

Population declines of Przewalski's gazelle around Qinghai Lake, China

Zhigang Jiang, Diqiang Li and Zuwang Wang

Abstract Przewalski's gazelle *Procapra przewalskii* is endemic to China and is classified as Critically Endangered by IUCN—The World Conservation Union. Historically, the species occurred in parts of the provinces of Gansu, Inner Mongolia, Ningxia and Qinghai but now appears to be restricted to three populations around Qinghai Lake. These three populations—Bird Island, Hudong-Ketu and Yuanzhe—have all declined since 1988. The populations have been monitored since 1994 and the smallest, on Bird Island, appears to be on the brink of extinction, with only seven individuals being recorded in 1998. In the same year, the Hudong-Ketu population comprised 56 individuals (29.4 per cent males, 50 per cent females and 21 per cent juveniles) and the Yuanzhe population 51 individuals (29.4 per cent males, 43.1 per cent females and 27.5 per cent juveniles).

The causes of the declines vary for each population but include loss of habitat as a result of desertification, poaching and, possibly, wolf predation. Human activity and high juvenile mortality are major threats to the continued survival of the gazelle. Conservation measures proposed are: (i) the establishment of a special reserve for Przewalski's gazelle; (ii) a study of the wolf–gazelle relationship and control of the number of wolves if necessary; (iii) a search for remnant populations of Przewalski's gazelle in other regions in their historical range and the identification of suitable sites for translocation and establishment of new populations.

Keywords China, conservation, gazelle, *Procapra przewalskii*, threatened species.

Introduction

Przewalski's gazelle *Procapra przewalskii* is endemic to China. It was named after the Russian explorer Nikolai Przewalski, who first collected specimens of the species in Inner Mongolia, China, some 120 years ago (Allen, 1940). Allen (1940) and Ellerman & Morrison-Scott (1951) listed Przewalski's gazelle as a subspecies of *P. picticaudata*. It was given specific status by Stroganov (1949), an opinion subsequently upheld by Groves (1967) and followed by Corbet (1978) and Honacki *et al.* (1982).

Historically, the species occurred in parts of the provinces of Gansu, Inner Mongolia, Ningxia and Qinghai. As a result of human activity, its habitat deteriorated and its distribution range shrank (Jiang & Wang, in press). In 1986, fewer than 350 gazelles remained, all found in the deserts around Qinghai Lake (Cai *et al.*, 1992), and by 1994 there were only about 200

left (Jiang *et al.*, 1994, 1995, 1996a). While it is possible that remnant populations survive outside the Qinghai Lake region, there have been no recent records and a survey carried out from 5 June to 7 July 1996 failed to find any sign of the species in western Inner Mongolia and adjacent Gansu (Wang & Schaller, 1996).

The critical status of the gazelle has aroused attention world-wide and it is listed as Critically Endangered by the Species Survival Commission of the IUCN (1996). The ecology and status of the species have not been documented thoroughly and, if we are to save this gazelle, research is needed to remedy this and to discover the causes of the declines. In 1994, we formed a research team to monitor the behaviour and population density of Przewalski's gazelle around Qinghai Lake. This paper summarizes the results of the research and presents recommendations for the conservation of the species.

Study area and methods

The study was carried out around Qinghai Lake (36°28'–38°25'N, 97°53'–101°13'E), which lies 3200 m above sea level and, at 4583 sq km, is the largest saline lake in China (Fig. 1). It is fed by c. 40 rivers and streams but has been shrinking as a result of a long-term change to drier climatic conditions: the water table has fallen 0.5–15 cm annually since 1960 (Tao, 1988).

The climate is continental, with dry, cold winters,

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strong winds, high levels of solar radiation and a short frost-free period. The mean annual temperature is 1.1 °C at Hudong on the east shore of the lake and 0.3 °C at Jiangxigou on its south shore. Temperature extremes are 25 °C and –31 °C. Annual precipitation varies from 360–370 mm in the north-west to 395–412 mm in the south-east, with most falling between June and September. The annual evaporation is about four times greater than the annual precipitation. The lake, except for the delta of the Buha River on the west shore, is frozen from December to March. It is extremely windy in winter and early spring.

Vegetation around the lake comprises steppe, desert shrub, alpine shrub and alpine meadow. Steppe is found mainly in the east, north and north-west parts of the region at 3000–3600 m. In the east, it is dominated by *Achnatherum splendens*, *Leymus secalinus* and *Stipa krylorii*, whereas to the north and north-west the dominant plants are *Stipa purpurea* and *Carex* spp. Desert shrub is distributed mainly in the north-east at 3100–3200 m with the dominant plants being *Ephedra intermedia* and *Artemisia desertorum*. Alpine shrub, dominated by *Sabina vulgaris* and *Salix oritreoha*, occurs at 3450–3650 m in the mountains around the lake. Alpine meadows, dominated by *Blysmus sinocompressus*, develop in wetlands, with large meadows being found on the south and west shores of the lake.

