

Reproduction and Mortality of Re-introduced Przewalski's Horse *Equus przewalskii* in Hustai National Park, Mongolia

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Abstract: The reproduction rate of *Equus przewalskii* in this study increased from year to year showing that the wild horses have already felt comfortable in the new environment and became acclimatized successfully. Of the mares which were born in Hustai National Park and successfully reached reproductive age, 24.7% first gave birth at age 3 and 55.6% of them first gave birth at age 4. The most effective age range within the breeding population was 5 to 15, 25%-89% of them giving birth and an average during 2002-2011 of 72.9%. Of the Przewalski's horses which died, 65% were foals, 9.4% subadult male, 7.7% subadult female, 7.2% adult male and 10.6% were adult females. Causes of mortality differed by age and sex although wolf attacks accounted for the predominant number of deaths among foals and subadults. Stallions usually died of bad condition and injuries but parturition problems were common causes of death among mares. The mortality rate of foals (40% in 1993-2011) is a matter of great concern since foals born in Hustai National Park are the only gain component now after the active reintroduction period came to an end. A total of 109 foals were killed by wolves in 1993-2011 but 52% of them were younger than one month.

Key words: Przewalski's horse, reproduction, mortality, seasonality, wolf attack.

1. Introduction

Eminent explorer and Russian army colonel N.M. Przewalski discovered a new species of wild horse from the Mongolian and Chinese frontier region in the year 1878, subsequently named *Equus przewalskii* Poljakov in 1881. Between 1898 and 1903, 88 foals were caught in the Mongolian gobi, but only 53 foals survived the transport to Europe [1]. Because of competition with livestock, illegal hunting and harsh climatic conditions the wild horse "takhi" probably became extinct in the wild in the 1960s [2]. However, the reintroduction started only in 1992 with the import of 16 Przewalski's horses from the Netherlands to Hustai National Park in Mongolia in association with the Foundation for the Preservation and Protection of the Przewalski horse and the Mongolian Association for

Conservation of Nature and Environment. During 1992-2000, over five occasions, 84 wild horses from European countries were reintroduced to Hustai National Park. At present 270 individuals of Przewalski's horses exist in Hustai National Park with 30 breeding harems and more than 50 bachelors competing for the mares. The aims of this study were to investigate reproduction and mortality of the reintroduced Przewalski's horse and conduct detailed analysis of key factors affecting population dynamics such as mortality age, sex, period and cause of death. Overall this research result should be the basis for guidelines of successful reintroduction of Przewalski's horse into the wild.

2. Materials and Methods

2.1 Research Area

Hustai National Park (HNP) is located 100 km west of Ulaanbaatar, the capital of Mongolia at

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105°40'-106°37' east and 47°35'-47°52' north. HNP is an area of scientific interest in terms of vegetation and geographic features. On the one hand, it comprises the four grassland zones of the Middle Khalkha vegetation region; on the other it spans over an area where the ancient remnant deciduous forest, at the south-western corner of the Hentii mountain region, comes into contact with some of the characteristic elements of the Central Asian desert steppe. It is worth emphasizing that all of these constitute a distinctive ecosystem structure and ecotonal boundary.

The climate of Hustai National Park is characterised by long cold winters with the lowest temperature of -40 °C, and a short temperate summer reaching a temperature of +40 °C. Spring and autumn are a bit longer with dry strong winds. The annual average air temperature is +0.2 °C, and annual average rainfall is 225 mm, July has the greatest precipitation.

There are 451 species of vascular plants and 208 species of non vascular plants registered. Of this protected area, 95% (or 48,345 ha) is covered by pasture land and by 200 species of pasture-significant plants. The forest of Hustai Nuruu mountain is in the southern most isolated fragment of the Siberian Taiga Forest and is surrounded by the dry steppe and mountain steppe of Mongol Dauria and Middle Khalkha. It is separated from Hentii Taiga as an isolated "island" and it is affected by the surrounding dry steppe and has composite vegetation diversity. Only 4% or 2,000 ha of the park covered by forest. From these, 66.2% is dominated by composite forest of birches (*Betula platyphylla*) and poplars (*Populus tremula*), 23.6% is only covered by birch and the remainder is poplar dominated forest. The vegetation season starts between April and May and ends in the beginning of September [3].

Previous research works at Hustai National Park have identified over 400 species of insects, 16 species of fishes, 2 species of amphibians, 3 species of reptiles, 221 bird species and 46 species of mammals. The dominant ungulate species is red deer (*Cervus elaphus*)

estimated as 600-700 individuals. There are 11 species of predators registered in Hustai National Park however the only one directly preying the reintroduced Przewalski's horse is the Gray wolf (*Canis lupus*).

