Final report

Influence of Fencing on Przewalski's Gazelle, Qinghai Province, China

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This project evaluated the impact of fencing on the survival of the highly endangered Przewalski's gazelle.
Field work period: April – November, 2009; July – August, 2010

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December 2010

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Abstract

The endangered Przewalski's gazelle (*Procapra przewalskii*) has endured severe habitat loss and population decline over the last century. Since 2002, illegal hunting of gazelles has been largely stopped, making fencing of pastures and competition with livestock the main threats. We quantified fencing and livestock on gazelle's habitat using parallel transects and analyzed spatial correlation among fence-density, livestock-density, and gazelle activity. We also compared birth rate and three-month-old calf mortality of gazelle populations on areas with different fence densities. Our study indicated that the high density of fences did impede gazelles' access to high biomass grassland. Meanwhile, higher fence density was correlated with higher calf mortality. We observed no significant spatial correlation between livestock density and gazelle activity, but more work is needed to evaluate the impact of livestock, especially the potential competition of habitat use both spatially and temporally.

Introduction

Przewalski's gazelle (*Procapra przewalskii*) is a rare species endemic to China. It was first described by a Russian explorer - Nikolai Przewalski - in 1875 and later named after him. Over-hunting and conversion of rangeland to farmland decimated the species to the point where only an estimated 300 individuals were left during the 1990s (Jiang et al. 1995), distributed in small, isolated patches around Qinghai Lake (Wang & Schaller 1998; Jiang et al. 2003; Zheng 2005). Government offices successfully concluded a gun confiscation campaign in 2002 (Schaller et al., 2006), leading to success in reigning in poaching. Meanwhile, conservation programs carried out by governmental agencies and NGOs since the 1990s have succeeded in increasing conservation awareness in local communities. However, despite the discovery of previously unknown populations, there is no evidence that the total gazelle population has grown in response to these programs (Jiang et al. 1995, Ye et al. 2006).

Scientists have repeatedly highlighted fencing as one of the main threats to the gazelle (Wei et al. 1998, Liu & Jiang 2002, Schaller et al. 2006), but few research projects have directly measured its impact. Our project aimed at evaluating the impact of fences in the entire area occupied by Przewalski's gazelle and improving conservation of the gazelle. We attempted to answer three questions. First, we attempted to determine the deaths and injuries directly attributable to fences. Second, we wanted to determine whether fences prevented gazelles from acquiring food. Third, assuming fences represent an obstruction, does it also influence reproduction of the gazelle population? The answers to these questions will provide guidance to fencing policies in China.

Dr. George Schaller and Wildlife Conservation Society-China Program have conducted prior surveys in this area to obtain basic information about the gazelle population and helped us to design our study. Conservation International and its Chinese partner Shanshui Conservation Center are carrying a community-based conservation program in the same area where we worked. These organizations have funded us to conduct surveys on gazelle status in 2008 and then helped us to refine the scope of our project.

Project members

Name	Relevant experience	Roles	Age
Lu Zhang	Lu graduated from Beijing Technology and Business University with a BS in Biological engineering. She is now a PhD student in Wildlife Conservation at Peking University. She has experience with large mammal distribution surveying and community work in Tibetan ethnic areas, and has been working on the Przewalski's gazelle project for more than two years.	Team leader, Zoologist and community worker	26
Jiazi Liu	Jiazi is now a PhD student in the Wildlife Conservation program at Peking University. She graduated Nanjing Agricultural University with a BS in Biological Science. She has experience in habitat analysis using remote sensing and can communicate proficiently with Tibetan locals.	Field work assistant and community worker	25
Yonglin Wu	Yonglin works in Qinghai Lake Nature Reserve. He has experience conducting field work and he is familiar with the distribution of Przewalski's gazelle and the community work around Qinghai Lake. He also has experience breeding several Przewalski's gazelles in the past 5 years.	Representative of local organization and field guide	41
Jianxin Cheng	Jianxin works in Qinghai Forestry Bureau. He has experience conducting community work, providing logistic support for field survey teams, and organizing workshops.	Logistics Office and community worker	30
Yanlin Liu	Yanlin is a PhD student in Wildlife Conservation program in Peking University. He has experience of conducting wildlife surveys and grassland biomass measurement, especially on Tibetan Plateau. He was mainly involved in project designing and data analysis.	Zoologist and field survey expert	28
Namjyal	Namjyal is a Tibetan from local community. He translated for other team members when doing interviews. He knows what local people think and want. He is enthusiastic about conservation and assists staff of Qinghai Lake Reserve to patrol and conserve wildlife around his community.	Logistics coordinator and community worker	44

Field work and research

Background

Przewalski's gazelle is endemic to China. It belongs to Order *Artiodactyla*, Family *Bovidae*, and Genus *Procapra*. It was once found over a vast part of north-western China (Jiang et al., 1995). However, it suffered severe habitat loss and population decline during the past century. In 1994, Jiang et al. reported no more than 300 gazelles and occupying only the north-eastern and the western shores of Qinghai Lake (Jiang et al., 1995). More recent work has revealed that the status of the species is less precarious than earlier reports indicated. More thorough surveys have uncovered new populations, with the result that Ye et al. (2006) tallied 602 animals in 2003, Schaller et al. (2006) recorded 471 in 2006 in a partial survey, and Zhang et al. (2007) reported 490 in 2007. However, these surveys did not present evidence that the overall population was growing. We counted 1320 gazelle individuals in our previous survey in 2008 but found that three populations, which accounted for 45% of the total gazelle population, had declined from 2003, and one of them was close to extinction (data from previous surveys).

It appears that hunting was the main cause to the decline of gazelle population over the last century (Zheng, 2005). By 2002, gun confiscation conducted by the central government largely brought an end to uncontrolled hunting on the Tibetan Plateau (hunting was banned well before 2002 but not enforced enough). As gazelle population did not increase distinctly, conservationists then identified currently several possible threats to the survival of the gazelle, including fencing (Wei 1998, Liu & Jiang 2002, Schaller 2006), competition with livestock (Wei et al. 1998, Schaller 2006, Liu & Jiang 2002), predation by wolves (Li et al. 1999), and human interference (Jiang et al. 2001, Liu & Jiang 2002). However, few research projects have directly evaluated these possible threats.

We focused on fencing because fences are relatively new in Qinghai Lake area, and their proliferation coincided with the decline of hunting. Local people traditionally lived as migratory nomads. In an effort to transform the economy of the region and preserve grassland, the government introduced the Household Responsibility Contract System in the early 1980s. The rangeland was then divided into patches and assigned to individual households. This policy was enforced later in Qinghai Lake region than in other grassland areas in northern and western China, as most rangelands were divided and assigned in early 1990s and the custom of fencing became prevalent after 1994 (Liu & Jiang 2002). After the year 2000, new policies aimed to control erosion of grassland and to restore forests and shrubs, encouraged fence building, as it removes livestock from certain areas (Yu, 2008).

