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Short communication

Reintroduction of Przewalski's horse (*Equus ferus przewalskii*) in Xinjiang, China: The status and experience

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ABSTRACT

Przewalski's horse reintroductions to Xinjiang, China were initiated in 1985. Here, we present the first data on population development and current problems of the Przewalski's horse in both captive and released populations in Xinjiang. From 1985 to 2005, a total of 24 captive Przewalski's horses (14 males and 10 females) were brought from western zoos to the Jimsar Wild Horse Breeding Center (WHBC) in Xinjiang. In 1988, the first foal was born. Since then, a total of 285 foals have been born and the number of animals in the captive population continues to increase. In August 2001, the first group of horses was released into semi-wild conditions in the Kalamaili Nature Reserve (KNR). Released horses were allowed to range freely from spring to fall, but were driven into a winter coral to allow for supplemental feeding and to increase winter survival, and to reduce competition with domestic horses from local herdsmen who use the KNR as winter pasture. By December 2013, a total of 89 horses (32 males and 57 females) in 14 groups had been transferred to semi-release; and within two years after the first release, the first foal was successfully born in the wild. By 2013, the reintroduced animals had formed into 16 groups (127 individuals, 13 breeding and 3 bachelor group) in 5 sites. To date, this is the most comprehensive and successful Przewalski's reintroduction effort in China.

1. Introduction

The Przewalski's horse (*Equus ferus przewalskii*) was first discovered in the Gobi Desert in Mongolia in 1880 by a Russian officer named Colonel Nikolai Przewalski; I.S. Poliakov was the first to scientifically document this species in 1881 (Poliakov, 1881). The last recorded sighting of a wild Przewalski's horse occurred in the Dzungarian Gobi of Mongolia in 1969 (Bouman, 2006), and since then, this species has been extinct in the wild with only a few remnant populations existing in small captive breeding herds in western countries (Kaczensky et al., 2007; Wakefield et al., 2002). All Przewalski's horses alive today are descendants from only 13 individuals that were the nucleus for captive breeding (Bowling and Ryder, 1987; Boyd et al., 1988; Wakefield et al., 2002). These initial animals reproduced successfully in captivity, with the current captive population now exceeding 1 800 individuals scattered across about 112 breeding centers and zoos around the world.

One ultimate goal of captive breeding of threatened species is to reintroduce animals back into their former habitats in the wild (Sheldon, 1986; Stanley-Price, 1989). Reintroduction efforts of Przewalskis's horse started in the 1990 in Central Asia – Mongolia, Russia and northwestern China (Boyd and Bandi, 2002; Kaczensky et al., 2007; King and Gurnell, 2005; Zimmermann, 2005; Pantel et al., 2006). To sustain reintroduction projects over the long term a well-managed, captive population of Przewalski's horses is needed. However, until recently most captive populations existed in western zoos, requiring expensive, logistically difficult, and potentially dangerous transport of captive animals for release from the west to Asia. In 1992 the first group of captive-born Przewalski's horses was transported to Mongolia, and to date, three reintroduction projects in Takhiin Tal, Hustai National Park and Khomiin Tal exist. Approximately 350 free-ranging Przewalski's horses now roam these sites in Mongolia (Walzer et al., 2012). Although the status of the captive breeding programs and the reintroduced Przewalski's horse populations in Mongolia have been reported on at length (Bouman, 2006; Boyd and Bandi, 2002; Kaczensky et al., 2008,2011; King and Gurnell, 2010; Zimmermann, 1999), data from China's program are largely lacking for both captive and released populations. In this paper, we will present the status and current challenges of the Przewalski's horse in both captive and released populations since 1985 – the year the first Przewalski's horse was returned to Xinjiang, China.