The investigations were conducted at the three major gazelle distribution areas around Qinghai Lake: Bird Island on the west shore, Hudong-Ketu desert on the north-east shore and Yuanze moraine to the south-east of the lake (Fig. 1). Between 1994 and 1997, surveys were carried out on transects by both foot and

automobile. An additional survey was conducted in June 1998 to check the Bird Island population. We also hired a worker to monitor the number of gazelles and wolves in the Hudong-Ketu region.

Wherever we found gazelles or signs of either gazelles or wolves, we used Global Positioning Satellite technology to determine site locations. Photographs taken during the survey were studied to verify number, sex and age of the gazelles.

The wolves *Canis lupus* around Qinghai Lake prey on plateau hares *Lepus oiostolus*, plateau pika *Ochotona curzoniae*, rodents, gazelles and domestic animals (Li, 1989; Cai *et al.*, 1992). We collected the skulls and skeletons of gazelles that had possibly been killed by wolves in the Hudong-Ketu desert. We classified these as juveniles or adults by size of bones and teeth, and as adult males or females by the presence or absence of horns.

All animals in this study were cared for in accordance with the principles and guidelines of the Chinese wildlife management authority.

Bird Island

Bird Island was once an island where tens of thousands of birds bred in summer but it is now a peninsula with a vast sandy beach as a result of the falling water table. The Bird Island Natural Reserve was established in the mid-1970s to protect the bird breeding grounds. A population of Przewalski's gazelles lives within the reserve, in the ecotone between steppe and desert. Because of the open nature of the area, we employed total count methods to record the number of gazelles.

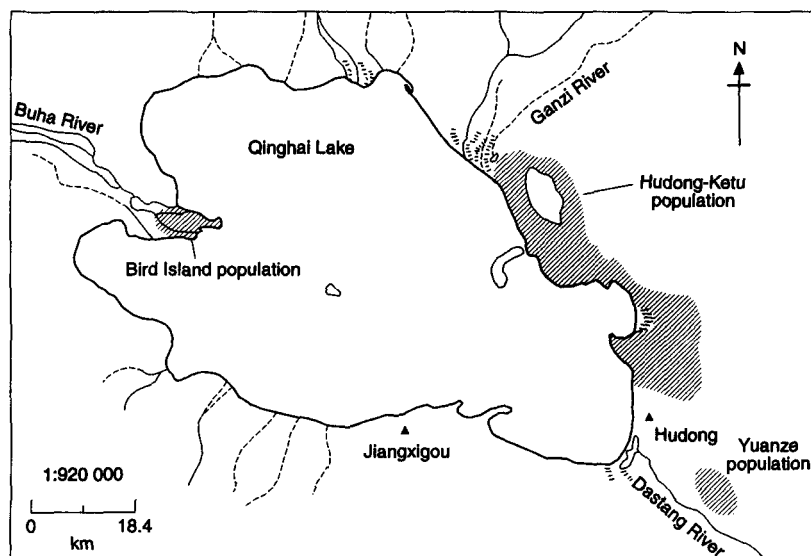


Fig. 1 Study site and the location of the three Przewalski's gazelle populations around Qinghai Lake, China.

Table 1 Geographic location and length of the transects used in the Hudong-Ketu desert at Qinghai Lake, China, in 1996 and 1997

Transect	Start point	End point	Length (km)
1	100°83'80"E, 36°83'18"N	100°77'83"E, 36°79'43"N	6.08
2	100°77'83"E, 36°79'43"N	100°77'83"E, 36°76'22"N	3.58
3	100°77'83"E, 36°76'22"N	100°71'06"E, 36°76'75"N	5.83
4	100°71'06"E, 36°76'75"N	100°69'86"E, 36°77'29"N	1.19
5	100°73'25"E, 36°72'10"N	100°75'57"E, 36°70'81"N	2.52
6	100°75'57"E, 36°70'81"N	100°78'95"E, 36°68'67"N	3.88
7	100°78'95"E, 36°68'67"N	100°79'55"E, 36°71'56"N	3.43
8	100°79'55"E, 36°71'56"N	100°82'67"E, 36°69'42"N	3.58
9	100°82'67"E, 36°69'42"N	100°83'53"E, 36°67'76"N	2.00
10	100°83'53"E, 36°67'76"N	100°87'98"E, 36°64'39"N	5.46