The central government has encouraged the wide use of fencing as a way to allow locals to manage movement of livestock, raise more livestock products, and to keep rangeland in good condition, though considerable doubt exists if fences perform their designated task (Ao 2004, Humphrey & Sneath 1999). In addition, some conservationists state that fencing may affect the survival of Przewalski's gazelle (Wei et al. 1998, Liu et al. 2002, Schaller et al. 2006). The entire range of Przewalski’s gazelle is sympatric with livestock managed through fencing. Gazelles are sometimes able to jump over or squeeze through fences, but they may be seriously hurt by the barbed wires on the top of fences or fatally entangled by other wires. Local people have reported deaths and injuries of the gazelles on their fences, and in pilot studies we have observed similar phenomena.

Quantitative analysis of impact of fencing is urgently needed because more fences are being built on grassland where gazelles inhabit.

Aim

Our project aimed to study in detail the relationship between fencing and the survival of the gazelle, contribute to its habitat management and public education. We had four main objectives:

1) Quantify fencing on the ten fragmented gazelle distributied areas and five areas where there used to be gazelles, and analyze spatial relationship between fence density and gazelle activity.

2) Survey on birth rate and young gazelle mortality of each small population and compare among areas with different fence dencities.

3) Improve the capacity of local conservation agencies and communities to implement wildlife conservation projects, monitor dinamics of gazelle populations and collect information of death and injuries of the gazelle.

4) Help in public education on protection of this species.

Study area

Our study area was located in the northeast corner of the Tibetan Plateau (98.40 ° -100.90 ° E, 36.20 ° N-37.60 ° N), and included all known areas occupied by gazelles except Bird Island (Fig.1), as well as five control areas (Fig.1 & Fig.2). We selected control areas just outside these known gazelle sites, in areas where no gazelle was sighted or known to exist based on interviews with local people.

Gazelles distribute in two adjacent basins: Qinghai Lake basin and Gonghe basin, with the Qinghai South Mountain lying between the two basins. Qinghai Lake is the largest saline lake in China, with an area of about 4200km^2. The average elevation is about 3200m in Qinhai Lake basin and 3000m in Gonghe basin. The climate in this region is continental; the vicinity of Qinghai Lake has an average annual temperature of about 0℃ and an annual precipitation of 400-500mm, while Gonghe basin is warmer and drier than Qinghai Lake Basin, with an average annual temperature of about 2℃, and annual precipitation of about 200mm. In Qinghai Lake basin, as the elevation rises, the main vegetation type transitions from steppe, to alpine meadow, and alpine shrub. In Gonghe basin, the main vegetation type is desert shrub.

The study area involves four counties- Haiyan, Gangcha, Tianjun, and Gonghe County, and one nature reserve – Qinghai Lake National Nature Reserve, which was established as a provincial reserve in 1975 and upgraded to a national reserve in 1997, with a current protected area of 4,952 km^2 (including the open water). Though a national reserve, there are still herders living within the reserve and using its grasslands to pasture livestock. The boundary of the reserve is formed by four main roads around the lake. There are several famous tourist destinations inside the reserve.

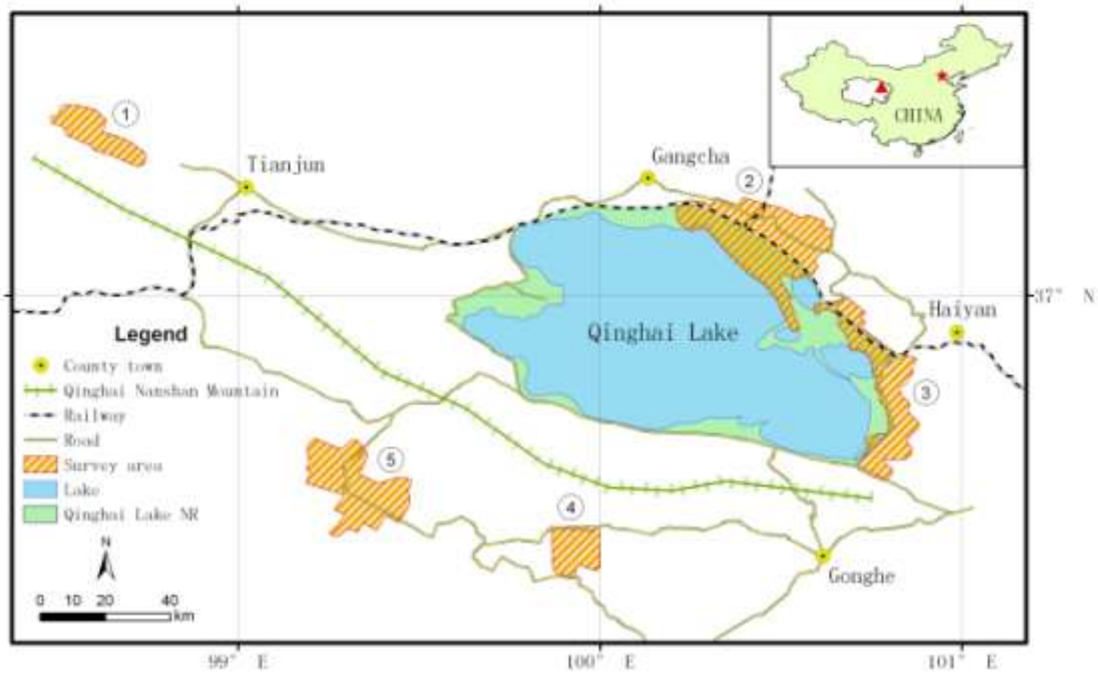

Fig.1 Location of our study area with an ID number beside each site (listed clockwise): ① Tianjun; ②Northern lake area; ③Eastern lake area; ④Qieji; and ⑤Wayu. Gazelle populations living at the vicinity of Qinghai Lake have been recorded since 1986. Tianjun and Qieji were first recorded in 2003 by Ye et al. (2006), whereas Wayu was first described by Zhang et al. in 2007. We did not find any gazelle individuals or trace of the gazelle in Qieji in our previous surveys and considered it a non-occupied area. The red star in the top right corner indicates Beijing, whereas the red triangle indicates the location of the study area in China. The polygon around the red triangle is the boundary of Qinghai Province. Basic information of each site can be found in Table 1. There are several small, isolated patches of gazelle occupied areas in area ③and ④. Details of these subpopulations can be found in Fig.2.

