Pakistan J. Zool., vol. 48(4), pp. 961-968, 2016.

Spatio-temporal Decline of Himalayan Griffon (*Gyps himalayensis* Hume, 1869) in Azad Jammu and Kashmir, Pakistan

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ABSTRACT

The population of three species of *Gyps* vultures has already declined in South Asia due to the use of diclofenac drug in veterinary practices. Therefore, in the wake of such alarming situation, there was a dire need to explore the current status of other *Gyps* species in the region. Correspondingly, our study assessed the status of breeding and overall population of Himalayan Griffon vulture *Gyps himalayensis* around Himalayan ranges of Muzaffarabad and Hattian districts, Azad Jammu and Kashmir, Pakistan during the years 2005, and 2007-2010 (year 1, 2-5). The Population was estimated by counting the vultures involved in active nest breeding (nesting site population) as well as, those encountered during transect surveys (transect count population). We found a mean (±SEM) population as 51.60±7.60 and 46±7.61 individuals on the basis of nesting site and transect survey counts during 2005, 2007-2010 in all study sites respectively. Eighty individuals with mean colony size 20±3.48 were recorded from all nesting sites in year 1 *i.e.*, 2005, which reduced to 51 (12.80±3.80) individuals in year 2007 translating to 36.25% overall decline in nesting site population at a rate of 12.08% per annum. This declining trend is further confirmed by a negative correlation of nesting site population (r= -0.76) and transect count population (r= -0.80) with study years. A decline of 75.31% in livestock population from year 1 to year 5 was recorded with annual decline of 12.5% (r= -0.79). There was strong positive correlation (r=0.95) between livestock numbers and nesting site population. Therefore, the shortage of food availability was found to be a major factor responsible for declining population of the Himalayan Griffon vulture in the area. Moreover, the reduction in carcass detectability by vultures, and changes in agro-pastoral system in the study area might also be among the contributing factors of declining vulture population.

Article Information
Received 6 June 2015
Revised 1 February 2016
Accepted 4 February 2016
Available online 1 June 2016

Authors' Contribution
MS designed and executed the study, analyzed the data and wrote the manuscript. AAK supervised the work.

Key words
Himalayan Griffon Vulture, population decline, food availability.

INTRODUCTION

Vultures perform important ecological, traditional and aesthetic functions. Vultures being the most successful scavengers dispose of carcasses and other organic wastes, providing highly effective free of cost sanitation services. They govern cleaning service, protect the health of humans, domestic animals and wildlife because without vultures, the other scavengers, some of which are established disease reservoirs increase considerably at carcasses (Pain *et al.*, 2003, 2008; Prakash *et al.*, 2003). However, their functions are now threatened following precipitous decline of more than 90% of their population throughout the Indian subcontinent (Prakash *et al.*, 2003).

Himalayan Griffon Vulture *Gyps himalayensis* is the bird of Palearctic and adjacent Indo-Malayan islands and is found in the mountains of south and central Asia, Himalayas in northern Pakistan, Kashmir, India, Nepal and Bhutan through Tibet and north Assam into central China, Afghanistan, Russia, Kazakhstan and Chinese Turkistan (Blandford, 1895; Baker, 1928; Bates and Lowther, 1952; Flint *et al.*, 1984; Lees and Christie, 2001). It is resident and relatively sedentary bird. In winter it haunts along the main valleys in the Himalayan foothills, ascending in summer to the highest alpine slopes, seen all over Chitral, Gilgit, Hunza, Baltistan, Kaghan Valley, Jhelum and Neelum valleys of Azad Kashmir (Roberts, 1991; Samant *et al.*, 1995; Awan *et al.*, 2004; Qamar *et al.*, 2008).

