Pakistan J. Zool., vol. 43(4), pp. 769-775, 2011.

Social Structure of Goitred gazelles *Gazella subgutturosa* in Xinjiang, China

Jianfang Qiao,[1] Weikang Yang,[1]* Wenxuan Xu,[1,2] Canjun Xia,[1,2] Wei Liu[1] and David Blank[1]
[1]*Key Laboratory of Biogeography and Bioresource in Arid Land, Xinjiang Institute of Ecology and Geography, the Chinese Academy of Sciences, Urumqi, 830011, China*
[2]*Graduate University of Chinese Academy of Sciences, Beijing 100049, China*

Abstract.- The social structure of Goitred gazelles (*Gazella subgutturosa*) in Xinjiang Province was studied over a two-year period (2005-2007). We observed 564 gazelle herds (3186 individuals), and distinguished among them 6 types: females, males, sub-adults, solitary individuals, mixed groups, and unidentified gazelles. In spring, male groups were noted most often (45.7%); in summer and autumn, female herds was more abundant (53.0% and 70.4%, respectively); and in winter, mixed groups were most numerous (60.0%). The observation frequency of herds varied significantly by season (χ^2 = 68.45, P < 0.01). Group size fluctuated from 1 to 95 individuals. Groups of 1-5 individuals were recorded most often (65.5%), while bigger groups (6 - 10 gazelles) were less abundant (23.1%). Large-scale groups (11 - 20 individuals) and groups of more than 20 individuals were quite rare (9.2% and 2.2%, respectively). Groups of 3 gazelles were most common (20.0%). In spring and summer, gazelles preferred to stay in smaller groups (mean group size was 4.45 and 4.94, respectively), while in autumn and winter, they stayed in larger groups (6.66 and 6.00, respectively). Spring group size was significantly different from the autumn and winter group sizes. Solitary gazelles were noted most often during the birthing season in spring and the rutting season in early winter.

Key words: China, *Gazella subgutturosa*, group size, social structure, goitred gazelle.

INTRODUCTION

Gazella subgutturosa are middle-sized gazelles, which live in semi-deserts and deserts on the Asian Continent, and are classified as a vulnerable species by IUCN. The natural habitat of the Goitred gazelle is vast compared to any other gazelle species, ranging from the deserts of the Arabian Peninsula, through Iran, Afghanistan, and the spacious arid regions of Middle Asia, to the deserts of northwestern China and Mongolia. In China, Goitred gazelles have spread to Xinjiang, Qinghai, and Gansu Provinces and Inner Mongolia. Goitred gazelle populations have steadily declined in number throughout their range due to habitat loss and poaching. Human activity has had the largest impact on habitat loss through factors such as the constant extension of agricultural lands and the degradation of pastures due to livestock overgrazing and mineral exploitation (Thouless *et al*., 1991; Kingswood and Blank, 1996; IUCN, 2006).

For herding ungulates, the size and composition of groups are the simplest and most basic elements of their social organization (Barrette, 1991; Raman, 1997). External ecological factors such as habitat, seasonal changes, and food quality and abundance influence group size (Berger, 1978; Clutton-Brock *et al*., 1982; Gerard *et al*., 2002; Hillman, 1987), as well as internal physiological factors connected to the reproductive cycle (Li *et al*., 2007; Lian *et al*. 2005; Lu and Wang, 2004). Some researchers in past studies of Goitred gazelles in Middle Asia (Mambetzhumaev, 1970; Sludsky, 1956; Zhevnerov, 1984) did not give special consideration to this subject, though they described some elements of group composition. Over the last few years, some authors have studied seasonal differences in group size (Gao *et al*., 1996; Xu *et al*., 2008) and spring social segregations (Habibi *et al*., 1993). Despite these investigations, our knowledge on the Goitred gazelle's social structure remains quite limited. That's why we devoted our study to group size and composition and their variations depending on seasonal changes and reproductive cycles over a year. This paper will help us not only to gain a better understanding of the Goitred gazelle's behaviour and fill in some gaps in our theoretical knowledge

* Corresponding author: yangwk@ms.xjb.ac.cn
0030-9923/2011/0004-0769 $ 8.00/0

on their social structure, but also to improve management conservation of this quite rare species.