Fig.2 Detail of study area in northern and eastern lake areas. B, C, D, G, H, and I are gazelle occupied sites, whereas A, E, F, and 10 are non-occupied sites. With the area of Yuanzhe (④ in Fig.1), we have five control sites.

Table 1 Basic information of survey areas. Vegetation information was obtained from Zhang (2004).

ID	Area name	Size of surveyed area (km^2)	Main vegetation type
1	Tianjun	181	Alpine meadow
2	Northern lake area	657	Alpine prairie
3	Eastern lake area	436	Alpine prairie
4	Qieji	165	Desert shrub
5	Wayu	421	Desert shrub

Methods: fieldwork and follow-up

Fieldwork methods

1) Parallel transects

In each survey area, we generated a random starting point using “Create Random Points” in ArcGIS 9.2. One transect was originated at this point and was oriented perpendicular to the nearest road. Additional transects were placed parallel to this transect at 1 km intervals until the estimated boundary of the area (approximately to where we found gazelles or traces of the gazelles in our previous survey). In part of the northern lake area and Wayu, transects were placed at 2 kilometers intervals due to manpower shortages.

All transects were conducted on foot and we recorded, with a GPS, the location of each fence crossed and gazelle feces found within 2m of the transect line. Gazelle feces were easily identified as gazelles stand still when defecating so the pellets are in piles whereas sheep and goats usually defecate while walking so pellets scattered. In addition, gazelle pellets are smaller and more extended than those of sheep and goats. We only recorded recent fecal groups (i.e. either soft and wet, or dry pellets with smooth and dark surface). For each fence encountered we also recorded its type (with or without barbed wires) and height.

On transects we also recorded groups of livestock, the sighting angle and sighting distance from the location. Using binoculars, we determined the species and number of individuals of the group. Though it is possible to detect herds of livestock up to 1 km away on the flat grassland, we only recorded herds within 500m of the transect. Locations of local people’s houses were determined by recording sighting angle and sighting distance from location sighted along the transects.

Parallel transects were conducted in April 13th to June 3rd, August 4th to 24th, and October 31st to November 22nd in 2009 to cover the whole study area.

2) Population reproduction

We conducted population surveys in August and November. Transects were conducted in the morning by vehicle or on foot to record group size, sex and age composition of gazelle herds. Transects were placed to detect as many gazelles as possible according to our experience and local knowledge. We repeated this survey two to five times (once every day) in the same area. We added data of these days together to obtain the calf/female (C/F) ratio for each population. We used the C/F ratio in August to indicate birth rate, and difference between the C/F ratios in August and November to indicate calves mortality during the three month period.

In the summer of 2010, we stayed in the community near gazelle’s habitat in the northern lake area for 11 weeks (July 4th to September 26th) and surveyed detailed about birth rate and calf/female ratio in two populations. The two populations were monitored in a 5-day interval to see changes of C/F ratio in the first two months after parturition.

3) Death and injury information collection

Two young herders from one community besides gazelle's habitat were trained to collect and record information of deaths and injuries around their community (the area is about 100 km^2). They were trained to use GPS and compass, and to fill recording tables. They collected information on their own rangelands and from their neighbours. There is a network of local herders to help patrolling and monitoring the gazelle for Qinghai Lake Nature Reserve. Our information also came from this network.

4) Household interview

We conducted household interviews in five communities on whose rangeland include area inhabit by gazelles in November, 2009. Ten families of each community were selected and interviewed about lengths of fences on their rangeland and changes of fences in the past ten years; local attitudes towards fencing, including whether they think fences are useful, whether they are willing to remove fences; livestock number and changes of number among months in a year; locations of rangelands and timing for transferring between these rangelands; disease and paradise of livestock; predators to livestock; cognition and attitude towards Przewalski's gazelle around their community.

Data analysis

All GPS records were transformed into data layers using ArcView GIS 3.2a. We got data layers about distribution of gazelle feces, and fences on transects; distribution of livestock herds, and local herders' houses in the study area. We used the Enhanced Vegetation Index (EVI) as an index of grassland quality. EVI data were obtained from MODIS products available at U.S. Geological Survey (USGS) website (https://lpdaac.usgs.gov/lpdaac/get_data/data_pool). We downloaded 2 scenes of MODIS 16-day EVI data. The dates of these datasets were from May 9th to 24th, and July 28th to August 12th.

Two sets of random points were generated within the study area using 'Create Random Point' in ArcGIS 9.2. The numbers of points in each set were equal to the numbers of fecal groups recorded on the transects in each of the two surveys: April – June, and in August. The value of the EVI cell (250 by 250 m) in which the point occurred was attached to each set of random points, and to all of the fecal and livestock locations. We compared the EVI scores of fecal locations with those of random points, and with those of livestock in SPSS15.0 using Mann-Whitney test (2-tailed).

Transects were divided into 1-km-long segments. Numbers of fences and fecal groups on each segment were summed (fallen fences were excluded in the count) and used as an index of density. Transects were buffered in ArcGIS 9.2 (500m on each side) to form 1km^2 cells. Livestock herds encountered in each cell were used as an estimate of livestock density and referred to as dry sheep equivalent, or DSE, per km^2. *DSE is a standard unit used to compare the feed requirements of different classes of livestock or to assess the carrying capacity and potential productivity of a given area of grazing land* (McLaren, 1997). A sheep or a goat was equivalent with one DSE, a yak equal to four DSEs, cattle equal to five DSEs, and a horse equal to six DSEs in our study area (Qi, 2009). We also measured distances from the center of each segment of transect to its nearest house in ArcGIS. The distance was used as an index of human disturbance. Length weighted mean (LWM) of EVI on each segment of transect was calculated using the function of Hawth's analysis tools for ArcGIS named 'Line raster intersection statistics' (more details can be found at: http://www.spatialecology.com/htools/linerasterstats.php).

We used Negative binomial regression to identify environmental factors associated with gazelle habitat use, as measured by fecal piles, in 1km^2 cells. We included five independent variables in the regression: fence density, EVI, livestock density, and distance to house. We examined all combinations of these variables in the regression. We used Akaike Information Criterion (Akaike, 1973) within the negative binomial regression as an indicator of fit. The model with the lowest AIC was selected as the best model for predicting fecal density of the gazelles. We assessed the effect of the variables on gazelles' fecal density by examining the parameter estimates of each variable within the best model for each season. Regression was conducted in R (version 2.11.1; packages including spam, xtable, and zoo were used). We conducted Negative binomial regression for both spring and summer surveys.

We averaged fence density in 1km^2 cell within each survey site, and compared fence densities between gazelle-occupied and non-occupied areas using Mann-Whitney test (2-tailed) in SPSS15.0. We also averaged EVI value in spring, EVI value in summer, livestock density in spring, and livestock density in summer within each survey site. We did correlation analysis between birth rate (calf/female ratio in August) and the five environmental variables, as well as between young gazelle mortality and the variables.