The population of *Gyps* vultures declined slowly during the 20th century in many parts of the world. About 96% decline in population of Oriental White-backed vultures (*Gyps bengalensis)* was recorded in India between 1991-1993 and 92% decline of Long-billed vulture *(Gyps indicus)* was recorded between 2000-2007 (Prakash, 1999; Prakash *et al.*, 2003, 2007). Similar declining population of Oriental White-backed vulture was also recorded in different areas of Nepal and Pakistan (Barel *et al.*, 2004; Gilbert *et al.*, 2002, 2004,). In Punjab (Pakistan), 50% per annum decline of Oriental White-backed vultures was recorded in years 2003-2004 (Gilbert *et al.*, 2004, 2006; Green *et al.*, 2004). Furthermore, similar population decline at an annual rate

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0030-9923/2016/0004-0961 $ 8.00/0

of 25% per year was recorded in the Long-billed vulture in Sindh Province of Pakistan (Gilbert *et al.*, 2004). In 2003, the Diclofenac, a non-steroidal anti-inflammatory drug (used to reduce the pain, fever and inflammation in livestock), emerged as the sole cause of rapid decline of Oriental White-backed vulture population in Punjab, Pakistan (Oaks *et al.*, 2004).

Due to the rapid decline in vulture populations, three species of *Gyps* vultures i.e., Long-billed Vulture, Oriental White-backed Vulture and Slender-billed Vulture have been listed as critically endangered by the International Union for Conservation of Nature (Birdlife International, 2013, 2014). However, the global population trends of Himalayan Griffon Vulture had not approached the thresholds for the declining population criteria of the IUCN Red List till 2012; hence, the species had been assessed as Least Concern (IUCN, 2012; Birdlife International, 2012). The best known stronghold for the Himalayan Griffon Vultures in Asia is Tibetan plateau having high density of this species (n=229,339) occupying the 2.5 million km^2 area (Xin Lu *et al.*, 2009). Besides these evaluations, the decline in their population had been reported in much of their range (Baral *et al.*, 2002; Green *et al.*, 2004; Acharya *et al.*, 2009; IUCN, 2012). Based on improved information, the global population status of these vultures has now been revised and shifted from "Least Concern" in 2012 to "Near Threatened" in 2014 (Birdlife International, 2014).

Five most important threats to vultures were identified as poisoning, habitat loss, disturbance, lack of awareness and declining food resources. Among these the ultimate limiting factor on the vulture population is food (Armstrong, 1993). Diclofenac appeared to be the main threat in subsequent years. Vultures exposed to diclofenac during feeding on carcasses of livestock dozed with the drug soon before death die of kidney failure within a few days of their exposure (Swan *et al.*, 2006). It has also been established that not only diclofenac but some other non-steroidal anti-inflammatory drugs (NSAIDs) are also harmful to vultures and other scavenging birds (Cuthbert *et al.*, 2006; Acharya *et al.*, 2009). Other reasons for the vultures' decline are development of modern agricultural methods and intensive use of pesticides; significant decrease in food sources due to the reduction in the number of sheep and cattle, wildlife hunting, low reproductive potential, habitat loss, infectious diseases, environmental pollution and damage to the natural environment (Leshem, 1985; Pain *et al.*, 2003; Prakash *et al.*, 2003; Green *et al.*, 2004).

However, the actual current status of Himalayan Griffon vulture has not been explored properly through most of its distribution range. Personal observations of authors in AJ&K indicate that the Himalayan Griffons once seen very frequently are nowadays encountered very rarely. Their unknown conservation status restricts the effective conservation measures in AJ&K/Pakistan and raises some critical research questions that whether these vultures have also been affected by the sudden population crash like other related three species? To address this issue and explore the unknown status of the species in question, the current study was designed to assess the spatial and temporal population trend of Himalayan Griffon Vulture in Azad Jammu and Kashmir.