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2. Materials and methods

2.1. Study sites

2.1.1. Wild horse breeding center

As an *ex-situ* conservation measure, a captive breeding program was initiated in 1985 at the Wild Horse Breeding Center (WHBC) Jimsar County, in the southern part of the Gobi's Junggar Basin in Xinjiang, China. WHBC's main objective is to establish a self-sustaining captive population from which animals can be released into the wild. WHBC is 600 ha in size and surrounded by a 2.5 m brick wall. The WHBC has two feed-storage sheds, three horse housings and eight enclosures, including enclosures for a breeding group, foal group, female-foal group, mixed group, male group, sick individuals and the biggest enclosure for acclimatization of horses before they are transported to the Kalamaili Nature Reserve (KNR) for release in the wild. The main food of the captive Przewalski's horses is alfalfa, supplemented by corn, carrots, watermelon given as required.

As the captive population continues to grow, WHBC is facing a shortage of space. Existing facilities are now >25 years old and are greatly in need of updating to improve animal care and management. The main problem is a lack of visual barriers and buffer areas between harem groups and between harem and bachelor groups. As a result, stallions exhibit increased stress and excessive herding behavior. Serious fights occur regularly along enclosure fences which can potentially result in serious injuries (Pantel et al., 2006).

2.1.2. Kalamaili nature reserve

The KNR and the adjacent areas in Mongolia were the last refuge for the Przewalski's horse (Allen, 1938; Bannikov, 1954; Gao, 1984, 1989). This reserve is located in the northeast part of Junggar Basin, only about 150 km from the WHBC and 200 km from the Great Gobi B Strictly Protected Area (SPA) in Mongolia. The KNR is at an elevation of 600–1700 m. This region has a harsh continental-type local climate with an average yearly temperature of +1.99 °C. Winters are long and cold; summers are hot and short. Average annual rainfall was 186.8 mm. Vegetation cover is quite sparse and consists mostly of desert shrubs and dwarf shrubs from the families Chenopodiaceae, Ephedraceae, Tamaricaceae, and Zygophyllaceae. The most common desert tree is the saxaul *Haloxylon ammodendron*. Common shrubs are *Anabasis salsa*, *Atraphaxis frutescens*, *Calligonum mongolicum*, *Ceratocarpus arenarius*, *Ceratoides latens*. Species from the genera *Sterigmostemum*, *Alyssum*, *Scorzonera* are common here. Around 3379–5318 khulans (*Equus hemionus*) and 6628–19,677 goitered gazelles (*Gazella subgutturosa*) also live in KNR (Chu et al., 2009).

In 2002 and 2004, KNR failed to upgrade its protection level due to the ongoing human activities inside the core reserve areas. Since then, KNR has been reduced from 18,000 km^2 to 12,800 km^2 due to coal mining. During winter, about 2000 herdsmen and 200,000 livestock (including horses) occupy the best pastures in the reserve (Chu et al., 2008; Liu et al., 2008). Moreover, national road line 216 is an important transportation route between Urumqi and Altay, and divides KNR into two parts. The line 216 became very dangerous to Przewlski's horses after it was upgraded to a highway in 2005, and five Przewalski's horses have been killed by motor vehicle collisions.

Prior to release, a 20-ha pre-release enclosure was constructed at the reintroduction site. Then enough hay/alfalfa and water was provided to allow the Przewalski's horses to acclimatize to their new environment. They were released when the chances for their survival were the most suitable – late spring when the temperature was increasing and food was more abundant. Released horses were allowed to range freely from spring to fall, but were driven into a winter coral to allow for supplemental feeding to increase winter survival, and to reduce competition with domestic horses from local herdsmen who use the KNR as winter pasture.

2.2. Data collection

Przewalski's horse at WHBC is marked by using plastic ear labels with individual number for identification and tracking released groups. Data from the development of the captive population were recorded by WHBC staff and the reintroduced population by KNR staff. These data included the number of pregnant and post-partum females, the number of newborn foals and surviving foals, and a total number of all individuals and their distribution. For the captive population, the Przewalski's horses were fed four times a day at 7:00, 13:00, 18:00 and 00:00. Each adult was fed 2.5 kg of food per feeding and each sub-adult was fed half of the adult portion (Wang, 2004). The status of animals were monitoring and checking during their feeding and cleaning routines. In the enclosure, Przewalski's horses were checked daily, while free roaming groups were checked from cars by KNR staff once per two days.