Results

1. Gazelle occupied and non-occupied areas

There was no significant difference of EVI between gazelle occupied and non-occupied areas, either in spring (Mann-Whitney U= 72687, $p > 0.05$), or in summer (Mann-Whitney U= 72304, $p > 0.05$). But fence density of occupied sites was significantly lower than that of non-occupied sites (Mann-Whitney U= 59409, $p < 0.01$) (Table 2).

Table 2 Comparison of EVI value and fence density between gazelle occupied and non-occupied areas. Fence density was indicated by number of fences per km transect.

	Gazelle occupied	Non-occupied
EVI spring	0.12 ± 0.04 (*n* = 693)	0.12 ± 0.05 (*n* = 224)
EVI summer	0.26 ± 0.11 (*n* = 693)	0.28 ± 0.13 (*n* = 224)
Fence density	1.9 ± 2.1 (*n* = 675)	2.4 ± 1.9 (*n* = 218)

2. Gazelles' selection of grassland

For the 8 occupied sites, there was no significant difference of the EVI values between locations containing gazelles' feces and random points, either in spring (Mann-Whitney U = 231225.5, n = 1364, p = 0.854), or in summer (Mann-Whitney U = 118490.0, n = 1000, p = 0.154), but locations containing gazelles' feces was significantly lower than those containing livestock in both of the seasons (Mann-Whitney U = 201892.5, n = 1576, p < 0.01 in spring; and Mann-Whitney U = 18686.0, n = 601, p < 0.01 for summer) (Table 2).

Table 3 Summary of EVI values of the locations containing gazelle feces, random points, and livestock in two survey seasons: spring – April to June; summer – August, 2009. EVI values were not normally distributed so their central tendencies were described by median values.

	Spring			Summer		
	Gazelle feces	Random points	Livestock herds	Gazelle feces	Random points	Livestock herds
N	682	682	894	500	500	101
Median EVI value	0.12	0.11	0.13	0.23	0.24	0.26
EVI variance	6.59e-04	1.50e-03	2.81e-03	3.16e-03	5.91e-03	7.92e-03

3. Spatial block of fences on the gazelle

Altogether we walked 793km transect in April, 453km in August, and 160km in November. We used 1046 (653 in spring and 393 in summer) segments of transect for the regression analysis.

Models for both of the seasons contained the variable "fence density" in the final models (Table 4). In summer, EVI and livestock density (DSE/ km^2) made significant contribution to the final model, but not in spring (Table 4). Distance from the central point to the nearest house was not important for predicting gazelle fecal density on a segment of transect during either spring or summer (Table 4).

Fence density was the sole variable selected for the final model using spring survey data, and fence density, EVI, and livestock density (DSE/ km^2) for finale the model based on the summer survey data. In spring, the negative binomial regression model predicting gazelle fecal density from fence density was statistically significant (likelihood ratio chi-squared = 5.62, df = 1, p< 0.05). The expected log count for a one-unit increase in fence density (one more fence on every 1 km transect) was -0.161 (Table 5). This translates to a decrease of about 15% feces density for a one standard deviation increase in fence density. In summer, gazelle fecal density was best predicted from combination of fence density, EVI, and livestock density (DSE/ km^2) (likelihood ratio chi-square = 28.60, df = 3; p-value <.0001). The expected log count for a one-unit increase in fence density (one more fence on every 1 km transect) was -0.287 (Table 5). This translates to a decrease of about 25% feces density for a one standard deviation increase in fence density when EVI and livestock density were held constant. The expected log count for a one-unit (0.1 of EVI value) increase in EVI was -0.554 (Table 5). This translates to a decrease of about 43% feces density for a one standard deviation increase in EVI when fence density and livestock density were held constant. The expected log count for a one-unit increase (one more DSE in every 1 km^2 area) in livestock density was -0.002 (Table 5). This translates to a decrease of about 0.2% feces density for a one standard deviation increase in livestock density when fence density and EVI density were held constant.

Table 4 Top of negative binomial regression models for environmental and human interference variables used to predict gazelle fecal density on 1 km segment of transent in all gazelle occupied sites, of data from surveys conducted in the spring and summer of 2009. Models are ranked in order of their AIC. Only models with a model weight (w) > 0.05 are shown. AIC: Akaike Information Criterion, ΔAIC: difference in AIC values between each model and the best model, w_i: AIC model weight, N Par: number of parameters, -2LL: twice the negative log-likelihood.

Survey season	Model variables	N Par	AIC	ΔAIC	w_i	-2LL
Spring	FEN	3	1418.14	0	0.328	-1412.14
	FEN, EVI	4	1419.94	1.8	0.133	-1411.94
	FEN, DSE	4	1420.13	2	0.120	-1412.13
	FEN, HOU	4	1420.09	2	0.120	-1412.09
Summer	FEN, EVI, DSE	5	972.91	0	0.440	-962.91
	FEN, EVI, DSE, HOU	6	974.30	1.39	0.219	-962.30
	FEN, EVI	4	975.15	2.24	0.143	-967.15
	FEN, DSE	4	976.65	3.74	0.068	-968.65
	FEN, EVI, HOU	5	976.72	3.81	0.065	-966.72

FEN: number of fences per kilometer transect; EVI: enhanced vegetation index, an index for grass biomass; DSE: dry sheep equivalent, measurement of livestock density in a 1 km^2 cell; HOU: distance from the central point of each segment of transect to the nearest house.

Table 5 Parameter estimates of negative binomial regression models of relate environmental and human interference variables to the gazelle fecal density on 1 km segment of transect in all gazelle occupied sites, of data from surveys conducted in the spring and summer of 2009.

Survey season	Variable	Parameter estimate	Standard error	z value	p-value
Spring	FEN	-0.161	0.059	-2.742	0.006
Summer	FEN	-0.287	0.074	-3.850	0.000
	EVI	-0.554	0.188	-2.947	0.003
	DSE	-0.002	0.001	-2.234	0.025

FEN: number of fences per kilometer transect; EVI: enhanced vegetation index, an index for grass biomass; DSE: dry sheep equivalent, measurement of livestock density in a 1 km^2 cell.

Data from the spring survey indicated that all of the four independent variables were correlated (Table 6). In summer, livestock density (DSE/km^2) was not correlated with any of the other three variables while all of the other three variables were correlated.

Table 6 Spearman's rho showed the collinearity of variables included in negative binomial regression in spring (April – June, 2009) and summer (August, 2009). The number of segments of transect used in the analyses was 653 in spring and 393 in summer. **: Correlation is significant at the 0.01 level (2-tailed); N.S.: not significant.