2.2 Reproduction and Mortality

A field study was conducted by biologists and rangers of the park. And data were collected by simple registration method. Information was recorded on birth, death date and cause, and movement among groups. DASHBOARD software was used to store this demographic information.

Reproduction rate describes the percent of mares that gave birth among each age group of females that were capable of reproduction. Reproduction rate % = (the number of female horses that gave birth in this age group/total number of female horses that should produce offspring in this age group)*100. Survival rate is the percentage of offspring which survived after birth. Survival rate % = (Survived foals/Total foals)*100.

Mortality date was registered daily and the cause of death determined by present evidence such as footprints and scats of predators, hunting strategy and the condition of the carcass.

3. Results

3.1 Reproduction by Age Group

Of the mares which were born in Hustai and successfully reached reproductive age, 108 were capable of conceiving at the time the report was produced. Of these, 81 (75%) have foaled to date: 24.7% foaled first at the age of 3 years, 55.6% foaled at the age of 4 years, 14.8% at the age of 5 years, 2.5% at the age of 6 years, and 2.5% at the age of 7 years (Fig. 1). 96% of the subadult females first gave birth between age three and five.

The most effective age range within the breeding population was 5 to 15. Between 1993 and 2011, the annual foaling rate of mares 5-15 years of age in

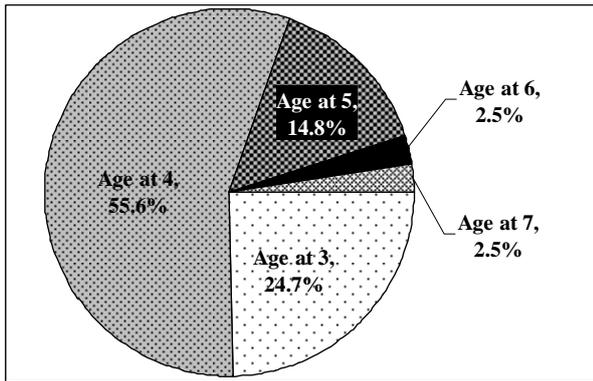


Fig. 1 Age at first gave birth of subadult females.

Hustai National Park was 25.0%-89.0% (Table 1). Recently, the Przewalski's horse population has increased steadily and the percentage of mares foaling has been stable since 1998 at 70%; this indicates that the Przewalski's horses are successfully adapting to their new environment. However, the percentage of mares foaling is lower after extremely harsh winters due to natural miscarriage induced by harsh weather

conditions. A similar phenomenon has been observed in domestic horses. In all animals reproductive success wanes with age and according to our observations 37.1% of mares have foaled by older than 16 years of age.

3.2 Seasonality

At Hustai, on average 50% of foals are born in May and 30% are born in June; an average of over 90% of mares gave birth between April and June. Very few births (2%) occurred between September and October in some years (Fig. 2). Following the 2000 shipment of mares, two gave birth in January, but this was highly unusual. Przewalski's horse mares usually foal around the middle of April but earlier or later foaling may occur depending largely on weather conditions. For example, in the spring of 2001, of the 44 breeding mares in Hustai only 10 mares foaled in the spring due to an extremely harsh winter: during the next year,

Table 1 Reproduction rate of females by age group.

Year	Age 3			Age 4			Age 5-15			Older than 16		
	Total	Foaled Quantity	%	Total	Foaled Quantity	%	Total	Foaled Quantity	%	Total	Foaled Quantity	%
1992	4	0	0.0	-	-	-	-	-	-	-	-	-
1993	5	0	0.0	4	1	25.0	-	-	-	-	-	-
1994	8	0	0.0	7	5	71.4	4	4	100.0	-	-	-
1995	1	0	0.0	7	0	0.0	12	8	66.6	-	-	-
1996	1	0	0.0	2	0	0.0	20	11	55.0	-	-	-
1997	8	4	50.0	1	1	100.0	20	10	50.0	-	-	-
1998	6	0	0.0	8	5	62.5	26	19	73.0	-	-	-
1999	8	1	12.5	2	1	50.0	29	19	65.5	-	-	-
2000	5	0	0.0	7	6	85.7	37	22	59.5	-	-	-
2001**	6	0	0.0**	5	1	20.0**	38	9	23.7**	-	-	-
2002	8	2	25.0	6	5	83.3	40	31	77.5	1	0	0.0
2003	8	0	0.0	8	6	75.0	42	23	54.8	2	0	0.0
2004	4	1	25.0	8	4	50.0	47	37	78.7	2	0	0.0
2005	11	4	36.4	4	4	100.0	52	32	61.5	3	1	33.3
2006	7	0	0.0	11	9	81.8	48	40	83.3	8	5	62.5
2007	10	3	30.0	7	4	57.1	51	43	84.3	11	6	54.5
2008	5	1	20.0	10	4	40.0	52	45	86.5	11	9	81.8
2009	13	7	53.8	5	5	100.0	59	52	88.1	12	6	50.0
2010**	11	0	0.0**	12	5	41.7**	58	22	37.9**	14	6	42.9**
2011	13	0	0.0	10	5	50.0	67	51	76.1	13	6	46.2
Average 2002-2011	19.0			67.9			72.9			37.1		