Hudong-Ketu

The Hudong-Ketu desert stretches from the north-eastern to the northern shore of the lake and covers an area of 462 sq km. The gazelles live in the ecotone between the steppe and desert. In August 1996 and July–August 1997, we carried out 4-day surveys in this ecotone. The large area and rugged topography made a total count of the gazelles impossible; we thus used an indirect census method by recording hoof prints within 100 m or gazelle sightings within 600 m along both sides of 10 transect lines, together totalling 37.55 km (Table 1). We drove along the transects at 5–10 km per h and when we saw a group of gazelles or signs of them we stopped the vehicle and counted the number of individuals or hoof prints and estimated group size. Hoof prints of juvenile gazelles are easily distinguished from those of adults because of their smaller size and shorter stride. When juvenile hoof prints were present, the group was assumed to consist of females and juveniles; otherwise, we recorded the hoof prints as those of adult males. During our surveys, we never observed adult male gazelles with females and juveniles during the post-reproductive period. If we found hoof prints left by the same number of gazelles in an adjacent area, we assumed that they were from the same group.

Yuanzhe

The Yuanzhe moraine is typical steppe grassland and is grazed heavily by domestic animals in winter. The herdsman in the region practise a seasonal grazing

regime, driving their livestock to the mountains in summer and moving them back to the lake region in winter. The gazelles are clearly visible in the 1–2-sq-km livestock paddocks in this area. We were thus able to use direct census methods.

Results

Field surveys indicated that all three gazelle populations around Qinghai Lake were declining (Fig. 2). However, the degree and causes of the declines differ for each population.

Bird Island population

In June 1988, the wardens of Bird Island recorded a total of 44 individual Przewalski's gazelles; however, in 1989, they found the remains of 2 gazelles. Daily censuses by the reserve wardens found 37 individual gazelles in December 1991 and only 19 in December 1994. In November 1996, we recorded on videotape 11 gazelles grazing in grassland: 2 adult males, 6 adult females and 3 juveniles. In October 1997, we saw no live gazelles in the reserve but found a piece of the toe bone of a juvenile in the desert part of the reserve. In June 1998, we recorded seven gazelles in the reserve.

Hudong-Ketu population

In 1996, during a 4-day survey in the Hudong-Ketu desert, we found 12 groups of gazelles comprising a total of 108 animals (32 males, 58 females and 18 juveniles). In the 1997 survey, we found 13 groups of gazelles comprising a total of 56 animals (16 males, 28 females and 12 juveniles). Thus, this population consisted of 29 per cent males, 50 per cent females and

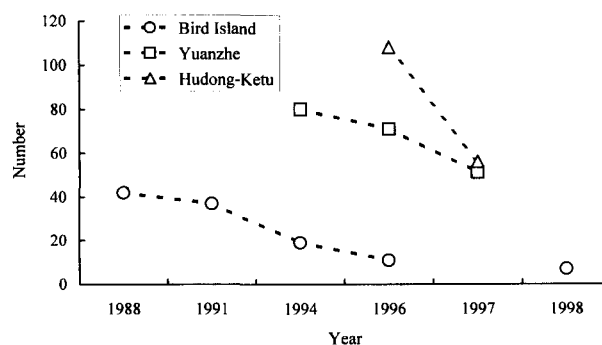


Fig. 2 Population trends in the three Przewalski's gazelle populations around Qinghai Lake, China. The number of gazelles at Bird Island and Yuanzhe were the results of total counts, while the Hudong-Ketu population was estimated using line-transect sampling.

Table 2 Number of Przewalski's gazelles in the Bird Island, Hudong-Ketu and Yuanzhe populations, 1988–97