3. Results

3.1. Population growth of the captive population

The WHBC breeding population of 24 animals (14 males and 10 females) arrived in five groups from captive facilities in Germany, the United Kingdom, and the United States over the period from 1985 to 2005 (Table 1). Prior to their arrival at WHBC, all Przewalski's horses were first kept at Urumqi Zoo in Xinjiang for a period of 16 months to allow them to adapt to the local environment and changes in climate.

Between 1988 and 2013, 339 foals were born and 285 survived at WHBC (Table 2). The mean survival rate of foals averaged 86.7%, resulting in a steady increase in the captive population that reached 142 individuals by 2006 (Table 2). This breeding success opened the door for the reintroduction of these horses into the wild, providing sufficient individuals with complete studbook information and relatively low inbreeding coefficients (<0.2, before 2006).

3.2. Population growth of the reintroduced population

In August 2001, the first captive-bred group of 27 individuals (11 males and 16 females) was released at KNR. Thirteen more groups followed and in total 89 captive-born Przewalski's horses (32 males and 57 females) were transported to the KNR between August 2001 and December 2013 (Table 3). Five release sites were chosen during that same time frame based on the combined impacts from available water resources, forage quality and quantity, and the interference level from human activities, as well as a

Table 1
Reintroduced Przewalski's horses from around the world.

Time of reintroduction	Numbers			Source area
	Male	Female	Total	
1985–08-06	2	3	5	Germany
1985–08-22	2	4	6	United Kingdom
1988–09-24	2	3	5	Germany
1991–12-28	2	0	2	United States of America
2005–09-07	6	0	6	Germany
Total	14	10	24	

Table 2
Reproduction of the captive Przewalski's horses in Wild Horse Breeding Center (WHBC).

Year	Number of foals		Number of surviving foals	Fertility rate (%)	Reproductive rate (%)	Foal survival rate (%)	Total number
	Males	Females					
1988	1	5	6	85.7	65.7	100.0	22
1989	2	2	4	57.1	57.1	100.0	25
1990	1	3	4	55.6	44.4	100.0	29
1991	2	4	5	66.7	66.7	83.3	36
1992	2	7	8	69.2	69.2	88.9	42
1993	5	4	7	52.9	52.9	77.8	49
1994	1	3	3	25.0	20.0	75.0	50
1995	1	13	11	79.0	73.7	78.6	45
1996	5	6	10	63.2	59.9	90.9	55
1997	3	6	7	55.0	45.0	77.8	61
1998	7	10	13	81.8	77.3	76.5	73
1999	4	10	11	48.4	45.2	78.6	84
2000	7	11	15	55.6	50.0	83.3	98
2001	15	9	20	64.1	61.5	83.3	90
2002	13	8	17	67.7	61.8	81.0	99
2003	17	12	24	76.9	74.4	82.8	121
2004	5	16	19	57.9	55.3	90.5	118
2005	7	7	13	51.7	48.3	92.9	130
2006	7	8	13	55.2	51.7	86.7	142
2007	12	12	16	64.1	61.5	66.7	117
2008	3	11	12	57.7	53.9	85.7	104
2009	2	1	3	100	75.0	100	83
2010	2	1	3	100	75.0	100	79
2011	9	10	14	61.3	61.3	73.7	93
2012	12	8	20	54.1	54.1	100.0	105
2013	4	3	7	30.4	30.4	100.0	86
Total	149	190	285			86.7	

Table 3
Number of the released Przewalski's horses in Kalamaili Nature Reserve (KNR).