**The authors highlighted severe winters of 2001, 2010 and its influence of reproduction.

Reproduction and Mortality of Re-introduced Przewalski's Horse *Equus przewalskii* in Hustai National Park, Mongolia

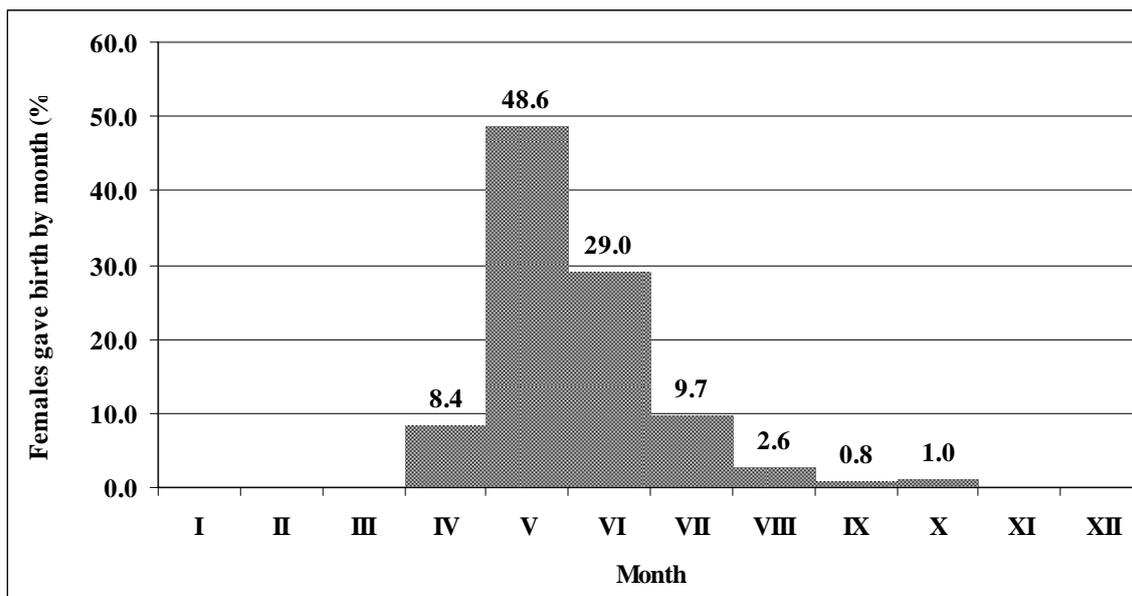


Fig. 2 Seasonality of Przewalski's horse.

2002, some of these mares foaled as early as 4th April which is probably due to early pregnancy resulting from infertility of their 2001 foals. Similarly, after the harsh winter of 2009-2010 only 27 mares foaled out of the breeding population of 70 mares. Between 1993 and 2011 608 foals were born in Hustai, 290 of these were female and 292 male. 26 of them died before their sex could be defined. The sex ratio of Przewalski's horse foals is thus approximately 1:1.

3.3 Infertility

Lengthy transport of ungulates carries great risks. Most research teams use a special anti-pregnancy injection for protecting mares during the transportation period. This is one of the causes of barrenness in the first or second year after

reintroduction (Table 2). A year before transportation from the Netherlands, mares were injected with anti-pregnancy drugs, so these mares were not able to get pregnant for some time after their transportation.

As it is not possible to distinguish barren mares from those that had naturally induced miscarriages these are combined in a single category: infertility. Decrease of the foaling after harsh winter is explained by miscarriage. Also mares with wrong positioned foals could not give birth naturally and so foals in this case are delivered by abortion which influences breeding success (Table 3).

3.4 Mortality and Its Cause by Age and Sex

Over the last 20 years, a total of 145 Przewalski's horses died from various causes (excluding foals)

Table 2 Reproduction and infertility of the transported females in a given and following year.