	Spring			Summer		
	FEN	EVI	DSE	FEN	EVI	DSE
EVI	0.443**			0.360**		
DSE	0.228**	0.254**		N.S.	N.S.	
HOU	-0.314**	-0.282**	-0.271**	-0.240**	-0.350**	N.S.

FEN: number of fences per kilometer transect; EVI: enhanced vegetation index, an index for grass biomass; DSE: dry sheep equivalent, measurement of livestock density in a 1 km^2 cell; HOU: distance from the central point of each segment of transect to the nearest house.

4. Fence density and birthrate / calf mortality

Correlation analysis indicated birth rate was not correlated with any of the variables, while calf mortality was correlated with fence density (Spearmen's rho = 0.782, n = 7, p<0.05), but not correlated with EVI or livestock density (Table 7).

Table 7 Birth rate and three-month-old calf mortality, as well as environmental variables of 8 gazelle occupied sites in 2009 ($\overline{X}$ ± SD). ID numbers were correspondent to those in Table 1 and Fig 2.

ID	Site name	Birth rate	Calf mortality	Fence density (n/km)	EVI (spring)	EVI (summer)	Livestock density (spring)	Livestock density (summer)
1	Tianjun	0.52	0.10	0.9±0.9	0.12±0.01	0.26±0.03	93±257	29±167
B	Haergai-Ganzi he North	0.40	0.35	2.9±2.4	0.12±0.01	0.28±0.05	267±401	4±11
C	Haergai-Ganzi he South	0.40	0.23	1.8±1.7	0.13±0.05	0.25±0.03	394±582	22±65
D	Tale Xuanguo	0.51	0.18	2.3±2.7	0.14±0.02	0.29±0.06	263±378	43±101
G	Shadao	0.61	0.48	2.9±1.9	0.12±0.02	0.24±0.03	121±182	39±112
H	Hudong	0.28	0.11	1.7±1.8	0.13±0.04	0.26±0.06	92±191	10±44
I	Yuanzhe	0.31	0.23	4.8±2.3	0.18±0.03	0.30±0.03	336±323	27±124
5	Wayu	0.50*		0.6±0.9	0.09±0.01	0.15±0.02	76±173	76±208

*: This number was not included in the correlation analysis because the sample size was too small (we recorded only 7 calves and 14 females while population size in Wayu was 179 according to our previous survey in December 2008).

Detailed population structure surveys conducted in two occupied areas in the summer of 2010 indicated that calf/female ratio grew distinctly in July, but stayed almost invariant from early August (Table 8).

Table 8 Changes of calf/female ratios of two populations during July to August 2010 in the northern lake area.

Date	Haergai-Ganzihe South			Haergai-Ganzihe North		
	Calves	Females	Calf/Female Ratio	Calves	Females	Calf/Female Ratio
10th July	5	127	0.04			
12th July				10	143	0.07
16th July	26	136	0.19			
17th July				33	97	0.34
20th July	23	104	0.22			
22nd July				29	77	0.38
25th July	25	106	0.24			
27th July				44	102	0.43
30th July	60	146	0.41			
31st July				31	54	0.57
5th August	65	152	0.43			
6th August				71	134	0.53
14th August	34	74	0.46			
15th August				77	143	0.54

5. Deaths and injuries of gazelles

In Haergai-Ganzihe South, two local herders have recorded 65 cases of death of the gazelle from October 2009 till this May 2010. Among these 65 dead gazelles, four were females, 60 were males, while the gender of the last gazelle could not be identified. Causes to most of these deaths were obvious: 60 of these gazelles were predated by wolves, 2 other gazelles died on fences, and there was also one gazelle that died on fence but still eaten by wolves. Causes to another two gazelles' death were not sure.

Locations of these deaths were not recorded as the herders did not have GPS units. They only recorded relative distances from fences, which were classified as NEAR or FAR from fences. 30 of the deaths happened relatively near fences and the other 34 deaths were far from fences.

Deaths of the gazelle occurred unevenly among months (Fig. 3). There were relatively more deaths during winter (from November through March), which may caused by less food acquirement in winter.

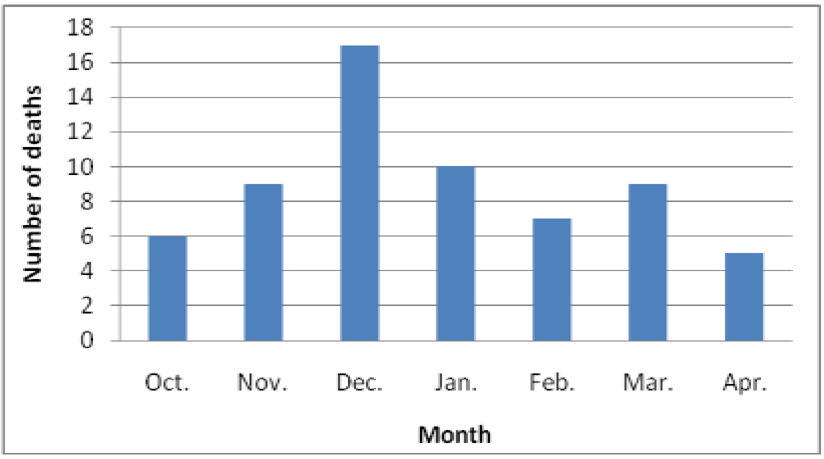

Fig. 3 Number of deaths of the gazelle in each month.

6. Social function of fences: Attitudes of local herders towards fencing

We conducted 46 interviews in five communities in and around gazelle's habitat. 44 of the 46 interviewees were males. Most of the interviewees were between 20 to 50 years old. All of the interviewees are Tibetan people.

Among the 46 interviewees, 43 indicated that fencing was useful and an efficient way to manage movement of livestock, thus reduced conflicts among neighbours. Only one interviewee indicated fencing was not useful due to poor quality of his fences since he did not have enough money to build better fences. When asked about removing fences or barbed wires, 12 of 19 interviewees who answered this question were unwilling to remove fences. Other 6 interviewees indicated that they had already removed barded wires as their rangelands were inside or near areas where community-based conservation program was ongoing. Only one of these interviewees said he is willing to remove barbed wires even though there is no conservation project carried out on his rangeland.

Interviewees had an average area of rangelands of 0.95km^2, an average length of fences of 6300m, and an average livestock of 380 Dry Sheep Equivalent. All families had winter pasture and summer pasture – winter pastures are fenced and near houses, while summer pastures are usually not fenced and hundreds of kilometers away. Livestock are usually grazed on summer pastures from June to August, and on winter pastures from December to the next May. Livestock are grazed either on winter pastures or leased pastures during September to November. 40 of the 46 families need to buy hey or rent pastures during winter.