MATERIALS AND METHODS

Study area

Our investigations were conducted from November 2005 to May 2007 in Kalamaili Mountain Nature Reserve (KNR) (88°30' – 90°03'E, 44°36' – 46°00' N). The reserve is located in eastern Junggar Basin, Xinjiang, China and covers an area of 18,000 km^2 (Chu *et al*. 2009). Junggar Basin lays in the tectonic depression between Altai and Tian-Shan mountains in northwestern China at a height between 500 and 1470 m above sea level (Unatov, 1960). Plains in the northern and southern areas, sand dunes in the western region, and the rolling hills in the center dominate Kalamaili reserve.

The climate is a harsh continental type with an average yearly temperature of +1.99°C, which is lower compared to Middle Asia, but higher than in Northern Mongolia. Winters are long and cold (average temperature in January is -24.3°C) with an uneven snow cover (thin on hills and deep on plains); summer is hot and quite short (average temperature in July is +20.5°C). Most precipitation is noted during spring and early summer. KNR has 186.8 mm average annual rainfalls and 2090 mm of an annual evaporation rate (Chu *et al*., 2009).

Such a climate system influences the vegetation of this region. Ephemeral plants are abundant and common in early spring. The vegetation cover is quite sparse and consists mostly of desert shrubs and dwarf shrubs (Unatov, 1960). The most common desert tree in the reserve is *Haloxylon ammodendron*, and the usual shrubs are *Anabasis salsa*, *Artemisia*, *Atraphaxis frutescens*, *Calligonum mongolicum*, *Ceratocarpus arenarius*, *Ceratoides lateens*, and *Reaumuria soongorica*. Of herbaceous species it's possible to find, mostly under shrub patches: *Allium polyrhizum*, *Chorispora tenella*, S*tipa glareosa*, and some *Astragalus* species. The species from genus *Sterigmostemum*, *Alyssum*, *Scorzonera*, *Erysimum*, *Eremurus*, *Sonchus*, and *Lappula* are common here.

Goitred gazelles and khulans (*Equus hemionus*) are the most common wild ungulate species in the reserve. There are also the more rare argali (*Ovis ammon*) and reintroduced Przewalski's horses (*Equus przewalskii*) released in the last several years. In addition, 2,000 herdsman and 200,000 head of livestock stay in the reserve during winter (Chu *et al*., 2008; Liu *et al*., 2008).

Behavioural observation

Our survey of Goitred gazelles was done monthly during 2005-2007. We went by car at a low speed (less than 30 km /h) from the center of the reserve to the east, south, west and north, each in turn. The length of transects varied from 30 to 53 km. We stopped the car and searched for gazelles using binoculars (magnification 8 ×) and a telescope (magnification 20 × -60 ×) every 5 km along each transect line. We recorded group size, sex and age of every gazelle. We distinguished three ranks of age: adults (more than 12 months of age); sub-adults (4-12 months); and young (younger than 4 months). Identifications were made based on the following criteria: adult males have remarkably long (20-30 cm) horns and females are hornless; sub-adults have a relatively smaller body size compared to adults and a black spot on their muzzle, as well as, relatively short horns (no longer than 10 cm); and young are distinguished by significantly smaller body size compared to adults.

We distinguished 6 types of groups: (1) male groups; (2) female groups, females with sub-adults and/or young; (3) mixed groups, male and female adults with sub-adults and young; (4) sub-adults, females and males under 12 months old; (5) solitary gazelles, dividing them further by single males and solitary females; and (6) unidentified gazelles, the sex and age of which were impossible to identify due to distance.

