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EVALUATION OF SOCIAL AND BREEDING BEHAVIOUR OF CHINKARA (*GAZELLA BENNETTII*) IN WILD AND CAPTIVITY

M. H. Aziz[1], K. M. Anjum[1], K. Javed[2], K. Samiullah[3], Z. Ali[4], S. A. Khan[1] and S. Suleman[1]

[1]Department of Wildlife and Ecology, [2]Department of Livestock Production, University of Veterinary & Animal Sciences-Lahore; [3]Department of Zoology, Government College University, Faisalabad; [4]Department of Zoology, University of the Punjab, Lahore
Corresponding author: dr.harisaziz@yahoo.com

ABSTRACT

Breeding behaviour of Chinkara (*Gazella bennettii*) is more conspicuous in the wild than captivity where individuals do not achieve enough chance to show normal behaviour. These behavioural changes were observed in wild and captive sites of Punjab province of Pakistan from April 2013 to December 2013. Animals were observed randomly using scan sampling technique. The parameters under study were Vigilance, Resting, Grooming, Defecation/Urination frequency, time spent together Male-Female, Grouping, Alone, Affinitive interaction, Agonistic activity, Mounting frequency and Mounting Number etc. Vigilance was significantly less in the captive population than wild population. Resting was noticed more in the captive population than wild population. Frequency of Mounting occurred more in the wild than in the captivity significantly. Grooming behaviour was non-significantly different between wild and captive population. Results of this study indicate that if captive population is kept with appropriate gender relation in an enclosure and environmental disturbance is minimum the captive Chinkara population can be as productive as the wild population.

Key words: Chinkara, Breeding and social behaviour, Ethology, Wild and captivity.

INTRODUCTION

Wildlife includes the entire undomesticated fauna and uncultivated flora. Wildlife plays significant biological role in the maintenance of ecosystem on earth. Pakistan is rich in indigenous and exotic wildlife (Khan, 2006) including Chinkara. Chinkara (*Gazella bennettii*) belongs to order Artiodactyla, family Bovidae, and genus *Gazella*. Chinkara dominates in South Asian region. The genus *Gazella* includes ten species all over the world but overhunting has reduced its population number and distribution. Chinkara is present in India, Iran and Pakistan. In Pakistan it is present in Baluchistan, Sindh and Punjab. A small population of Chinkara is also reported from Margalla Hills in Islamabad, Kala Bagh area in Salt Range and Cholistan Desert (Roberts, 1997). Chinkara is nocturnal animal and prefers to browse small trees and shrubs at dawn and dusk (Bohra *et al*., 1992).

The IUCN status of Chinkara is declared Least Concern (LC) according to IUCN red data list in 2013 (IUCN, 2017). The physical appearance and fur colour of Chinkara is variable in different seasons.The coat colour also varies seasonally with darker brown and greyish in summer and winter, respectively. Body weight and horns are the characteristics of sexual dimorphism. Male have larger and circular rings on horns, while female have thin and without rings (Prater, 1971; Habibi, 2001). The height is from 0.6 to 0.8 m and length from 0.9 to 1.2 m, weight of an adult is 20 to 25 kg. The Chinkara males are highly territorial and can defend their territories. Males are more aggressive while females are more receptive for males in the breeding season. A group of Chinkara is called harem. Dominant males are capable of taking part in breeding (Dookia *et al.,* 2013). Indian Gazelles are polygamous and have defending horns in males. Male to male competition is frequent during the mating season. Mating begins by touching the laufschlagor under parts of female (Bohra *et al*., 1992; Habibi, 2011). Indian Gazelles have a gestation period of 5 to 5.5 months and often twins are reported. A majority of births occur in April (Mallon 2008; Arshad *et al*., 2010). Offspring are prosocial and they may stay with their mother for up to 12 months. Female Indian gazelles conceive at yearling stage (Mallon, 2008; Arshad and Gill, 2010; Habibi, 2011).