Time of release	Number released			Sites of release
	Male	Female	In total	
2001-08-18	11	16	27	Southern bank of Ulungur River
2002-02-09	2	0	2	Southern bank of Ulungur River
2002-05-24	5	0	5	Southern bank of Ulungur River
2004-07-30	2	8	10	Southern bank of Ulungur River
2007-06-03	1	5	6	Kamusite
2008-07-20	1	5	6	Kamusite
2009-05-20	0	6	6	Qiaomuxibai
2010-05-20	1	5	6	Qiaomuxibai
2013-05-29	1	1	2	Sangequan
2013-05-29	1	5	6	Yegezituobie
2013-06-06	0	1	1	Sangequan
2013-06-18	1	5	6	Sangequan
2013-06-25	5	0	5	Qiaomuxibai
2013-12-10	1	0	1	Yegezibieke
Total	32	57	89	

distance from roads for logistical purposes (i.e. difficulty of transporting animals to release site) (Fig. 1).

In 2003, the first foal was born in KNR by the group released in 2001, and by 2013, a total of 107 foals had been born, of which 88 (75.3%) survived their first year (Table 4). In 2013, the total population of the released Przewalski's horses was 127 individuals divided into 16 groups (13 breeding and 3 bachelor groups), which mainly distributed in five areas within KNR: one group moved on their own to Burxiakebai and Sangequan from the release site at Kamusite (Fig. 1, Table 5), while the other groups remained around their release sites. To survive the harsh winters and avoid the competition with domestic animals in KNR, the released horses are still driven to the protection found inside the fences of the reserve during each winter. This type of management, however, may adversely affect social organization of the released Przewalski's horses and prevent their dispersal to find suitable winter habitats. Therefore this reintroduction project remains only partially effective at this time, and the released population of Przewalski's horses in KNR can only be considered a semi-wild population.

4. Discussion

Working for more than 25 years, and using effective breeding techniques combined with transfers of horses from the U.S.A, England, and Germany, WHBC successfully established a self-sustaining captive population. These horses, then, were ready for release, based on a high foal survival rate (Table 2), complete studbook information, and relatively lower inbreeding coefficients than the worldwide average (Liu et al., 2014). These satisfied the criteria as stated in the IUCN reintroduction guidelines: "if captive bred stock is to be used for reintroductions, it must be from a population which has been soundly managed both demographically and genetically" (IUCN, 1998). This achievement by WHBC has been accomplished in spite of the age and limited space of the current facilities, which have impeded the effective management and husbandry required by international standards. If improvements were realized, the captive population of Przewalski's horses would have the ability to increase rapidly. In May 2012, four male Przewalski's horses were transported to Mongolia from WHBC to reinforce the Mongolia population's genetic diversity. This opened an exchange gate between Mongolia and WHBC. Transferring Przewalski's horses from WHBC to Mongolia rather than western zoos is much more economical, less stressful on the horses and easier to acclimate to the local climate. WHBC's future goal is to become a Przewalski's horse regional conservation breeding center, not only for China's reintroduction projects, but also for those of surrounding countries, ultimately playing an important role in supporting Przewalski's horse reintroduction projects in Asia.

The reintroduction site was chosen within KNR. Historically the last groups of living wild Przewalski's horses were extirpated from this area in China, although this semi-desert region was actually the last refuge for these animals. Primarily through excessive hunting and pasture competition with domestic livestock (Gao, 1989; Kaczensky et al., 2007; Walzer et al., 2012), the wild horses were forced out of their natural habitats by people living in the steppe regions of Kazakhstan and Mongolia (Heptner et al., 1988). The first reintroduction project of Przewalski's horses that occurred in the