Four biological seasons were determined: spring (April to May); summer (June to August); autumn (September to October); and winter (November to March). Based on these biological periods, we thought that patterns in group size and composition would correlate according to seasonal changes of external ecological and internal physiological factors.

Statistical analyses

Mean group size (MGS) was calculated by arithmetic means. First, we calculated MGS in

different months and seasons. Then MGS of various group types in different seasons was computed. One-way ANOVA was used for searching any differences in MGS between seasons. Male groups, female and mixed groups were also tested by ANOVA to determine any differences between seasons. Second, Chi-square analyses was used for frequency testing of male groups, female and mixed groups between seasons. Estimates of group composition and size were based on 3186 sightings of Goitred gazelle in 564 groups. Some groups could not been identified due distance, and these data were used for calculation of MGS only.

RESULTS

Group size

The MGS for all group types for an entire year was 5.49. MGS for each month changed significantly from 4.14 (May) to 7.53 (January) (Fig.1). MGS was 4.45 (n=108) in spring, 4.94 (n=96) in summer, 6.66 (=112) in autumn, and 6.00 (n=248) in winter.

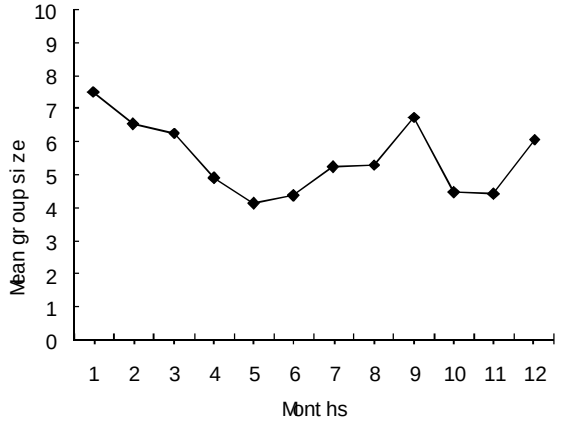

Fig. 1. Mean group size fluctuation during a year.

We found that the MGS had significant differences between seasons (ANOVA, df=3, F=2.85, p<0.05), among them the MGS in spring was significantly different from the MGS in autumn (ANOVA, df=1, F=2.21 P<0.05) and winter (ANOVA, df=1, F=1.54, P<0.05). Group sizes varied from 1 to 95 individuals (Fig. 2), with groups of 3 animals the most often noted at 20.0%. We registered 63 solitary gazelles (11.2%); 306 groups of 2-5 individuals (54.3%), 130 herds of 6-10 gazelles (23.1%), 52 groups of 11-20 individuals (9.2%), and 13 groups of more than 20 animals (2.2%). The largest groups (more than 20 animals), including the biggest (95 gazelles), were observed in autumn.

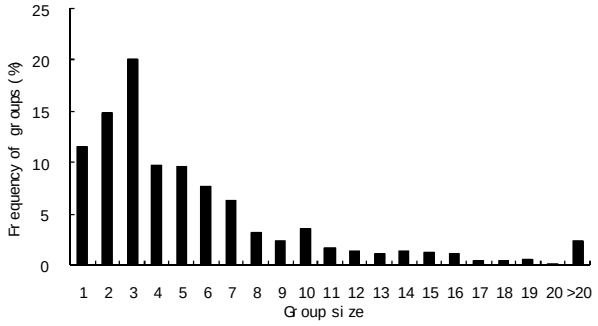

Fig. 2. Distribution of group sizes in Goitred gazelles.