The threatened animal species are bred in captivity and reintroduced in their natural habitats (Rahbeck, 1993; Snyder *et al.,* 1996; Komers and Curman, 2000). Animals in captivity face different environmental conditions from wild (Price, 1999; Waples, 1999). Due to unnatural sounds, limited space, light conditions etc. captivity condition is more stressful than wild (Morgan and Tromborg, 2007). Captivity leads to stress and abnormal behavior, as reported by Lattin *et al*. (2017) that when wild house sparrow was kept in captivity, the behaviour of the bird changed. Further, it was observed that the stress hormone, corticosterone level increased in captivity. Similarly Love *et al*., (2017) reported that captivity enhances the stress related hormones. Captivity altered the normal innate immune system, bactericidal ability of plasma and wound healing.

Further, it was reported that captivity reduced the size of spleen and liver. Likewise, faecal concentrations of cortisol metabolites (FCM) is a commonly used stress indicator was found significantly higher in the population of African wild dogs when kept in captivity (Van-der Weyde *et al*., 2016).

The current study was designed to evaluate the comparative differences in the social and breeding behaviour of Chinkara in wild and captivity. The study may help us to make the managemental changes of Chinkara in captivity for their conservation and successful breeding.

MATERIALS AND METHODS

Site selection: Study was conducted from April, 2013 to December, 2013 at two different sites for observation of captive and wild population, respectively. Captive population was studied at Captive Breeding facilities for ungulates at University of Veterinary and Animal Sciences, Ravi Campus Pattoki, Punjab Pakistan. Wild population was studied at His Highness Sheikh Zayed Wildlife Park, Rahim Yar Khan which is 5000 Acre of fenced free range sanctuary area in the desert of Cholistan.

Collection of data: Behavioural aspects such as vigilance, resting, grooming, defecation/urination, time spent by male and female together, time spent in group, time spent alone, affinitive interaction, agonistic interaction, mounting, number of mounts and miscellaneous behavioural (feeding drinking etc.) were recorded with naked eye, by aid using the Bioscope, Binocular and Digital camera where necessary. Frequency of all the activities was recorded on Ethogram. All the observations were noted at considerable invisible heighted site without disturbing their normal activities according to the animal welfare regulations. If the animals were disturbed the data collection was stopped or shifted to other group until the group under observation started normal behaviour. All the data collected was added to Microsoft Excel Professional Plus 2013 data table in which an Ethogram was developed after consolidating the total data of 9 months.

Sampling Technique: Data were collected according to the scientific method of Instantaneous Scan Sampling. This method is constantly used in the sampling methodology of behavioural studies (Morrison *et al.,* 2006). Scan sampling is useful when data is collected for large animal population. To record the behaviour of each individual or a subset of the individuals; individual identification is usually not made. The behaviour of each individual scanned is intended to be an instantaneous sample.

Ethogram: An Ethogram was developed according to the requirement of current study plan. In which activity was added to the columns and animal identification was inserted in the rows, hence obtaining activity frequency along with the specific individual for four altered durations of study after Schleidt *et al. (*1984).

Frequency of observation: The data were collected thrice a day; dusk, noon and dawn. One hour was specified for each calculation time as ungulates activity is supposed to be maximum during dawn and dusk. One hour of observation was further divided into four parts with a gap of 10 minutes. Scan sample of observation was collected by keenly observing the group member and activity of each individual was noted in the ethogram according to the defined parameters of the study at that specific time interval.

Definition of the Parameters: Following parameters were studied and each was defined as follows:[1]

Male-female together (M-F): A pair of male and female individuals with each other apparently involved in similar activity and away from the other group members.

Group (GR): More than two individual are together at same place and involved in same activity were considered as a group.

Alone (AL): The animal was spotted separate from the group and was involved in individual different activity than group.

Affinitive Interaction (AI): Direct body-touching activities without apparent encounter among individuals, including mutual grooming and licking.

Mounting (MO): When male try to climb on the back of female for copulation was considered as Mount either successful or not.

Number of mounts (MO N): Each mounting attempt of male upon female was considered one mount, either successful intromission or not.

Resting (RE): The animal was declared resting while lying on the ground and in inactive state.