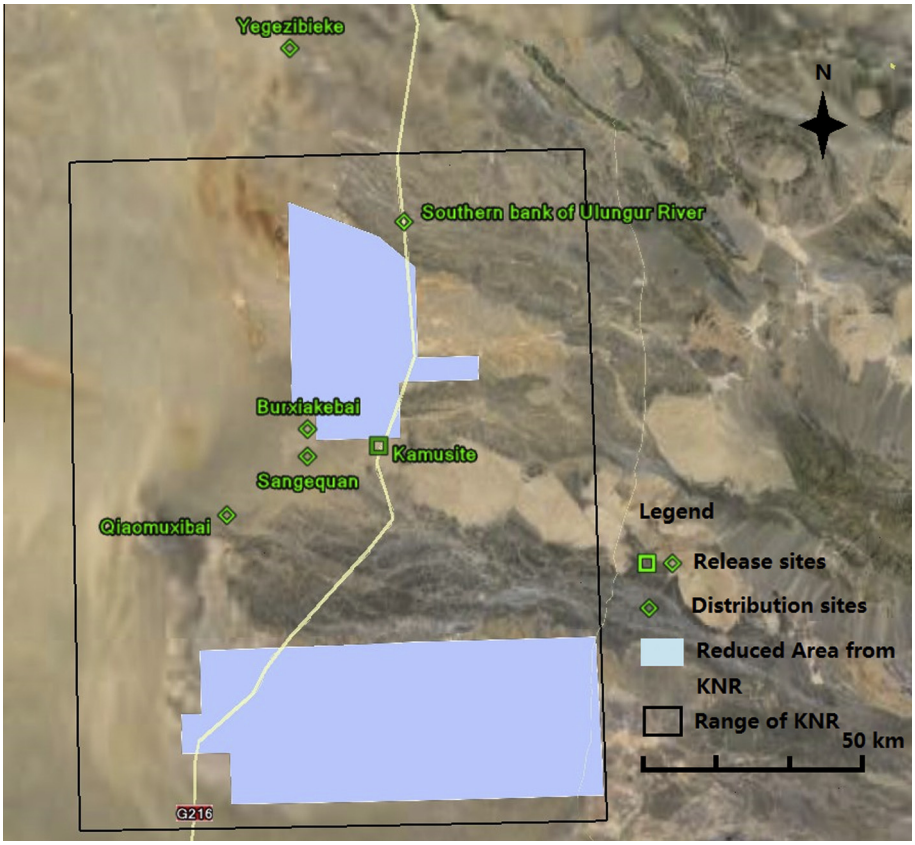

Fig. 1. Release and distribution sites of Przewalski's horses in Kalamaili Nature Reserve (KNR), Xinjiang China from 2001 to 2013.

Table 4
Breeding status of the released Przewalski's horses in Kalamaili Nature Reserve (KNR).

Year	Number of foals			Number of foals surviving	Foals survival rate
	Male	Female	In total		
2003	3	4	7	3	42.9
2004	1	2	3	2	66.7
2005	0	3	3	2	66.7
2006	4	7	11	9	81.8
2007	7	5	12	9	75.0
2008	3	6	9	5	55.6
2009	2	2	4	2	50.0
2010	5	4	9	9	100.0
2011	8	6	14	14	100.0
2012	9	10	19	17	89.5
2013	9	7	16	16	100.0
Total	51	56	107	88	75.3

Hustai National Park in Mongolia, situated in the steppe ecological zone, was the most successful out of all reintroduction projects for this species (Souris et al., 2007), and confirmed that the steppes provided the most favorable conditions for the survival of the Przewalski's horse.