Group types over seasons

We noted 51 male groups containing 274 animals and accounting for 15.4%, with a MGS of 5.37; 120 female groups containing 465 animals and accounting for 36.3% with a MGS of 3.88; 107 mixed groups containing 727 animals and accounting for 32.3% with a MGS of 6.79; and 6 sub-adult groups containing 22 gazelles and accounting for 1.8% with a MGS of 3.67. Also identified were 47 solitary gazelles, 33 males, 13 females and 1 sub-adult, accounting for 14.2%. Mixed groups were larger in size compared to other group types in all seasons, except spring (Fig. 3). Significant differences in size among male groups were not found over seasons; the same results were determined for female and mixed groups. (ANOVA, df=3, F=0.28, p> 0.05; F=0.41, p> 0.05; F=2.55, p> 0.05 – Fig. 3). The monthly MGS of female groups fluctuated from 2.40 to 4.50 individuals. The MGS of female groups in spring decreased to a minimum of 3.36 just prior to parturition, with the biggest group containing only 6 animals during that time. The MGS of female groups in autumn increased to a maximum of 4.10, with the biggest group consisting of 22 animals. Young were noted in 66 female groups; 57 females were observed to have young, with 44 (77.2%) having twins. The MGS of male

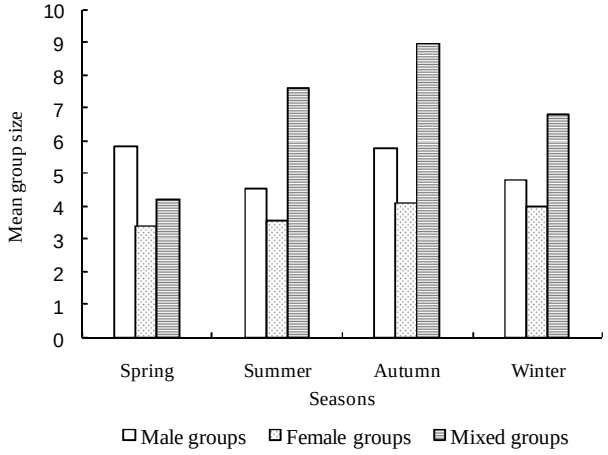

Fig. 3. Variation of mean group size of different kinds of group over seasons.

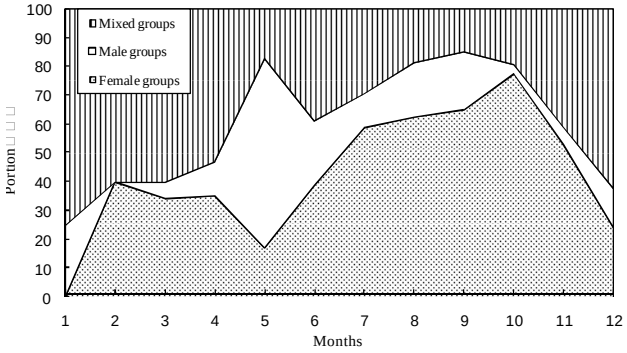

Fig. 4. Correlation between different group types over a year.

groups decreased to a minimum in summer at 4.56, with the biggest male group containing only 7 gazelles, and reached their maximum size in spring at 5.86, with the biggest group containing 19 animals. The MGS of mixed groups increased to a maximum in autumn of 8.92, with the largest group at 95 animals, and decreased to a minimum in spring of 4.26, with the biggest group containing only 8 animals. Male groups were noted most often in spring (45.7%), reaching a maximum in May (65.5%). Female groups were most common in summer and autumn (52.9% and 70.4%, respectively), with a maximum in October (77.4%). Mixed groups were found most frequently in winter (60.0%), with a maximum in January (75.0% - Fig. 4). The frequency with which we observed social groups varied significantly by season (χ^2 = 68.45, P< 0.01).