[1]Abbreviations: International Union for Conservation of Nature *(*IUCN); Kilogram (kg); Meter (m); Vigilance (VI); Resting (RE); Grooming (GM); Defecation/Urination frequency (D/U); Male-Female time spent together (MF); Time spent in Group (GR); Time spent Alone (AL); Affinitive interaction (AI); Agonistic activity (AA); Mounting frequency (MO); Mounting Number (MO N); Miscellaneous behaviour (MB); Frequency of Mounting (MO); Least Concern (LC); Captive Male 1-3 (CM1-3); Captive Females 1-7 (CF1-7); Wild Males 1-3 (WM1-3); Wild Females 1-7 (WF1-7).

Vigilance (VI): The condition of being watchful and alert, especially to danger.

Grooming (GM): Cleaning any personal body parts or other animal by using own body parts especially using head.

Agonistic Activity (AA): Animals are physically fighting with each other or involved in obvious agonistic activities.

Urinations/Defecation attempts (U/D): Animals is excreting faecal balls, urinating and hiding/spreading them with foot.

Miscellaneous Behaviour (MB): All Behavioural other than above parameters e.g. feeding, drinking, browsing, walking and standing etc. were recorded as miscellaneous.

Statistical Analysis: The data thus obtained were evaluated by Mann-Whitney U test. This test is globally used in ethological practices by the scientists and is more accurately result oriented (Meng *et al.,* 2010). The $P \leq 0.05$ was considered significant.

RESULTS AND DISCUSSION

Ethogram consists of 12 dependent variables of captive and wild population in Table 1 and Table 2, respectively. Then a statistical comparison of captive males with wild males (Table 3) and captive females with wild females (Table 4) was concluded from the data of Table.1 & Table 2. The results indicate that Resting, Agonistic interaction and Mounting behavioural pattern is significantly higher in wild population than the wild. Rest of all other parameters were found non-significantly different in both captive and wild populations.

The data were compared for 12 dependent variables. The results are noticeable for different variables which are significant while others are non-significant. The final activity percentage was calculated after developing frequency of each activity for the period of four and half months three times daily, each for captivity and wild which has been shown in different tables. Activity percentages of all parameter wereadded into row while Animal ID's were inserted in the column hence the tabular form achieved is Table 5 for captive population and Table 6 for wild population.

For second category same parameters were studied to compare wild and captive female behaviour. Both the population showed significant difference except for the Grooming. Vigilance was less in the captive females than wild females ($P \leq 0.05$). Resting parameter showed that females in captivity spent more time in resting than wild ($P \leq 0.05$).

Grooming showed non-significant results ($P = 0.180$) because the time spent in grooming was almost similar and it was more of the self-directed behaviour was also similar in the studies of (Canjun *et al.,* 2010). Defecation/ Urination parameter showed that in captivity individuals showed more frequency ($P \leq 0.006$) because of the readily available food resource. This difference may be due to the availability of water and fodder which is definitely higher in captive which showed more frequency (Makagon *et al.,* 2012) showed that at the individual level, the factors permit heterogeneity of social connection within group and identification of individuals who may show exclusively significant roles in maintaining social steadiness or information flow throughout the network. Male-Female together parameter showed that in captivity they spent more time together and in wild less chance of combined activity with frequency ($P \leq 0.05$). The possible reason for this difference may be that in wild individual had more time to spend in browsing and mating more frequently with different available mates rather than spending time with the single mate.

Time spent in group was more in wild and less in captivity with frequency ($P \geq 0.848$). This is due to the group formation and survival chances increases as the individual remains in the group especially the females which always prefer to remain in the group for protection and successful mating. Alone individuals spotted were more in the captivity and less in wild having ($P \leq 0.025$) may be due to less competition for water and food resources. Females in captivity showed more Affinitive interaction than in the wild with ($P \leq 0.025$). Females in captivity showed less Agonistic behaviour than in wild having ($P \leq 0.05$) because of less competition among individuals. Mounting frequency which for females was also taken as mounting the other females or being mounted was noticed more in the wild than captivity with ($P \leq 0.05$). The reason for enhanced mounting frequency may be the females being more productive because of the less captive stress on individuals. Male M1 was dominant in the captive enclosure and showed maximum mounting. This male was huge in size and body weight than the others two under study. Horn length was also more in this dominant male. This proved that female preferred dominant male which has larger body size and horn length, attractive body appearance and physique. Same was observed in the Wild which gave more Mounting number and male M1 was huge in size and also participated more in agonistic interactions.