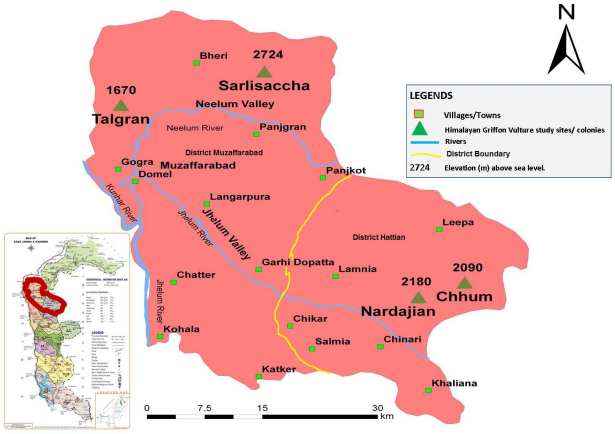

Fig. 1. Location/Distribution map of Himalayan Griffon Vulture colonies in AJ&K during 2005-2010.

MATERIALS AND METHODS

Study area: Nesting sites

We actively monitored four vulture colonies during 2005-2010, with the exception of 2006 owing to the Kashmir earthquake. Two colonies (Nardajian and Chhum) were located in Jhelum Valley and other two (Talgran and Sarli Sacha) in Neelum Valley (Fig. 1). All these colonies were named after the nearby villages. The first colony (Nardajian colony, 34˚12 13.41N, 73˚50 35.80E; 2180 m above mean sea level, amsl) was established on a steep rock at a height of 500 m from Nardajian Village. The second colony (Chhum colony, 34˚12 43.32N, 73˚56 17.88E; 2090 m amsl) was situated about 3 km away from Nardajian near Chhum village. Both colonies were located at a distance of about 20-23 km north-east from Chinari, a famous town on Srinagar-Muzaffarabad Highway. The third colony *i.e.*, Talgran colony (34˚27 49.41N, 73˚27 32.03E, 1670 m amsl) was located in Neelum Valley near the western boundary of Machiara National Park (MNP), at a distance of about 3 km from Talgran village and 5 km from Batal village on

Kahori-Saidpur road. The fourth colony, Sarli Sacha colony (34˚3051.80N, 73˚3923.43E, 2724 m amsl) is located at a distance of 500 m from Sarli Sacha village inside the south eastern boundary of MNP.

Methods

In order to collect field data on population dynamics of Himalayan Griffon vulture, 187 transect surveys of the breeding areas were carried out in both the Jhelum and Neelum Valleys during the breeding seasons of 2005, 2007-2010 with the exception of year 2006, when the study area was struck by a massive earthquake on October 8, 2005 and destroyed roads and bridge structures leading to these sampling sites. Two breeding sites in Jhelum Valley are geographically isolated from the sites of Neelum Valley (Talgran and Machiara National Park) by a road distance of about 70 km between them. Generally, roads towards the colonies were used as transects to assess the population status of Himalayan Griffon vultures. Sometimes it was difficult to find out the exact distance from transect to the vultures, especially when they were soaring. Therefore, the fixed width strip transect method was adopted using 1000 m strip-width (Bibby *et al*., 2000). Outside the colonies, a vehicle (4×4 Jeep) was driven at a speed of 20 km/hour with 2-5 observers keeping record of individuals. All counts were conducted during breeding season, starting from January to December except September, October and November. The density of Himalayan Griffon was calculated using the data collected during transect surveys and individuals observed in nesting sites of the colony. To minimize the double counting, method of Virani *et al.* (2008) was adopted and the probability of counting of the same bird twice was low because of rarity of their occurrence (Xin Lu *et al.,* 2009). Counting the number of raptors observed over the distance travelled is usually the primary method of estimation of population index (Fuller and Mosher, 1981; Bibby *et al.,* 2000). The length of transects varied depending upon the human settlements, altitude and climate. All vultures were observed from both sides of the road at a distance of 500 m, however, some bias may also be present in each year. The observations were made from 7.00 to 11.00 a.m. and 2.00 to 6.00 p.m., when vultures were more active (Postupalsky, 1974).