39 of the interviewees answered the question about population trend of Przewalski's gazelle: 32 of them considered gazelle population increased during the last ten years, 4 of them considered unchanged, whereas only 3 of them considered decrease of gazelle population. All interviewees in Tianjun and Yuanzhe considered increase of gazelle population; 90% of interviewees in Hudong considered increase of gazelle population, whereas 67% and 60% of interviewees in Haergai-Ganzihe North and Haergai-Ganzihe South, respectively, considered increase of gazelle population.

Discussion and conclusions

1. The impact of fencing on the gazelle

Fence densities of gazelle-occupied areas are significantly higher than those of non-occupied areas, indicating fences may be important to determining the distribution of gazelles within a region. Within occupied areas, negative binomial regression indicated that fencing was the most affective factor for indicating fecal density of gazelles, which is an index of usage in an area, especially in spring. High density of fences reduced gazelles' access to the area. Because fence density was positively correlated with grassland biomass (EVI value), the effect of obstruction of fences reduces gazelles' access to high biomass area. Meanwhile, we found livestock occupy higher EVI value places than gazelles and random points. As gazelles and livestock have high diet overlap (61% in summer and 81% in winter, Liu & Jiang. 2004), we supposed areas favoured by livestock are also important for the gazelle. Thus, fences reduced gazelles' access to good habitat.

Fence density positively correlated with three-month-old calf mortality, though it did not correlated with birth rate of gazelle population. Gazelles inhabit winter pasture for livestock. These pastures have few livestock but high grassland biomass in summer, and more livestock but low biomass in spring (Table 7). Thus, gazelles are less affected by grassland biomass, livestock competition, and human interference during the summer. Our data confirmed the hypothesis that calf mortality was not correlated with EVI or livestock density in summer. Correlation between calf mortality and fence density indicated fencing directly increased calf mortality, or fencing increased the risk of predation of calves. More research projects are needed to verify these alternatives.

Fences are built to manage the movement of livestock, and hopefully to preserve grassland while provide more livestock products. According to "Qinghai statistic yearbook 2008", livestock number varied a lot during the year 1978 to 2007, but the total trend was declining. Meanwhile, there were complaints by local herders about grassland degradation. We did not see evidence of fencing being an effective management tool. On the other hand, as Robert Frost stated: "Good fences make good neighbours." Fencing is an effective way of reducing conflicts among local neighbours, according to local interviewees.

We suggest removing certain portion of fences in areas where fence density is higher than three fences per km transect (the mean density of feces was lower than one per km transect when there were more than three fences on the transect, according to our data). However, since most locals stated that fences are useful and did not want to remove them, community works are needed before fences can be modified. One possible solution is to encourage neighbours to collaborate in small groups, such as three to five families, and remove fences among their rangelands.

2. Livestock competition with gazelles

We found that livestock density in summer is a significant variable for predicting gazelles' habitat use, but not in spring. This factor was important despite there being much less livestock in gazelle habitat in summer than in spring. There are three possible explanations to this phenomenon: 1) livestock density in spring is uniformly high and there is no difference among sample units (1 km^2 cells) for predicting gazelles' habitat use; 2) since fecal density was used as the index of habitat use, we cannot tell the temporal difference of habitat use between gazelles and livestock; and 3) niche differentiation in summer is significant because there is enough food and space for both gazelles and remained livestock; while in spring, less food and more livestock caused niche shift and overlap, thus livestock negatively affected gazelles habitat use in summer while such effect was not significant in spring, just as negative binomial regressions showed.

All of the explanations implied possible competition between livestock and gazelles. 85% of local families need to buy hay in winter or rent pastures according to our interviews. Mishra (2004) indicated that rangeland might be overstocked in most areas with supplemental feeding in the Trans-Himalaya. Data from governmental agency also indicated overstocking in Qinghai Lake area: till 2002, communities around the Qinghai Lake possessed about 2.9 million livestock (~ 4.4 million DSE), and stocking rate was one time higher than the suitable rate (Qi, 2009). Future projects can focus on evaluating the impact of livestock, i.e. collaring gazelles and livestock to analyze habitat use of the two spatially and temporally.

3. Potential conflict between the gazelle and local communities

The result of household interviews indicated a disconnect between the perceived and actual status of the gazelle among local communities. 90% of the herders interviewed in Hudong and 100% in Yuanzhe indicated that the gazelle populations around their communities increased in the past several years, while we found that the two populations actually decreased from 2003 to 2009 comparing our survey result with data that has been published by other researchers. This bias implied a potential conflict between the gazelle and local communities. It also implied an education requirement and the need for more detailed community work to understand the demands of local people.

4. The best time for surveying birth rate

Parturition of Przewalski's gazelle has generally considered occurring from May (Wallace, 1913) to mid-June (Jiang et al., 1996). However, reserve staff and local herders consistently told us that the calving season of Przewalski's gazelles begins at the end of June, although opinions differed about its conclusion. Mongolian gazelle (*Procapra gutturosa*) calves adopt a hiding strategy during their first 2-3 weeks of life (Odonkhuu, 2009), and neonates of Tibetan gazelle hide for up to 2 weeks (Schaller, 1998). Similarly, in 2008 we found calves of Przewalski's gazelle hiding alone several times in July, but no hiding calf was found after August 1st (data from previous surveys). Our data from survey in the summer of 2010 confirmed that C/F ratio remained relatively stable since early August. We suggest it is better to conduct birth rate survey in early August.

5. Mortality information

The number of death detected was high in December. Since nearly all of these records of death were male gazelles, we supposed that behaviours of male gazelle might cause this high mortality. The rut of Przewalski's gazelle is from late November through early January according to our previous observation. Male gazelles fight for copulation and spend time to guard their own females. These behaviours may cost them large amount of energy and make them weaker to predation by wolves. The number of deaths of the gazelle in February was relatively low compare to those in January and March. Possibly the lack of data in February was due to Chinese New Year occurring in this month and herders may have completed less patrol work.

Education and Communications

1. Environmental education campaign for middle school students

This campaign was launched by Qinghai Forestry Bureau, Xining municipal Education Bureau, and Shanshui Conservation Center in May 9th, 2009. More than 120 students from 8 middle schools joined this campaign. Lu Zhang and Jiazi Liu took part in this campaign by giving an introduction of Przewalski's gazelle to the students in the field, on the edge of gazelle's distribution area, and later answering all the questions following a presentation of video materials of the gazelle on Bird Island.

Fig.4 Lu Zhang was giving an introduction of Przewalski's gazelle to middle school students in

May 9th, 2009.