Total Number of Mounts observed was more in captivity than in wild with ($P \leq 0.05$). This difference may be due to the reason that less interaction chances were offered in the wild than in captivity where more frequency was observed as individual approach was easy.Miscellaneous behaviour which includesbehaviour other than set parameters foraging and browsing etc. were more in wild than in captivity with ($P \leq 0.565$). Wild animals spent more time in browsing and foraging than

captive ones which were used to the offered fodder. Less effort was paid in the captive animal along with the less time spent in the browsing and search for food. Captive animals were used to offered fodder and gathered at the feeding points at the time of feeding. Though, reasoned that differences between wild and domestic stocks are quantitative in character and are best explained by response limits or behavioural frequency (Andersen *et al.,* 2006). Same results were conducted from our study that captive stocks behave differently in those traits which were mostly quantitative in character.

For third category when Males were compared for the Vigilance behaviour, they showed more in wild than in captivity with because of more competition in the wild. Resting behaviour was more observed in the captive than in wild with ($P \leq 0.05$) as discussed before. Parameter of Defecation/ Urination was more observed in captive than in wild with ($P \leq 0.827$) which may be because of the feed available in the captivity.

Male-Female together spotted were more in captivity than in wild with ($P \leq 0.658$). Group frequency was more in wild males than in captive with ($P \leq 0.827$). Time spent alone in males was more while in females was lower with ($P \leq 0.05$). Affinitive interaction was more noticed in the female population than in wild with ($P \leq 0.268$). Agonistic behaviour was more noticed in male with ($P \leq 0.050$) which proved to be the significant result in this category. This hypothesis was supported by our results indicating that the Wild population engaged in significantly more aggressive interactions as compared to the Captive. Meng *et al*., (2010) reportedsame results that males of wild population were found more aggressive. Mounting was also observed more in wild than in captivity with ($P \leq 0.05$). This is the reason the wild population are more productive and participate more in active breeding.

The mounting number was more observed in wild than in captive with ($P \geq 0.796$). Miscellaneous behaviour was more in wild males than in captive males with ($P \geq 0.50$). These results show the strong evidences to the point that the captive population show some behavioural variations which are due to environmental differences. In this study females showed more variations than the males.

Thus, based on our study it was concluded that if some factors of wild environment e.g. space allocation and proper sex ratio may be assured in the captivity then breeding efficiency can be improved in captivity. The current study only reported the differences in behavioural observations in wild and captivity. The exact reasons behind these changes are still unknown. Future studies may be planned to evaluate the physiological/hormonal changes in captivity.

Table 1. Shows the frequency % of each activity in captivity by respective animal

Activity	CM1	CM2	CM3	CF1	CF2	CF3	CF4	CF5	CF6	CF7
Vigilance	7.38	16.08	10.65	9.78	8.47	13.223	9.85	11.66	14.13	11.00
Resting	10.20	13.18	14.20	16.63	15.01	14.86	13.84	16.20	13.75	15,24
Grooming	15.70	18.65	12.36	6.60	7.99	5.62	6.86	7.12	5.50	5.32
Der/Urin	3.49	9.81	7.10	2.69	4.12	4.37	3.49	3.56	3.88	2.30
Male-Female	12.89	2.41	0.00	0.37	0.73	1.62	2.74	3.56	3.25	1.57
Group	14.23	13.02	23.58	34.47	34.26	31.71	32.79	31.04	31.00	32.77
Alone	10.87	14.47	12.50	2.69	1.94	2.00	1.75	0.98	1.63	2.66
Affinitive	12.75	1.93	0.14	0.37	0.73	1.87	2.49	3.68	2.75	1.57
Agonistic	0.54	0.16	0.28	0.00	0.00	0.00	0.00	0.00	0.13	0.12
Mounting	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00
Mounting No	0.27	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.13	0.12
Misc.	11.54	10.29	19.18	26.41	26.76	24.72	26.06	22.09	23.75	27.33

Abbreviations used: CM1-CM3 depicts Chinkara ID of Captive Male 1 to 3 and CF1-7 shows captive females 1 to 7. Table.1 shows the frequency % of all dependent variables (behaviour parameters) with respect to each captive animal studied.

