65	0.44	0.71	0.77	1.00	
Mean population of site	0.84	-0.29	0.81	0.96	-0.11	0.64	-0.64	-0.11	0.33	-0.70	0.82	-0.82	0.19	0.81	0.90	0.97	1.00

Table 5. Correlation matrix between various anthropogenic variables and population parameters within the habitat of Himalayan Griffon’s vulture.

	% of pasture (within radius of 5km of cliff)	% of vegetation cover (within radius of 5km of cliff)	% of cultivation (within radius of 5km of cliff)	% of rural development (within radius of 5km of cliff)	Distance to nearest village from cliff (m)	Distance to paved road from cliff (m)	Distance to unpaved road from cliff (m)	Total numbers of households within radius of 5km of cliff	Mean numbers of active nests	Mean numbers of occupied nests	Mean numbers of young fledged	Mean population of site
% of pasture (within radius of 5km of cliff)	1.00											
% of vegetation cover (within radius of 5km of cliff)	-0.76	1.00										
% of cultivation (within radius of 5km of cliff)	-0.15	-0.45	1.00									
% of rural development (within radius of 5km of cliff)	-0.24	-0.13	0.86	1.00								
Distance to water from cliff (m)	-0.35	-0.27	0.98	0.86								
Distance to nearest village from cliff (m)	0.07	0.25	0.02	0.50	1.00							
Distance to paved road from cliff (m)	0.28	-0.68	0.29	-0.23	-0.87	1.00						
Distance to unpaved road from cliff (m)	0.15	-0.75	0.86	0.50	-0.39	0.72	1.00					
Total numbers of households within radius of 5km of cliff	0.31	-0.80	0.89	0.67	-0.04	0.48	0.93	1.00				
Mean numbers of active nests	0.46	0.14	-0.95	-0.88	0.04	-0.13	-0.71	-0.70	1.00			
Mean numbers of occupied nests	0.68	-0.19	-0.79	-0.86	-0.19	0.15	-0.43	-0.44	0.94	1.00		
Mean numbers of young fledged	0.25	-0.06	-0.67	-0.95	-0.73	0.51	-0.23	-0.47	0.71	0.77	1.00	
Mean population of site	0.47	-0.19	-0.70	-0.95	-0.59	0.46	-0.24	-0.41	0.81	0.90	0.97	1.00

Table 6. Estimated livestock population in District Muzaffarabad and Hattian during five-year study period.

Year	Total No. of households	Estimated total numbers of livestock in Study Area								Total
		Cows	Bulls	Buffaloes	Horses/ Mules	Donkeys	Goats	Sheep	Dogs	
2005	127324	499585	214724	20501	19422	63662	570800	357154	107902	1853750
2007	111549	119112	35923	5672	9453	11344	109659	65228	27415	383805
2008	114673	104955	29154	4859	4859	7774	101067	62195	19436	334300
2009	117884	106894	29970	4995	5994	7992	87913	68932	18981	331672
2010	148346	140803	41487	7543	6286	8800	134517	95545	22629	457610

Conclusion: Different habitat variables have substantial impact on the breeding activities of the HG in the study area. Selection of breeding cliffs by vultures was found one of the very important factors for vulture breeding population. Cliff elevation above the sea level, cliff height from ground, cliff length, cliff exposure and the open rocky area in the cliff were found strongly correlated with the breeding activities of the vulture. The maximum (70%) nests were placed in open rocky area at the Eastern exposures (60-98%). Food availability is also a critical factor having positive correlation with the breeding activities of the vulture in the study area.

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