DISCUSSION

Group size over seasons

Goitred gazelles prefer to stay in small herds (Sludsky, 1956; Zhevnerov, 1984), though large groups, which consisted of thousands of animals, also were seen occasionally in former times (Kingswood and Blank, 1996). Group size of Goitred gazelles is usually varied from 1 to 9 individuals during spring and summer (Heptner *et al*., 1988). Most of the groups in our study area consisted of 1-7 animals (79.78% from all groups) (Fig. 2). This same group size has been described for this species all over of its range in China (Gao, 1996; Sun, 2003) and some populations in Kazakhstan (Blank, 1990; Zhevnerov, 1984). Goitred gazelles have one or often two young. Females of 3-7 years old have twins, as a rule, but younger and older females give birth to singles. The overall portion of females having twins may reach 75% (Kingswood and Blank, 1996). In our study area, we noted 57 female groups, which consisted of only one female and 1-2 young. Among these, 44 females were seen with 2 young, resulting in a twin rate of 77.2%. That, in turn, meant most of the female gazelles were between 3-7 years old, and the population in the KNR had a high breeding potential.

Both biological characteristics of a species and environmental factors affect group size of ungulate populations (Poole, 1985). Biological factors play a most important role in gazelle life: parturition for females and rutting for males. In Kazakhstan, most pregnant females leave their groups and stay alone during the two weeks prior to giving birth. As a result, large female groups break up into smaller ones or disappear altogether (Blank, 1992). This same phenomenon occurred in our study area, when the MGS decreased to its minimum in May due to the many solitary pregnant gazelles (Fig.1). Several weeks later, after parturition, two or more females with young gradually gathered together into female-young groups. Later still, males began to join the female-young groups to form relatively bigger mixed groups. As a result, the MGS increased in summer compared to spring.

During rutting season (October-December), adult males left mixed groups and started to establish their own individual territories for

pursuing females. As a consequence, the mixed groups, once quite large, disintegrated into smaller groups, and the MGS decreased accordingly. During the rutting peak of male sexual activity in December, temporary mixed groups consisting of one male and 1-9 female(s) were most frequently observed. Therefore, MGS started to increase. Rutting season ended in December, individual territories disappeared, and solitary males joined female groups to form mixed herds with females and sub-adults. These relatively larger mixed groups then became the most frequently noted. So, our study found that internal physiological factors (parturition and rut) have a powerful influence on characteristics of gazelle group size.

The most important external ecological factors that determined the group size were the availability and distribution of food and water, and the pressure from predation (Alexander, 1974; Jiang, 2004). During the hot, dry seasons (summer-autumn), most plants in the pastures dried out, and the water content in available food decreased considerably. At this time, gazelles had more need of water, especially females suckling young. But the quantity of water resources, which were available during spring, gradually decreased during summer, and became very limited during this hottest period of the year. As a result, available watering places became the most dominant factor in determining group size. In order to get necessary water, many gazelles gathered nearby the few waterholes, and formed large temporary groups. We observed one group with 31 individuals on September 8, 2006, and one group with 31 individuals and one with 95 individuals on September 6, 2006. As a result, the MGS remarkably increased from June to September.

During the cold season, the quantity and quality of available food decreased significantly, due to natural seasonal changes in plant content (Zhevnerov, 1984). And snow cover restricted food choices to an even greater degree. In addition, the dietary overlap between Goitred gazelles and domestic livestock (Chu *et al.*, 2008) was a very powerful factor in determining group size during winter: with domestic animals occupying and overgrazing the most suitable pastures, the quality of available grazing land decreased considerably (Li *et al.*, 2010). Gazelles gathered together and formed larger herds in areas where they found enough suitable food. Though the largest groups were noted during the dry seasons, the MGS was higher during the cold season and reached its peak for the whole year.