Table.2 Shows the frequency % of each activity in wild by respective animal

Activity	WM1	WM2	WM3	WF1	WF2	WF3	WF4	WF5	WF6	WF7
Vigilance	15.64	24.52	19.29	22.74	19.42	21.14	21.52	24.33	24.31	17.29
Resting	9.07	8.01	9.91	9.90	9.65	10.97	11.11	9.89	8.77	10.24
Grooming	15.51	14.74	10.04	3.79	1.80	2.29	3.74	9.67	6.77	6.59
Der/Urin	4.07	8.01	5.86	3.55	1.23	0.91	0.47	1.00	0.88	0.59
Male-Female	3.42	0.16	0.00	0.49	0.45	0.23	2.74	3.56	3.25	1.57
Group	20.24	6.89	26.55	32.27	36.48	36.34	32.63	28.22	28.70	31.88
Alone	3.94	17.79	6.47	1.34	0.79	1.14	0.82	0.44	2.26	0.82
Affinitive	4.47	0.00	0.00	0.49	0.34	0.23	0.47	1.00	0.88	0.59
Agonistic	4.47	3.85	1.72	0.00	0.11	0.34	0.35	0.22	0.75	0.12
Mounting	2.50	0.80	0.26	0.12	0.45	0.00	0.94	0.78	0.75	0.00
Mounting No	1.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Misc.	14.27	15.22	20.08	25.31	29.29	26.40	26.32	23.56	24.81	29.65

Abbreviations used: same as in Table.1 Table.2 shows the frequency % of all dependent variables (behaviour parameters) with respect to each wild animal studied.

Table.3 Showing the Mann-Whitney U test and P Value among Males of Captive and Wild origin in Table 1 & 2

	Vigilance	Resting	Grooming	Def/urin	Mf	Group	Alone	Affinitive	Agonistic	Mounting	Mounting no	Misc.
Mann-Whitney U	1.000	.000	2.000	4.000	3.500	4.000	3.000	2.000	.000	.000	4.000	2.000
P value. (2-tailed)	.127	.050	.275	.827	.658	.827	.513	.268	.050	.046	.796	.275

Table.3 is statistical comparison of Table 1 & 2 respective values. It shows that Parameters of resting, agonistic and mounting are significant and show difference in the behaviour of captive and wild Chinkara. Rest all behaviour parameters are almost same in both populations.

Table.4 Showing the Mann-Whitney U test and P Value among Females of Captive and Wild origin Table 1 & 2.

	Vigilance	Resting	Grooming	Def/urin	Mf	Group	Alone	Affinitive	Agonistic	Mounting	Mounting no	Misc.
Mann-Whitney U	.000	.000	14.000	3.000	8.000	23.000	7.000	7.000	8.500	9.000	10.500	20.000
P value. (2-tailed)	.002	.002	.180	.006	.035	.848	.025	.025	.033	.028	.025	.565

The table above shows that Females of Wild and captive origin behave more differently than males and show Significant value for Vigilance, Resting, Defecation/Urination, Male-Female time spent together, Time spent alone, Affinitive interaction, Agonistic interaction, Mounting and Mounting Number.