Date	Survey method*	No. recorded			Total	Gazelle remains	Survey personnel
		Males	Females	Juveniles			
Bird Island							
July 1988	D	–	–	–	44	–	Zhen <i>et al.</i>
June 1989	–	–	–	–	–	2	Zhen <i>et al.</i>
December 1991	D	–	–	–	37	–	Li
26 December 1994	D	–	–	–	19	–	Jiang <i>et al.</i>
25 August 1996	–	0	0	0	0	1	Jiang <i>et al.</i>
3 November 1996	D	2	6	3	11	–	Jiang <i>et al.</i>
9 October 1997	D	–	–	–	–	1	Jiang <i>et al.</i>
19 June 1998	D	2	4	1	7	–	Jiang <i>et al.</i>
Hudong-Ketu							
23 August 1996	I	9	0	0	9	–	Jiang <i>et al.</i>
23 August 1996	I	4	0	0	4	–	Jiang <i>et al.</i>
23 August 1996		0	0	0	0	2	Jiang <i>et al.</i>
23 August 1996	D	0	0	1	1	–	Jiang <i>et al.</i>
24 August 1996	D	5	0	0	5	–	Jiang <i>et al.</i>
24 August 1996	I	0	9	2	11	–	Jiang <i>et al.</i>
25 August 1996	D	0	21	4	25	–	Jiang <i>et al.</i>
25 August 1996	I	0	3	1	4	–	Jiang <i>et al.</i>
25 August 1996	I	0	5	1	6	–	Jiang <i>et al.</i>
25 August 1996	D	0	8	6	14	–	Jiang <i>et al.</i>
26 August 1996		0	0	0	0	7	Jiang <i>et al.</i>
26 August 1996	D	0	12	3	15	–	Jiang <i>et al.</i>
26 August 1996	I	2	0	0	2	–	Jiang <i>et al.</i>
26 August 1996	I	12	0	0	12	–	Jiang <i>et al.</i>
Total 1996		32	58	18	108	9	
30 July 1997	D	0	6	0	6	–	Jiang <i>et al.</i>
30 July 1997	D	0	4	1	5	–	Jiang <i>et al.</i>
30 July 1997	I	2	0	0	2	–	Jiang <i>et al.</i>
30 July 1997	I	4	0	0	4	–	Jiang <i>et al.</i>
31 July 1997	D	1	0	0	1	–	Jiang <i>et al.</i>
31 July 1997	–	0	0	0	0	2	Jiang <i>et al.</i>
31 July 1997	D	2	0	0	2	–	Jiang <i>et al.</i>
31 July 1997	D	0	4	1	5	–	Jiang <i>et al.</i>
31 July 1997	D	4	0	0	4	–	Jiang <i>et al.</i>
1 August 1997	I	2	0	0	2	–	Jiang <i>et al.</i>
1 August 1997	I	1	0	0	1	–	Jiang <i>et al.</i>
1 August 1997	D	0	8	7	15	–	Jiang <i>et al.</i>
1 August 1997	D	0	6	2	8	–	Jiang <i>et al.</i>
2 August 1997	I	0	0	1	1	–	Jiang <i>et al.</i>
Total 1997		16	28	12	56		
Yuanzhe							
October 1994	D	–	–	–	80	–	Herdsmen
21 November 1996	D	–	–	–	71	–	Jiang <i>et al.</i>
7 October 1997	D	15	22	14	51	–	Jiang <i>et al.</i>

* D, direct census; I, indirect census.

21 per cent juveniles. In 1997, the group size was 4.2 ± 3.9 (mean \pm SD), which is significantly smaller ($P < 0.05$) than that in 1996 (9.0 ± 6.9). Although the population size had decreased, there was no difference between the size of the female–juvenile groups between 1996 and 1997.

During the 1996 survey, we found 10 gazelle skeletons (1 at Bird Island and 9 in Hudong-Ketu): 1 male,

1 female and 8 juveniles (Table 2). It is possible that these individuals were killed and eaten by wolves. In summer 1997, we discovered one skull and two forelegs of gazelle in two separate locations. The herdsmen in the Hudong region reported that they had lost more than 60 sheep and 2 horses to wolves in 1997. In October 1997, a herdsman saw a pack of wolves near his tent south of the Hudong-Ketu desert.

The Yuanzhe population

The first thorough census of the gazelles in the Yuanzhe region was carried out in October 1994, when 80 individuals were recorded. In November 1996, we counted 71 gazelles in the region. In early October 1997, we recorded 51 gazelles in the fenced paddocks using the total count method. The size of this population decreased by about 36 per cent in 3 years. By direct census and using the photographs taken during the October 1997 survey, we identified 15 males, 22 females and 14 juveniles; thus, the population consisted of 29.4 per cent males, 43.1 per cent females and 27.5 per cent juveniles.

Discussion

Cause of population declines

Bird Island population

This population of Przewalski's gazelle is threatened by a combination of desertification, poaching and, possibly, wolf predation (Table 3). In the mid-1970s, when the reserve was first established and fenced, there was still grassland in the northern part. However, in the following 20 years the area of desert in the reserve increased to 14 sq km and the original fence was buried by sand. There is now little grassland remaining for the gazelles.

Although the reserve is patrolled by wardens, most of the human resources are allocated to the protection of breeding birds in summer rather than to anti-poaching efforts for gazelles.

There were at least two wolves inside the fenced region of the reserve according to footprint evidence. We found two skulls and skeletons of gazelles in active sand dunes. Presumably, the gazelles were killed by wolves because the wolf is the only animal in the region strong enough to kill them, but there are no direct observations to confirm this. People in the region have only witnessed wolves killing domestic animals. Further analysis of wolf scats needs to be carried out to discover whether wolves prey on these gazelles.