Group composition over seasons

Goitred gazelle females experience parturition in spring. Young were born mostly from mid-May to early June in our study area, and the females stayed alone during this period. As a consequence, female groups of more than one individual were less frequently observed (only 17.2%). In contrast, males gathered together into male herds that reached their maximum portion of the whole year during this time. As a result of these groupings, the portion of mixed groups was low in May (Fig 4). In summer and autumn, many groups consisting of females and young were very common in our study area, and the portion of female groups increased correspondingly. Rutting season occurs during winter, and during December, males were most actively courting females inside their individual territories. During this time adult males joined female groups, and the number of mixed groups increased substantially (60%), most of which (51%) were herds of 1 male and several females. After rutting season, males left their territories and joined female groups forming larger herds during the cold season. Therefore, the portion of mixed groups reached its maximum in January (75.0%); however male groups, consisting of adult and sub-adult males, still could be seen in January (Fig 4). Sub-adult males were seldom solitary; they grouped together or joined adult males, as a rule. We noted 22 sub-adults among 6 herds, in total, and this portion made up 1.8% of other types. Goitred gazelles usually reach sexual maturity at the age of one year, but they participate in breeding only at the age of 3 or more years (Kingswood and Blank, 1996). The sub-adults in our study were only seen in autumn (1.4%) and winter (4.6%). Female groups were most frequently noted in October (77.4%). The rutting season of goitered gazelles occurs from mid October to mid December with a peak during 1-10 December (Blank, 1985; Blank, 1992). Most adult males started to leave mixed groups in October to establish their individual territories for courting, and

as a result, the portion of female groups increased to their maximum for the whole year. Therefore, we think that the sexual segregation of Goitred gazelles over seasons is in accord with the "reproductive strategy hypothesis" (Main *et al*., 1996), and that seasonal changes on group composition were affected remarkably by their intrinsic reproductive cycles (rutting and parturition). Similar results have been reported from studies of Tibetan antelope, Tibetan gazelle and blue sheep (Li *et al*., 2007; Lian *et al*., 2005; Lu and Wang, 2004).

Solitary gazelles

Solitary individuals are very common for ungulates species such as the wood bison (*Bison bison athabascae*) (Komers *et al*., 1993), European bison (*Bison bonasus*) (Krasin'ski and Krasin'ska, 1992), golden takin (*Budorcas taxicolor bedfordi*) (Yuan *et al*., 1990; Zeng and Song, 1999), Argali sheep (*Ovis ammon*) (Yu *et al*., 2000), and Tibetan antelope (*Pantholops hodgsonii*) (Lian *et al*., 2005). Solitary Goitred gazelles were observed very often in our study area, though most were alone only temporarily. Sixty-three solitary gazelles (11.2%) were noted during our survey: solitary males inside their individual territories during the rutting season (October-December), and females, single exclusively during the birthing season and the first month of rearing young (May-June). After the rut, the males returned to groups; and after birthing young, females formed groups with other mothers and sub-adults. Solitary gazelles in some Kazakhstan populations were documented also, with the portion of singles even larger compared to our study area, making up to 24.1% of the whole population. These solitary gazelles were noted most often during the birthing season in May (33.4%) and the rutting season in November (37.1% - Zhevnerov, 1984).

Investigations of Goitred gazelles in Middle Asia (Blank, 1992; Mambetzhumaev, 1970; Sludsky, 1956; Sokolov, 1959) have demonstrated that this species prefers to stay in small groups (1-3 individuals) during most seasons. Here in our study, groups consisting of 1-3 individuals accounted for nearly 50% of the total groups of the year (Fig. 1). Apparently, Goitred gazelles use the strategy of the highest possible population dispersion over the whole of their extensive natural range: a strategy that seems optimal under the conditions of limited and uneven distribution of food and water resources in desert regions.

ACKNOWLEDGEMENTS

We are grateful to Chinese Academy of Sciences Visiting Professorships for Senior International Scientists (2009Z2-5) and Sino – Italian Cooperation Project (0866031) for financing this research. We thank Patricia Johnston for editing our manuscript, Altay Forestry Bureau for permitting us to conduct this work on Kalamaili Mountain Ungulate Nature Reserve, and Dr. Chu Hongjun, and Staff from the Reserve for providing logistical support during the fieldwork period.