Detailed surveys based on interviews and questionnaires were carried out in the nearby villages of the study colonies. Efforts were made to find out the knowledge, views and perceptions of local people about vulture population decline, encounter with carcasses, hunting of vultures, use of pesticides and diclofenac, use of veterinary services, decrease/increase of livestock or any other impact of vulture decline, and the awareness about the use of pesticides. Interviews were also carried out with nomads, government veterinary officials and veterinarian storekeepers to obtain the information about the availability and use of diclofenac drug for livestock in the study area.

Appropriate statistical tests were performed using MS Excel 2010 and SPSS (ver.16).

RESULTS

Himalayan Griffon vulture is one of the two vulture species (other is Oriental White-backed vulture) occurring in AJ&K. During initial surveys of different areas, six active colonies of these vultures were found to exist in the northern parts of AJ&K. Two colonies, one each in Districts Neelum and Haveli were located in very remote areas, difficult to reach, hence these were excluded from detailed studies, and four colonies located at Nardajian, Chhum (District Hattian), Sarli Sacha and Talgran (District Muzaffarabad) were selected for detailed investigations.

At all sites, the mean (±SEM) population of Himalayan Griffon was estimated as 51.60±7.60 and 46±7.61 individuals on the basis of nesting site population count and transect survey counts, respectively. About 75 % (n=38) of the total population comprised of adult breeding individuals while the remaining 25% (n=13) comprised of newly fledged chicks.

Spatio-temporal population fluctuations

The maximum nesting site population was recorded from Sarli Sacha (18±3.30) followed by Chhum (15±2.25), Nardajian (9±2.44) and Talgran (6.6±1.56) (Table I). A sudden decline in population was recorded from 2005 population to 2007 population probably due to the drastic earthquake experienced in AJ&K in October 2005. A consistent decline in nesting site population was subsequently recorded during the years 2005, 2007, 2008; however, a slight increase was recorded in the following two years. A sum of 80 individuals with mean colony population of 20±3.48 (mean±SEM) were recorded from nesting sites in year 1, which reduced to 50 (10.00±2.72 individuals per colony) in year 5, suggesting a decline of 37.50% @ 7.50% p.a. in vulture population (Table II). Similar trends were also recorded in the mean transect count population in different vulture colonies during the study period. Mean transect count population was recorded as 70.4 (17.60±1.3) in year 1 which was sharply declined to 55.6 (13.90±2.6) in year 2007 (Table II).

The sharp declining trend in nesting site counts as well as transect counts from year 1 to 5 was observed at all sites. Although a slight increase in population was recorded at the end of the study period, not a single site

Table I.- Estimated mean (±SEM) population of Himalayan Griffons in AJ&K during the period 2005, 2007-2010

Study sites	Mean No. breeding individuals	Mean No. of fledglings	Mean nesting sites population	Mean transect count population
Nardajian	7.2±2.41	1.8±0.48	9.0±2.44	11.2±2.31
Chhum	10.8±1.49	4.2±0.86	15.0±2.25	11.2±1.93
Sarli Sacha	13.6±2.13	4.4±1.28	18.0±3.30	14.4±2.46
Talgran	4.8±1.01	1.8±0.58	6.6±1.56	8.0±2.10

showed complete recovery as of year 2005 (Fig. 2). The maximum population was recorded during February-May and minimum during December-January and July-August (Fig. 3). Among all sites, the highest mean transect count (n=54) was recorded in the month of April followed by March (n=53). However, at Sarli Sacha and Nardajian, the highest mean transect count was (n=16; n=14) recorded during the months of March and May respectively (Fig. 3). Similar trends of seasonal fluctuations were recorded during all study years (Fig. 4).

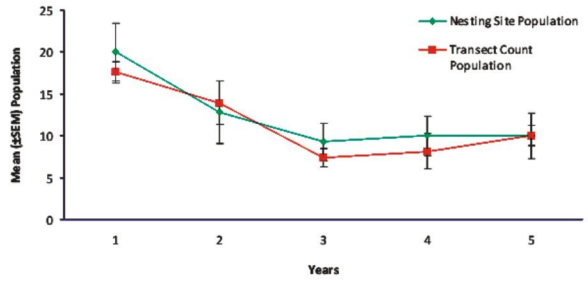

Fig. 2: Population dynamics of Himalayan Griffon.