According to the guidelines of international conservation authorities, reintroduction programs should be considered only if the factors that caused the decline of the species are entirely removed from their habit, so as to effect any new populations (Dowell, 1990). However, it is difficult to completely avoid the pressures of human activities on the Przewalski's horses. This is especially difficult in China, where according to legislation, even a status of "nature reserve" does not protect reserved areas from agricultural and industrial development. For example, along national road line 216, which runs through KNR, there have been several collisions between Przewalski's horses and commercial trucks that have resulted in the deaths of five horses in 2007. Different government departments are making a combined effort to help drivers avoid these accidents, such as increasing public awareness of the Przewalski's horse reintroduction project and using warning signs in key areas in KNR, etc. Five release sites were chosen based the availability of water and forage, the degree of human interference, and distance from road. Of these five sites, one, Kamusite, is a transfer station for people traveling between Urumqi and Altay, with around 20 families living there year round to serve travelers. Consequently, all two groups of Przewalski's horses released at this site moved to adjacent areas in Sangequan and Burxiakebai, presumably to escape this area with relatively high human activity, indicating that human interference may be one of the more important factors to consider in planning future reintroductions.

KNR has been reduced in size due to mineral exploitation activities. (A coal mine opened in 2007 in the center of KNR, only 4 km away from the Kamusite release site.) These reduced areas have prevented the Przewalski's horses from spreading in KNR as far as they might otherwise, resulting in habitat isolation to some extent, and limits the choice for future suitable reintroduction sites. Moreover, Przewalski's horses need larger areas during catastrophic draughts or snowstorms to find water or avoid deep snow. Experiences from successful projects in Hustai, Mongolia, showed that the Przewalski's horse needs a bigger range size, but over time they established home ranges further away from where they were released (King and Gurnell, 2005).

During the 13 years period from 2001 to 2013, 69 (35.2%) semi-wild horses (including foals) died from the first release, representing a high mortality for the released Przewalski's population as a whole. The most negative factor contributing to this phenomenon

Table 5
Status of the released Przewalski's horses in Kalamaili Nature Reserve (KNR).

Number of groups	Kinds of groups	Male	Female	Foals	In total	Distribution areas
1	Breeding group	1	7	1	9	Qiaomuxibai
2	Breeding group	1	7	2	10	Qiaomuxibai
3	Breeding group	1	2	1	4	Qiaomuxibai
4	Breeding group	1	6	2	9	Qiaomuxibai
5	Male group	24	0	0	24	Southern bank of Ulungur River
6	Breeding group	1	5	1	7	Burxiakebai
7	Breeding group	1	4	1	6	Qiaomuxibai
8	Breeding group	1	4	1	6	Qiaomuxibai
9	Breeding group	1	4	2	7	Qiaomuxibai
10	Breeding group	1	1	1	3	Qiaomuxibai
11	Breeding group	1	3	3	7	Qiaomuxibai
12	Breeding group	1	5	0	6	Qiaomuxibai
13	Male group	5	0	0	5	Qiaomuxibai
14	Breeding group	1	5	1	7	Yegezibieke
15	Male group	9	0	0	9	Sangequan
16	Breeding group	1	7	0	8	Sangequan
Total		51	60	16	127	

was the intensive industrial development in the most southern parts of KNR, where the best winter and spring pastures for wild ungulates are located. All wild and domestic ungulates were forced out of this area into the northern parts of KNR, increasing competition for the lower quality pastures. As seen in the Mongolia project, domestic animals also pose a significant threat to the Przewalski's horse population through overgrazing of prime pasture land, epizootic dispersal and interbreeding (Bouman, 1998; Pantel et al., 2006). A consideration for successful reintroductions that was emphasized by Duncan (1992) and Stanley-Price (1992) is to create benefits to local people from the establishment of protected areas. Through previous experiences in Mongolia, the local nomadic communities needed to be brought into the reintroduction effort to help address the threats posed by domestic livestock (Van Dierendonck and De Vries, 1996). Therefore herdsmen in KNR need to be involved in the process and to be able to see benefits from the reintroduction project to compensate for their loss of pastures to the released horses. As an example of this involvement, WHBC began a Przewalski's horse ecological tourism program, which expanded the knowledge of the local people as to the project's goals and problems facing its success; through education, people are able to develop a stronger sense of cooperation and a vested interest in its realization. Work has also been done in the community with local herdsmen, where KNR has offered free coal to help reduce illegal saxaul collection, and thus reduced the herdsmen's impact on environment (Liu et al., 2013). For future reintroduction projects, it would be beneficial for local communities to be included either directly or indirectly in the efforts to solve the various human related conflicts that have been experienced by Mongolia's reintroduction program (Souris et al., 2007).