2. Two talks and volunteer recruitment

On 13 May, Qinghai Forestry Bureau and a student association named Blue Eye-Scientific Exploration and Environmental Protection, held a conservation education campaign in Qinghai Normal University. Lu Zhang gave a talk in the university with a brief introduction of Przewalski's gazelle and a description of our project. Other team members - Jiazi Liu and Jianxing Cheng - together with Xin He, from Shanshui Conservation Center, attended this talk and answered questions posed by students. The purpose of this talk was to inform the status of this endangered species to young students, and to recruit possible volunteers for our summer survey. Most of the attending students majored in Biology and Ecology. They were interested in what we were doing and were enthusiastic about the opportunity to volunteer. Later in August, we had five students volunteer from this university. They joined in the whole summer survey, gained first-hand information of the gazelle, and learned skills for conducting wildlife surveys. The Blue Eye association is planning a series of publicities of Przewalski's gazelle later this year.

On 4 Jun., Lu Zhang and Jiazi Liu gave another talk in Qinghai University for Nationalities, with the help of a local conservation NGO, The Snowland Great Rivers Environmental Protection Association. Most of the attending students were minority people and some of them even came from the gazelle areas. We presented about the status of the gazelle and our activities, and encouraged them to join in the conservation of this animal.

3. Training course

Qinghai Forestry Bureau and Shanshui Conservation Center conducted a training course for herders from local communities, as well as staff of nature reserve and local government agencies in 21st May, 2009. The course focused on principles of Ecology and Conservation Biology, together with knowledge and skill on project management and publicity, since those trainees were all from communities which were having an on-going conservation project. Lu Zhang helped to give a talk on basic knowledge of ecology and monitoring, and discussed how to apply this knowledge to their community work.

4. Posters made and delivered

We made 160 pieces of poster in the end of October and delivered to households around habitat of the gazelle when we were doing interviews. These posters were welcomed by local people.

Fig.5 We made three types of posters and delivered to local herders during our survey in November 2009.

5. Project presentations

Qinghai Forestry Bureau and Shanshui Conservation Center held a meeting in December 7th, 2010 in Xining to discuss future work to conserve Przewalski's gazelle. Most of attendees are from Qinghai Forestry Bureau and Administration of Agriculture and Animal Husbandry of Qinghai Province. Researchers and students from Peking University, Chinese Academy of Sciences, and Chinese Academy of Forestry Sciences attended this meeting. There were also herders from communities around Qinghai Lake at the meeting. Lu Zhang presented the results of our project by giving a 20-min talk, and Jiazi Liu introduced continued work that we were planning to conduct on the meeting. Attendees reached the consensus that fencing largely affected the survival of the gazelle. Qinghai Forestry Bureau was preparing a motion to the State Forestry Administration (SFA), to state current status of Przewalski's gazelle and request for permit and fund for more detailed study and conserve of this species. Przewalski's gazelle is Class Ⅰ Protection animal in China. Certain kind of studies like collaring of the gazelle need permit from SFA. Support from SFA will help to secure a brighter future for the gazelle.

Conclusion

1) Our project quantified fences density in all gazelle habitat. We found high density of fences impeded gazelles' access to high biomass grassland, as well as contributed to higher calf mortality. Fencing has been highlighted as a threat to survival of the gazelle for many years, but our project provided the first time quantified evidences of fences' impact.

2) There is a contradiction between Forestry Bureau and Animal Husbandry Administration about building fences. Our project provided quantified evidences of harms caused by fences to the endangered Przewalski's gazelle. This may help to refine policy of fencing in Qinghai Lake

area to form a better living condition for the gazelle.

3) Herders from local communities were involved in this project and were trained initially to conduct monitoring work about gazelle population. The network of local people for patrolling and monitoring gazelles are not steady. More efforts are needed to stabilize patrolling team and make monitoring activities regular. Meanwhile, locals need more trains to provide more useful data.

4) We recommended removing some fences in areas with high fence density (more than three fences per km transect). Since most of local people considering fencing an effective way of reducing conflicts among neighbours and do not want to remove fences, we recommended a possible solution: encouraging collaboration among neighbours to graze livestock, thus fences among pastures of these families can be removed without causing conflicts.

5) Livestock competition and over stocking of rangeland might be the root factor that restricts the recovery of gazelle populations. Future project can focus on evaluating the impact of livestock on the gazelle, i.e. collaring gazelles and livestock to analyze habitat use of the two spatially and temporally. On the other hand, as we found most of deaths were caused by predation, surveys on predators are needed. One particular question is whether fences increase the risk of being predated.

Acknowledgements

This project was funded by Conservation Leadership Programme and Peking University. We thank Qinghai Forestry Bureau, Conservation International, Shan Shui Conservation Center, Wildlife Conservation Society, and Qinghai Lake National Nature Reserve for cooperating and help. We also thank staff of forestry bureaus of Haiyan, Gangcha, Gonghe, and Tianjun County, and staff of Hudong Farm for helping with field surveys. Our sincere thanks go to George B. Schaller, William J. McShea, Zhi Lu, and Dajun Wang for their invaluable advice and effort to edit this report. We are grateful for Hua Qingjia, Kebujinjia, Li Bao for helping with household interview, and for Rui Wang, Chunxia Tuo, Yufang Yang, Lang Feng, and Wen Zhu (Qinghai Normal University), for helping us as volunteers.

Appendices

1. Summary of finances

Itemized expenses	Total CLP requested	Total CLP used (USD)

	(USD)	
PHASE I - PROJECT PREPARATION		
Administration		
Communications (telephone/internet/postage)	50.00	96.34
Books and printing journal articles/materials	50.00	123.89
Insurance		
Visas and permits		
Team training (Please detail:)		
Reconnaissance		
Medical supplies/first aid	200.00	37.67
Equipment		
Scientific/field equipment and supplies (Please detail: GPS unit 214.82×2, compass 29.33×2, spring balance 1.51×2, reagent 6.03×1, note book 0.5×3)	400.00	498.85
Photographic equipment (Please detail: Batteries and charger 28.01, SD card 8.8)	50.00	36.81
Camping equipment (Please detail main items: Sleeping bags , ropes, quilt, candle, tank, thermos bottle)	0.00	216.04
Field guides		
Maps		
Boat/engine/truck		
Fuel		
Other (Please detail:)		
PHASE II - IMPLEMENTATION EXPENSES		
Administration		
Insurance	200.00	52.79
Transportation		
Flight from Beijing to Xining (2 persons × 4 trips)	840.00	1,102.70
Accommodation for team members and local guides (Detail: see the Transportation sheet)	2,920.00	2221.24
Food for team members and local guides (Detail: see the Transportation sheet)	2,520.00	2,226.77
Transportation (Vehicle renting 2904.85, fuel 875.15, field vehicle maintenance 19.21, train 36.1, bus 39.65, taxi 164.53, parking fee 12.76 and toll 46.19)	3,600.00	4,098.44
Customs and port duties		
Field guides	500.00	861.47
Workshops		
Outreach/education activities and materials (brochures, posters, video, t-shirts, etc.) (Please detail: posters * 160 items, t-shirts * 50 items)	250.00	644.92