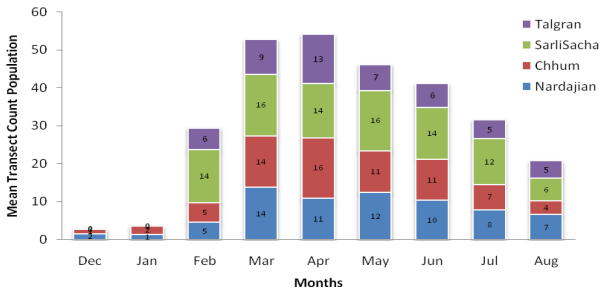

Fig. 3. Seasonal fluctuations in Mean Transect Count population of Himalayan Griffon at different study sites.

There was a negative correlation between the nesting site population and years (r=-0.76) and between mean transect population and years (r=-0.80). A two-way ANOVA showed a significant difference ($F_{(4,3)}$=7.12, p=0.003) in nesting site population of vultures during different years and between different sites ($F_{(3,4)}$=11.34, p=0.001). Further post-hoc analysis showed a significant difference (LSD=3.97) in nesting site population between Sarli Sacha-Talgran (11.4), Sarli Sacha-Nardajian (9.2), Chhum-Talgran (8.4) and Chhum-Nardajian (6.2).

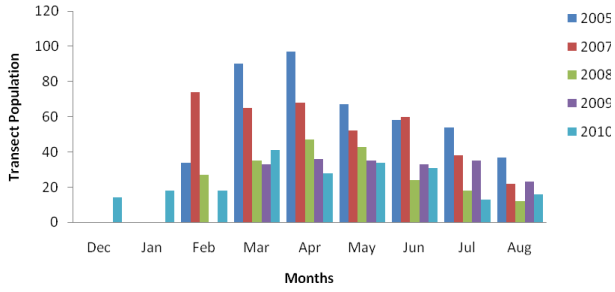

Fig. 4. Seasonal variations in population of Himalayan Griffon during different breeding cycles in different years.

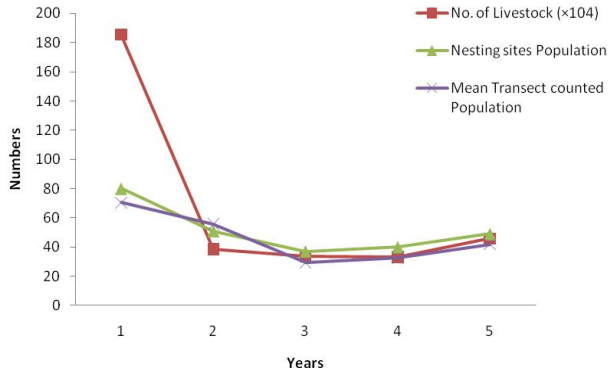

Fig. 5. Comparison between number of livestock and Himalayan Griffons' population during the period 2005, 2007-2010.

All vulture sites were explored in 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. In order to assess the food

availability of vultures, the livestock population of two districts was also estimated. Impact of food availability on population trend was determined. Based on livestock survey of 118 randomly selected households, a total of 1,853,750 livestock were estimated, however, during first four years, there was a steep decline from 1,853,750 livestock in 2005 to 383,805 and to further small decline of 334,300 and 331,672 (year 4) and then a sharp rise to 457,610 number of livestock in year 5 (2010), suggesting about 75.31% overall decline from year 1 to the year five with 12.5% annual decline (Table III).

Comparison of livestock and vulture population showed similar declining trend during the succeeding study years (Fig. 5). There was a sharp decline in population of livestock and vultures from year 1 to 2 and it remained stable from year 2 to 3 with a slight increase recorded in both populations (Fig. 5). There was a negative correlation (r=-79) between livestock and years and a strong positive correlation (r=0.95) was observed between nesting site population and livestock. Similarly a positive correlation (r=0.82) was observed between mean transect count of vulture population and numbers of livestock. A dramatic decline in the livestock population, observed after first year, seemed to be responsible for decline in the daily food availability to the vultures.