Although having different chromosomal numbers genetically separates the Przewalski's horse from the domestic horse, the two have been known to interbreed with each other and to produce fertile offspring (Short et al., 1974). Hybridization with domestic horses may directly threaten the long-term success of any reintroduction Przewalski's horses, and there have been three cases of hybridization recorded in 2003, 2006 and 2007, respectively (Chen, 2008). Domestic horses, therefore, should be excluded in the release areas in KNR, especially during the rut, to protect the gene pool of the Przewalski's horse. In addition, diseases, including parasites, transferred from domestic horses to semi-wild horses may be another factor affecting the survival of the Przewalski's horse, and reinforces the need to limit contact between these two distinct populations (Mark and Zhang, 2003; Zhang et al., 2008).

Extremely low temperatures and insufficient food during winter can lead to a sharp decline in the number of wildlife. For example, the Przewalski's horse population in the Gobi B in Mongolia crashed during the harsh winter of 2009/2010, only 30% of the individuals survived (Kaczensky et al., 2011). We learned from Mongolia's project experience that more Przewalski's horses needed to be released in different, spatially distributed release sites, so one of our important considerations was to establish multiple reintroduction sites that would support spatially dispersed populations. Since small populations are more vulnerable to stochastic events such as severe weather (Kaczensky et al., 2011), diversifying population release sites spread the risk of such events. The survival of the Przewalski's horse in the wild should increase under this system, in contrast to the free-ranging population in KNR with only 127 individuals in 2013 that demonstrated a lower capability to survive severe winters and needed additional resources supplied by the reserve to help them survive.

Based on the factors outlined above, and because herdsmen drive their herds to winter over in KNR pastures, KNR staff drive the Przewalski's horses back into the fence-protected areas in the reserve during winter. This is done as a precautionary measure to avoid potential hybridization with domestic horses during the rut, to alleviate the risk from harmful disease transmissions, as well as to eliminate resource competition with domestic horses and possibly other livestock. The aim of a reintroduction program is to establish a free-ranging, self-sustainable population, and should allow for the continued evolution of the species by natural selection (Seal et al., 1990). There are, however, several conditions lacking for the creation of a truly free-ranging, self-sustaining population of Przewalski's horses in China: (a) a steppe environment in the Northern area of KNR; (b) nature reserve status for protections against industrial and agricultural development (to minimize human interference); (c) several large enough groups for re-acclimatization; and (d) higher quality project facilities that meet international standards. Because these elements are not currently available and because additional reserve support for the Przewalski's horse is still necessary during the winter months, the reintroduction of Przewalski's horses to China – compared to the first such project in Mongolia – remains only partially effective at this time. It is, however, a vital first step to successfully reestablishing this endangered wild species back into its native habitat in China.

5. Recommendations

A successful reintroduction project requires that the species concerned develop a self-sustaining population, independent of human intervention. Compared to the reintroduction projects in

the Great Gobi B in Mongolia, where all Przewalski's horses are free ranging all year round, the KNR population is still dependent on human support for its survival. Consequently, KNR needs to gradually reduce the anthropogenic impacts on the released population, especially during winter, whatever the mortality rate. It is also necessary to release many more individuals into KNR in order to maintain a viable population. Meanwhile, the number of domestic livestock, especially horses, should be strictly limited to eliminate any potential threat to the survival of the KNR population. Even though the mortality of the released animals might be high initially, this is the only effective way to ensure a self-supporting, free ranging population of Przewalski's horses over the long term.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.biocon.2014.06.021. These data include Google maps of the most important areas described in this article.

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