REFERENCES

ALEXANDER, R.D., 1974. The evolution of social behaviour. *Ann. Rev. Ecol. Syst.*, **5**: 325–383.

BARRETTE, C., 1991. The size of Axis deer fluid groups in Wilpattu National Park, Sri Lanka. *Mammalia*, **55**: 207–220.

BERGER, J., 1978. Group size, foraging, and antipredator ploys: an analysis of Bighorn sheep decision. *Behav. Ecol. Sociobiol.*, **4**: 91–99.

BLANK, D.A., 1985. Peculiarities of social and reproductive behaviour of *Gazella subgutturosa* in the Iliisky Valley. *Zool. Z.*, **64**: 1059–1070.

BLANK, D.A., 1990. Persian gazelle. In: *Rare animals of desert regions* (eds. A. Kovshar). Nauka of Kazakh SSR, Alma-Ata, Kazakhstan, pp. 56-80.

BLANK, D.A., 1992. *Social and reproductive behavior of the* Persian gazelle. Ph.D. dissertation, The University of Tel-Aviv, pp. 189.

CHU, H.J., JIANG, Z., GE, Y., JIANG, F., TAO, Y.S. AND WANG, C., 2009. Population densities and number of khulan and goitred gazelle in Mt. Kalamaili Ungulate Nature Reserve. *Biodiv. Sci*., **17**: 414–422.

CHU, H.J., JIANG, Z., LAN, W.X., GE, Y., WANG, C., TAO, Y.S. AND JIANG, F., 2008. Dietary overlap among kulan *Equus hemionus*, goitered gazelle *Gazella subgutturosa* and livestock. *Acta Zool. Sinica.*, **54**: 951–954.

CLUTTON-BROCK, T.H., GUINNESS, F.E. AND ALBON, S.D., 1982. *Red deer: Behaviour and ecology of two sexes*. University of Chicago Press, Chicago, USA.

GAO, X.Y., XU, K.F., YAO, J. AND JIA, Z.X., 1996. The population structure of Goitred gazelle in Xinjiang. *Acta Theriol. Sin.*, **16**: 14–18.

GERARD, J.F., BIDEAU, E., MAUBLANC, M.L., LOISELP, AND MARCHAL, C., 2002. Herd size in large herbivores: encoded in the individual or emergent? *Biol. Bull*., **202**: 275–282.

HABIBI, K., THOULESS, C.R. AND LINDSAY, N., 1993. Comparative behavior of sand and mountain gazelles. *J. Zool.* **229**: 41–53.

HEPTNER, V.G., NASIMOVICH, A.A. AND BANNIKOV, A.G., 1988. *Mammals of the Soviet Union. Artiodactyla and Perissodactyla.* Smithsonian Institution Libraries and the National Sciences Foundation.

HILLMAN, J. C., 1987. Group size and association patterns of the common eland (*Tragelaphus oryx*). *J. Zool. Lond.* **213**: 641–663.

IUCN, 2006. IUCN Red list of threatened species [EB/OL]□[2007–03-20]□http□// www. Redlist. org

JIANG, Z., 2004. *Przewalski's gazelle*. China forestry publishing house, Beijing, China.

KINGSWOOD, S.C. AND BLANK, D.A., 1996. *Gazella subgutturosa*. *Mammal. Sp.*, **518**: 1–10.

KOMERS, P.E., MESSIER, F. AND GATES, C.C., 1993. Group structure in wood bison: nutritional and reproductive determinants. *Can. J. Zool*., **71**: 1367–1371.

KRASIN'SKI, Z. AND KRASIN'SKA, M., 1992. Free ranging European bison in Borecka Forest. *Acta Theriol.*, **37**: 301–317.

LI, X.Q., LIU, Z.S., WANG, X.M., CUI, D.Y., LI, Z.G. AND HU, T.H., 2007. Group characteristics of blue sheep (*Pseudois nayaur*) during rutting season in the Helan Mountains, China. *Acta Ecol. Sin.*, **27**: 39–44.