Ethno-vulture relationship

About 60% of the respondents agreed with the statement that vultures had declined from the study area; however, 40% respondents disagreed with the statement. The majority of respondents (97%) reported that livestock population had decreased in the area. About 98% of respondents disagreed with the statement that vultures were hunted. About 77% respondents used the pesticides (Aldrin, Ethion, Usathion, Arathion, Endrin, Heptachlor, Thiodane) in agriculture lands that were bought from the Agriculture departments and local Veterinary dispensaries. About 89% of respondents confirmed that veterinary services were present in the area, while rest of the respondents were unaware of these services. About 75% respondents were in favor of wildlife conservation in the area, and about 15% were not in this favor, while 10% were not aware of wildlife conservation. All of the respondents were unaware of any impact of pesticides on the vultures in the study area and similarly no any significant incidences of dead vultures were recorded during the filed surveys.

DISCUSSION

During the five year long survey period the mean (±SEM) nesting sites population and transect count population was estimated as 51.60±7.60 and 46±7.61 individuals respectively. A consistent decline in population was observed during first three years (1-3), followed by a slight increase in 2009-2010 in both nesting site and transect count vulture population. However, the population declined from 80 individuals in year 1 to 50 individuals in year 5, suggesting some 37.50% @ -7.5% per annum decline in vulture population. Iqbal *et al.* (2011) observed 64 Himalayan Griffon Vultures from February 28 to May 30, 2011 in Pitheali, Sanikot, Low Gali, Dao Khan, Reshian and Machiara National Park of Azad Jammu and Kashmir. Pitheali is near Talgran site, Sanikot, Low Gali and Daokhan are near to Chhum and Nardajain colonies, while, fourth colony Sarli Sacha is inside the Machiara National Park.

Observation of 64 individual indicates a positive sign of increase in vulture population from 50 to 64 individuals during year 2010 to 2011. Acharya *et al.* (2009) also observed 67-70% decline in Himalayan Griffon vulture population in 2002, 2004 and 2005 in upper Mastang, Nepal. They recorded a decline rate of 31-33% per year. According to Xin Lu *et al.* (2009), the recent population estimates of Himalayan Griffon vultures are approximately 286,749 (±5059) individuals in Tibetan plateau. According to Virani *et al.* (2008), the population of Himalayan Griffon vulture is slowly declining in Annapurna conservation area, Mastang, Nepal.

In current study, 7.50% annual decline is alarming as the population of these vultures is also suffering substantial declines likely due to diclofenac poisoning throughout the world (Acharya *et al.*, 2009; Das *et al.*, 2011). However, the use of diclofenac in current study area was very low as compared to Nepal studies. During current study, the maximum population was recorded in the months of February-May and minimum during July-August. Among all sites, the highest mean transect count population was recorded in the month of April; which is the most crucial time for egg laying and incubation.

A negative correlation between nesting site population (r= -0.76) and years and the transect count population and years (r= -0.80) suggested a sharp declining trend in first three years. Both of these population counts were positively correlated to the availability of livestock, which constitute the major part of the vulture food. Kushwaha and Kanujia (2010) pointed out that diclofenac is not the sole cause of vulture decline in India. They pointed out that habitat loss and food shortage were the other reasons responsible for the decline. Current findings agree with the study of Kushwaha and Kanujia (2010) as the use of diclofenac drug was not very common in the study area.

Table II.- Nesting Sites estimated population of Himalayan Griffons in AJ&K during the period 2005, 2007-2010.