Table.5 Shows the frequency % of each activity in captivity by respective animal

Activity	CM1	CM2	CM3	CF1	CF2	CF3	CF4	CF5	CF6	CF7
VI	7.38	16.08	10.65	9.78	8.47	13.23	9.84	11.64	14.13	11.00
RE	10.20	13.18	14.20	16.63	15.01	14.86	13.82	16.18	13.75	15.24
GM	15.70	18.65	12.36	6.60	7.99	5.62	6.85	7.11	5.50	5.32
D/U	3.49	9.81	7.10	2.69	4.12	4.37	3.49	3.55	3.88	2.30
MF	12.89	2.41	0.00	0.37	0.73	1.62	2.74	3.55	3.25	1.57
GR	14.23	13.02	23.58	34.47	34.26	31.71	32.75	31.00	31.00	32.77
AL	10.87	14.47	12.50	2.69	1.94	2.00	1.74	0.98	1.63	2.66
AI	12.75	1.93	0.14	0.37	0.73	1.87	2.49	3.68	2.75	1.57
AA	0.54	0.16	0.28	0.00	0.00	0.00	0.00	0.00	0.13	0.12
MO	0.13	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.13	0.00
MN	0.27	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.13	0.12
MB	11.54	10.29	19.18	26.41	26.76	24.72	26.03	22.06	23.75	27.33

Abbreviations Used: Vigilance (VI); Resting (RE); Grooming (GM); Defecation/Urination frequency (D/U); Male-Female time spent together (MF); Time spent in Group (GR); Time spent Alone (AL); Affinitive interaction (AI); Agonistic activity (AA); Mounting frequency (MO); Mounting Number (MO N); Miscellaneous behaviour (MB). Captive Male 1-3 (CM1-3); Captive Females 1-7 (CF1-7); Wild Males 1-3 (WM1-3); Wild Females 1-7 (WF1-7) The table shows the behaviour parameters of captive males and females elaborating the percentage time spent in each behavioural presentation. Resting, Grooming and Miscellaneous behaviour was higher in captive population.

Table.6 Shows the frequency % of each activity in wild by respective animal

Activity	WM1	WM2	WM3	WF1	WF2	WF3	WF4	WF5	WF6	WF7
VI	15.64	24.52	19.29	22.74	19.42	21.14	21.52	24.33	24.31	17.29
RE	9.07	8.01	9.91	9.90	9.65	10.97	11.11	9.89	8.77	10.24
GM	15.51	14.74	10.04	3.79	1.80	2.29	3.74	9.67	6.77	6.59
D/U	4.07	8.01	5.68	3.55	1.23	0.91	1.64	0.89	1.13	2.24
MF	3.42	0.16	0.00	0.49	0.45	0.23	0.47	1.00	0.88	0.59
GR	20.24	6.89	26.55	32.27	36.48	36.34	32.63	28.22	28.70	31.88
AL	3.94	17.79	6.47	1.34	0.79	1.14	0.82	0.44	2.26	0.82
AI	4.47	0.00	0.00	0.49	0.34	0.23	0.47	1.00	0.88	0.59
AA	4.47	3.85	1.72	0.00	0.11	0.34	0.35	0.22	0.75	0.12
MO	2.50	0.80	0.26	0.12	0.45	0.00	0.94	0.78	0.75	0.00
MN	1.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MB	14.72	15.22	20.08	25.31	29.29	26.40	26.32	23.56	24.81	29.65

Abbreviations Used are same as in table 5. The table shows the behaviour parameters of wild males and females elaborating the percentage time spent in each behavioural presentation. Vigilance and time spent in group was higher among wild population.

REFERENCES

Andersen, I.L., E. Nævdal, K.E. Boe and M. Bakken (2006). Significance of theories in behavioural ecology for solving problems in applied ethology-Possibilities and limitations. Appl. Anim. Behav. Sci. 97: 85-104.

Arshad, M.I. and A.H. Gill (2010). Population Status of Indian Chinkara in Cholistan Game Reserve, Punjab, Pakistan. Russian J Ecol. 41 (6): 524-530.

Bohra, H., S. Goyal, P. Ghosh and I. Prakash (1992). Studies on ethology and eco-physiology of the antelopes of the Indian desert. Ann. Arid. Zone. 31(2): 83-96.

Canjun, X., X.U. Wenxuan, Q.I.A.O. Jianfang, Y.A.N.G. Weikangh and L.I.U. Wei (2010). Diurnal behavioural time budgets of the Goitered gazelle across seasons in the Kalamaili Mountain Ungulate Nature Reserve, Xinjiang. Acta. Ther. Sinica. 30(2): 144-150.