Table 3 Causes of declines in and continuing threats to three populations of Przewalski's gazelles around Qinghai Lake, China

Population	Habitat loss/ modification	Wolf predation	Hunting
Bird Island	Yes	Possible	Yes
Hudong-Ketu	Yes	Possible	No
Yuanzhe	Yes	No	Yes

Hudong-Ketu population

This region's population decline was possibly caused by wolf predation in conjunction with competition with domestic animals for grazing (Table 3). The desert has not expanded much here in the last 10 years. The juvenile: female ratio was 20 per cent lower in this population than that in the Yuanzhe population, a difference that is possibly the result of wolf predation. In 1996, 80 per cent of the gazelles that we recorded as probably having been killed by wolves were juveniles. Wolf predation on old and young ungulates is high (Boyd *et al.*, 1994). Przewalski's gazelle takes refuge in the desert to avoid human disturbance, and livestock grazing forces them to shift their grazing activity to the evenings and to the oases in the desert (Jiang *et al.*, 1994). This change of activity pattern has increased the chances of gazelle-wolf encounters. As Scheel (1993) pointed out, predation risk is related to activity patterns and exposure of prey. Local people recalled that there used to be fewer wolves in the region and that their numbers have increased in the past 4–5 years. In 1997, wolves were shifting their diet to more domestic animals; this may be the result of declining gazelle numbers or an increased wolf population, or both. In winter 1997, wolf packs of 20–30 individuals were sighted.

Yuanzhe population

This population has declined because of habitat loss/modification and hunting (Table 3). It is a remnant of the thousands-strong population that once lived in the Daotonghe River drainage, according to local people. This population is now surrounded by human settlements. Because the moraine region has good, highly productive pastures and good water sources, it has been fenced by landowners to increase livestock productivity in recent years. The herdsmen build turf walls to make 1–2-sq-km paddocks. In places, the turf walls collapse, leaving gaps that enable the gazelles to move freely between paddocks. In summer the gazelles are able to hide in tall grass but in winter the paddocks are heavily grazed by livestock (Jiang *et al.*, 1995). Loss of habitat is the major threat to Przewalski's gazelle in this area. Poaching is also a large threat because a highway and several minor roads cross the region. During our 1996 survey, herdsmen told us that some people drive up to the paddocks and shoot gazelles.

Current threats to the gazelles

Although the three populations of Przewalski's gazelle in the Qinghai Lake region are all declining, they are not all threatened by the same factors. However, the main threats operating now can be summarized as

follows. (1) Human density has increased since the 1950s with consequent increases in livestock numbers and area of farmland. This has reduced feeding habitat availability for the gazelle (Jiang *et al.*, 1996b). (2) High juvenile mortality. In the Hudong-Ketu population, surviving juveniles made up only 17 and 22 per cent of the total in 1996 and 1997, respectively. Even in the Yuanzhe population, where there are no wolves, only 27 per cent of the population were juveniles. (3) Small population size caused by habitat fragmentation. The existing populations of the gazelle are surrounded by areas of human settlement and natural exchange of genes is extremely difficult, if not impossible.

Conservation proposals

We propose the following measures to conserve Przewalski's gazelle in the Qinghai Lake region. (1) Establish a special reserve for the species in the ecotone between grassland and desert in the Hudong-Ketu region. This will be difficult because of conflict of interest among different interest groups in the region (including policy makers, herdsman, farmers and collectors of medicinal plants). It will also be difficult to resolve the ownership of the grassland for the reserve. However, it is necessary to solve these problems for the sake of conserving the species. The reserve should have a totally protected inner zone where livestock grazing is banned. Such a reserve would also ensure a habitat corridor linking the Hudong-Ketu and Yuanzhe populations. This corridor would also allow the gazelles in the desert to move to feeding grounds with less snow and thus reduce the impacts of snowstorms in the winter. (2) Investigate whether the wolf is a threat to Przewalski's gazelle by assessing the diet of the wolf using scat analysis and, if necessary, take measures to control the density of wolves in the Hudong-Ketu region. (3) Search for other Przewalski's gazelle populations in other regions in the historical range and look for a site that is suitable for *ex situ* conservation. It is possible that there may be remnant populations of the gazelle outside Qinghai Lake. We propose a large-scale survey in north-west China to look for these populations and to identify a suitable site for *ex situ* conservation, i.e. for translocation of individuals to establish a new population. If a suitable translocation site cannot be found, we should concentrate our efforts on the *in situ* conservation of the survivors.

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