Year	Colony	Total No. breeding individuals	Total No. of fledglings	Total nesting site Population	Mean transect count population
2005	Nardajian	16	1	17	17.0
	Chhum	16	7	23	17.8
	Sarli Sacha	20	8	28	20.8
	Talgran	8	4	12	14.7
	Total	**60**	**20**	**80**	**70.3**
2007	Nardajian	8	3	11	16.6
	Chhum	8	4	12	8.7
	Sarli Sacha	16	7	23	19.9
	Talgran	4	1	5	10.5
	Total	**36**	**15**	**51**	**55.6**
2008	Nardajian	6	3	9	9.0
	Chhum	10	2	12	6.6
	Sarli Sacha	10	3	13	9.3
	Talgran	2	1	3	4.6
	Total	**28**	**9**	**37**	**29.4**
2009	Nardajian	4	1	5	6.5
	Chhum	8	3	11	12.7
	Sarli Sacha	14	2	16	10.3
	Talgran	6	2	8	3.0
	Total	**32**	**8**	**40**	**32.5**
2010	Nardajian	2	0	2	7.0
	Chhum	12	5	17	10.2
	Sarli Sacha	8	2	10	11.7
	Talgran	5	1	6	7.4
	Mori Donala	10	5	15	5.7
	Total	**37**	**13**	**50**	**41.9**

Table III.- Estimated livestock population in District Muzaffarabad and Hattian during five year the period (2005, 2007-2010)

Estimated total number of livestock in the study area	2005	2006	2008	2009	2010
Total No. of households	127,324	111,549	114,673	117,884	148,346
Cows	499,585	119,112	104,955	106,894	140,803
Bulls	214,724	35,923	29,154	29,970	41,487
Buffaloes	20,501	5,672	4,859	4,995	7,543
Horses/mules	19,422	9,453	4,859	5,994	6,286
Donkeys	63,662	11,344	7,774	7,992	8,800
Goats	570,800	109,659	101,067	87,913	134,517
Sheep	357,154	65,228	62,195	68,932	95,545
Dogs	107,902	27,415	19,436	18,981	22,629
Total	1,853,750	383,805	334,300	331,672	457,610
%age decline / increase		79.29	12.89	0.78	27.52

In the study area, availability of food and sight ability of food to soaring vultures were important factors which might be responsible for declining population of Griffon vulture. Fakhar-e-Abbas *et al.* (2013) have also reported population decline of vultures in Pakistan due to shortage of food in the form of carcasses. According to

Zuberogoitia *et al.* (2009) reduced food availability induces behavioral changes in *Gyps* and systematic removal of ungulates from the mountains have caused the local population of vultures to decline.

Besides the food availability, reduction in the faculty of spotting the food by vultures is one of the newly emerging factors which might be responsible for annual decline in Himalayan Griffon vulture in Azad Jammu and Kashmir, Pakistan. In AJ&K, changed agro-pastoral trend has resulted in increase of shrub cover (Pers Obs.). This assumption is supported by the studies on vegetation cover. Dar (2012) also reported an increase in scrub vegetation from 6.8% to 30% /ha during years 1998 to 2009 in Machiara National Park that might cause hurdles in searching for carcasses by the soaring vultures. It is hypothesized that annual decline in winter grass cutting, promotion of stall feeding to livestock and decreasing nomadic pastoralism might be among the key factors responsible for annual increase in scrub cover around human settlements.

CONCLUSION

Eighty individuals were recorded from nesting sites in year 1 that reduced to 50 individuals in year 5, suggesting 37.5% overall decline in nesting site population at the rate of 7.5% per annum. There was 75.31% decline in livestock population from year 1 to year 5 with 12.5% annual decline. There was a strong positive correlation (r=0.95) between livestock numbers and vulture population.

Shortage of food was found to be the major factor responsible for declining the population of Himalayan Griffon vulture in the area, this factor was found strongly correlated to vulture population. Besides, the reduction in carcass detectability by vultures and changes in agro pastoral system in the study area might also be among the contributing factors in declining vulture population. Therefore, restoration of the traditional agro-pastoral system may be promoted by increasing livestock population on the open grasslands for the sustainable survival of the species in their native haunts.

Conflict of interest statement

There is no any conflict of interest among authors.

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