Other (Please detail: workshop)	800.00	0.00
PHASE III - POST-PROJECT EXPENSES		
Administration		
Report production and results dissemination	100.00	0.00
Other (Please detail:)		
Total	**12,480.00**	**12,217.93**

2. Field data

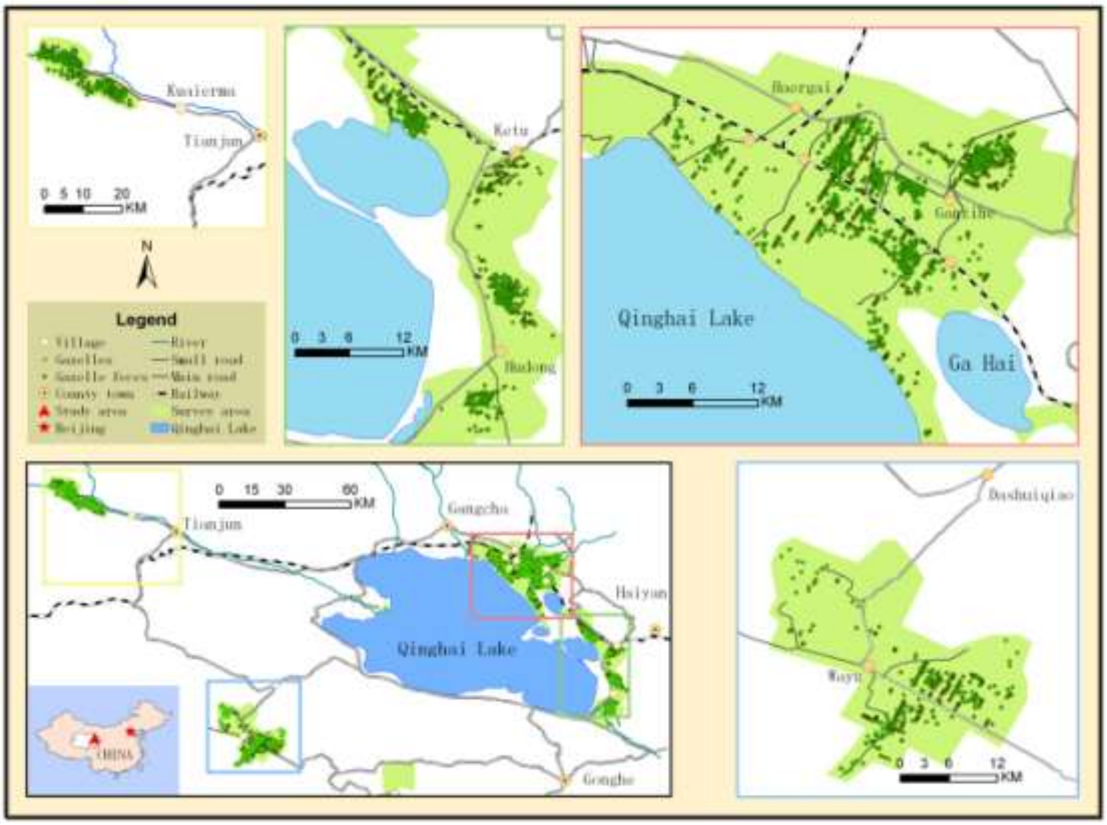

Fig.6 Detailed distribution of gazelles in the study area. Feature layers of gazelle feces and fences are available if asked.

3. Copies of articles

1) A manuscript named “Status and distribution of Przewalski’s gazelle” using part of data from this project had been submitted to Biological Conservation in November 2010, and now the manuscript is under review. We are preparing another manuscript about the impact of fencing on Przewalski’s gazelle.

2) An article about the status and conservation of the gazelle has been published on a local magazine – “DEEP – Scientific discovery in China” (Volume 11, 2009).

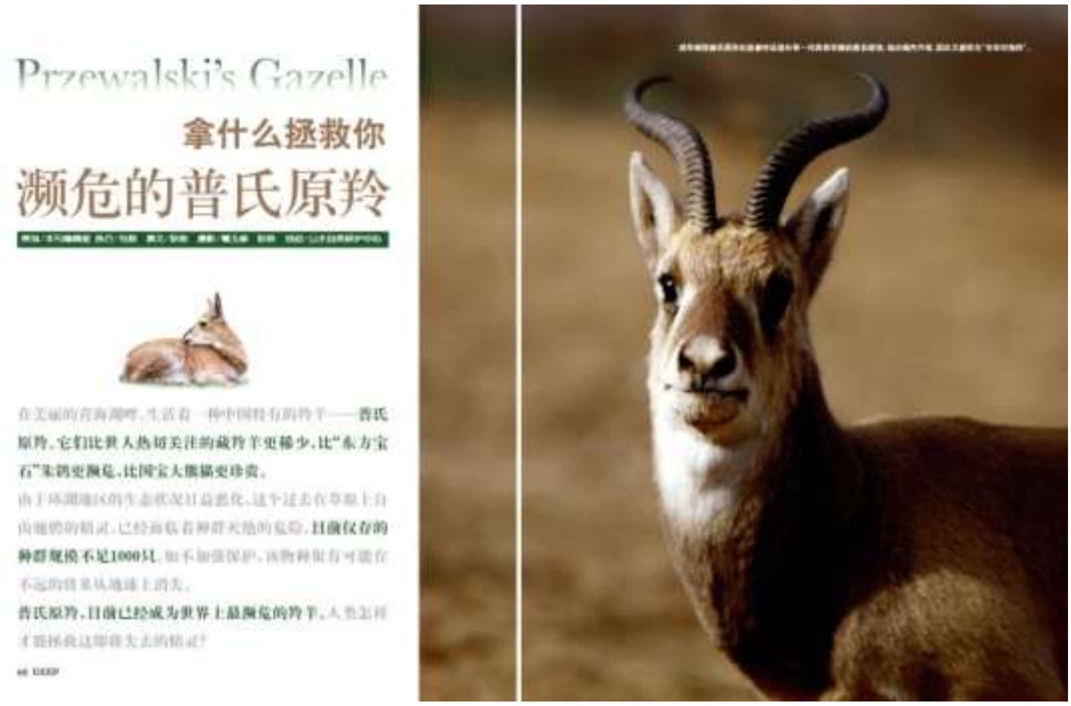

Fig.7 The first page of the article published on "DEEP – Scientific discovery in China" (Volume 11, 2009).

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