Dookia, S. and G.R. Jakher (2013). Social organization and population dynamics of Indian Gazelle (gazellabennettii) in Thar desert of Rajasthan, India. Tiger paper. 40(1): 5-14.

Habibi, K. (2011). "Chinkara" (on-line). Encyclopaedia Iranica. Accessed Sep, 17, 2013 at http://www.iranicaonline.org/articales/chinkara-chinkara-gazella-bennetti-indian-gazelle-is-a-small-antelope-of-slender-build-its-tawny-coat-has-poorly-marked.

Habibi, K., D.P. Mallon and S.C. Kingswood (2001). Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge. 122-128p.

IUCN SSC Antelope Specialist Group(2017). Gazella bennettii. The IUCN Red List of Threatened Species 2017: e.T8978A50187762. Downloaded on 24 September 2017.

Khan, M. S. (2006). Amphibian and reptiles of Pakistan. Krieger Publishing Company. Krieger drive Malabar, Florida 32950. 42-242.

Komers, P.E. and G.P. Curman (2000). The effect of demographic characteristics on the success of ungulate re-introductions. Biol. Conserv. 93: 187-193.

Lattin, C. R., A. V. Pechenenko and R. E. Carson (2017). Experimentally reducing corticosterone mitigates rapid captivity effects on behavior, but not body composition, in a wild bird. Horm. Behav. 89: 121-129.

Love, A. C., M. B. Lovern and S. E. DuRant (2017). Captivity influences immune responses, stress endocrinology, and organ size in house sparrows (Passer domesticus). Gen. Comp. Endocrinol. 252: 18-26.

Makagon, M. M., B. McCowan and J. B. Mench (2012). How can social network analysis contribute to social behaviour research in applied ethology? Appl. Anim. Behav. Sci. 138: 152-161.

Mallon, D. (2008). "*Gazellabennettii*." (On-line). In: IUCN 2011. IUCN Red List of Threatened Species.

Meng, X., Y. Hong, Y. Qisen, F. Zuojian, P. Xu, C. Genevieve and Perkins (2010). Preliminary findings of behavioural patterns in captive alpine musk deer (*Moschussi fanicus*) and prospects for future conservation. Turk. J. Vet. Anim. Sci. 34(2): 111-117.

Morgan, K.N. and C.T. Tromborg (2007). Sources of stress in captivity. Appl. Anim. Behav. Sci. 102(3): 262-302.

Morrison, M.L., B.G. Marcot and R.W. Mannan (2006). Wildlife Habitat Relationship: concepts and application. 3rd edition. Island Press, 1718 Connecticut Ave., NW, Suite 300, Washington, D.C. 20009. 7: 220-253.

Prater, S.H. (1971). The book of Indian animals. Bombay Natural History Society, Bombay. 324.

Price, E.O. (1999). Behavioral development in animals undergoing domestication. Appl. Anim. Behav. Sci. 65: 245-271.

Rahbeck, C. (1993). Captive breeding – A useful tool in the preservation of biodiversity? Biodivers. Conserv. 2: 426-437.

Roberts, T. J. (1997). The Mammals of Pakistan.Revised Edition, Oxford University Press Karachi, Pakistan. 525pp.

Schleidt, W.M., G. Yakalis, M. Donnelly and J. McGarry (1984). A proposal for a standard ethogram, exemplified by an ethogram of the bluebreasted quail (Coturnixchinensis). Zeits.Tierpsy. 64: 193-220.

Snyder, N.F.R., S.R. Derrickson, S.R. Beissinger, J.W. Wiley, T.B. Smith, W.D. Toone and B. Miller (1996). Limitations of captive breeding in endangered species recovery. Conserv. Biol. 10: 338-348.

Van-der Weyde, L., G. Martin and M. Paris (2016). Monitoring stress in captive and free-ranging African wild dogs (Lycaon pictus) using faecal glucocorticoid metabolites. Gen. Comp. Endocrinol. 226: 50-55.

Waples, R.S. (1999). Dispelling some myths about hatcheries. Fisheries. 24: 12-21.