LI, Y., XU, W.X., YANG, W.K., QIAO, J.F., LIU, W. AND XIA, C.J., 2010. Habitat suitability assessment of Gazella subgutturosa in Kalamaili Mountain Nature Reserve. *Acta Theriol. Sin.*, **30**: 11 – 20.

LIAN, X.M., SU, J.P., ZHANG, T.Z. AND CAO, Y.F., 2005. The characteristics of social groups of the Tibetan antelope (*Pantholops hodgsoni*) in the Kekexili region. *Acta Ecol. Sin.*, **25**: 1341–1346.

LIU, W., YANG, W.K. AND XU, W.X., 2008. Food habits of the Kulan (*Equus hemionus*) in autumn. *Acta Theriol. Sin.*, **28**: 33–36.

LU, Q.B. AND WANG, X.M., 2004. Group structure and diurnal behavior of tibetan gazelle during the birth period. *Acta Theriol. Sin.*, **24**: 192–199.

MAIN, M.B., WECKERLY, F.W. AND BLEICH, V.C., 1996. Sexual segregation in ungulates: new directions for research. *J. Mammol.*, **7**: 449–461.

MAMBETZHUMAEV, A.O., 1970. On number and distribution of Goitred gazelles in the Ustiurt Plateau and Kyzylkum Desert. *Zool. Z.*, **49**: 431-434.

POOLE, T., 1985. *Social behavior in mammals*. Chapman and Hall, New York, USA.

RAMAN, T.R.S., 1997. Factors influencing seasonal and monthly changes in the group size of chital or axis deer in southern India. *J. Biosci.* **22**: 203–218.

SLUDSKY, A.A., 1956. Reproduction of Persian gazelles. *Proc. Zool. Inst., Kazakhstan Acad. Sci.*, **6**: 78–108.

SOKOLOV, II., 1959. *Fauna of the USSR. Mammals*. Academy of Sciences of the USSR, Moscow-Leningrad, USSR.

SUN, M.J., 2003. *Habitat selection and food habits of Goitred gazelle*, Gazella subgutturosa sairensis *in southeast of Jungar basin*. MSC. D. Dissertation, Graduate School, Chinese Academy of Science.

THOULESS, C.R., GRAINGER, J.G., SHOBRAK, M. AND HABIBI, K., 1991. Conservation status of gazelles in Saudi Arabia. *Biol. Conserv.*, **58**: 85–98.

UNATOV, A.A., 1960. *Natural conditions of Xinjiang*, Academy of Sciences USSR, Moscow, USSR.

XU, W.X., QIAO, J.F., LIU, W. AND YANG, W.K., 2008. Ecology and biology of *Gazella subgutturosa*: Current situation of studies. *Chinese J. Ecol.*, **27**: 257–262.

YU, Y.Q., LIU, C.G., GUO, S.T., GU, Z.G., TU, X.J. AND WANG, X.J, 2000. A study on the aggregate behavior of Argali (*Ovis ammon*) in Tianshan Mountains. *Acta Theriol. Sin.*, **20**: 101–107.

YUAN, C.G., HU, J.C., WU, Y., WEI, F.W., JIANG, M.D. AND DENG, Q.C., 1990. Ecological research of solitary Takins in winter in Tangjiahe Natural Reserve. *Zool. Res.*, **11**: 203–207.

ZENG, Z.G. AND SONG, Y.L., 1999. Preliminary observation on the phenomena of solitary individuals in Golden Takin (*Budorcas taxicolor bedfordi*) in Qinling Mountain ranges. *Acta Theriol. Sin.*, **19**: 169–175.

ZHEVNEROV, V.V., 1984. *Goitred gazelle of the Barsa-Kelmes Island*. Nauka Kaz SSR Publication, Alma-Ata, Kazakhstan.

(Received 27 November 2010, revised 7 January 2011)