Transported years	Foaled in a given year					Foaled in a following year				
	Breeding mares	From these		Foaled mares	Got barren mares (%)	Breeding mares	From these		Foaled mares	Got barren mares (%)
		Young mares	Adult mares				Young mares	Adult mares		
1992.06.05	10	10	0	0	10 (100%)	9	5	4	1	3 (75%)
1994.07.22	12	9	3	0	9 (100%)	11	1	10	1	9 (90%)
1996.06.12	11	6	5	1	3 (100%)	9	4	5	3	2 (40%)
1998.05.28	15	10	5	0	4 (100%)	7	5	2	1	2 (66%)
2000.05.31	12	5	7	0	• 7 (100%)	12	1	7	2	5 (71%)

Table 3 Infertility of mares 1993-2011.

Year	Total	Infertility by quantity	Infertility by %
1993	4	3	75.0
1994	11	2	18.2
1995	19	11	57.9
1996	22	11	50.0
1997	21	10	47.6
1998	34	10	29.4
1999	31	11	35.5
2000	44	16	36.4
2001	43	33	76.7
2002	46	10	21.7
2003	50	21	42.0
2004	55	14	25.4
2005	56	20	35.7
2006	59	10	16.9
2007	58	11	18.9
2008	62	13	20.9
2009	64	7	10.9
2010	70	43	61.4
2011	77	21	27.3

(Table 4). Of these, 39 animals were subadult males ($1 \leq, \geq 4$ years old), 30 were adult males ($5 \leq$ years old), 32 were subadult females ($1 \leq, \geq 3$ years old) and 44 were adult females ($4 \leq$ years old). During the reintroduction programme no adult Przewalski's horse died of viral disease, the only losses due to viral diseases were through foal strangles. This indicates that Przewalski's horses are not currently at risk from such disease. Some fatalities were caused by blood parasites carried by ticks, which are most active during spring months. In the initial stages of Przewalski's horse reintroduction (1992) we were not able to diagnosis blood parasites, but we later learnt

how to diagnose and treat infected individuals. Przewalski's horses are most commonly infected with blood parasites in the first year after their arrival: parasites are not found in subsequent years or in Przewalski's horses born at Hustai.

There are several miscellaneous causes of foal stillbirth, including wrongly positioned foals. Of 44 mares which died, 31.8% died due to a wrongly positioned foetus: this condition appears to be very common but reasons for this are still unknown. If a wrongly positioned foetus is detected early, an abortion can be induced and the mother saved, but it is not easy to predict when the free-ranging mares are going to give birth or to identify if any mares are having trouble in giving birth. Among the stallions there were several cases of fatality caused by injuries sustained during fights. Such injuries account for 18.8% of mortality among young and adult stallions. Another cause of mortality is the numerous rock-filled gullies crossing hill slopes, which are filled with snow in winter: when Przewalski's horses cross these rocky gullies they sometimes trap their leg between rocks and end up breaking them. 22.1% of mortalities were the result of attacks by wolves and 31.0% resulted from bad condition during extremely harsh winters with deep snow (Table 4).

Concerning foal mortality (Tables 5 and 6), 39.2% were due to wolf attacks. 9% of foals were killed by stallions. One was observed to be taken by force by a barren mare from his mother, and subsequently died from starvation. In 17.3% of deaths the causes are

Table 4 Mortality and its cause of Przewalski's horse between 1993 and 2011.

Cause of mortality	Subadult horses		Adult horses		Total mortality	Mortality cause by %
	Male	Female	Male	Female		
Blood parasites	1	1	1	0	3	2.1
Endo-parasites	1	1	0	0	2	1.4
Other diseases	1	5	2	3	11	7.6
Parturition problem	0	0	0	14	14	9.7
Injury	3	1	10	4	18	12.4
Wolf attack	16	6	4	6	32	22.1
Bad condition	16	12	7	10	45	31.1
Other causes	1	1	1	0	3	2.1
Unknown causes	0	5	5	7	17	11.7
Total	39	32	30	44	145	100.0

Reproduction and Mortality of Re-introduced Przewalski's Horse *Equus przewalskii* in Hustai National Park, Mongolia

Table 5 Survival and death of foals in a given year between 1993 and 2011.

Year	Total foal	From these		Survival rate
		Died	Survived	
1993	1	0	1	100.0
1994	9	2	7	77.8
1995	8	5	3	37.5
1996	11	5	6	54.5
1997	15	9	6	40.0
1998	24	10	14	58.3
1999	21	9	12	57.1
2000	28	5	23	82.1
2001	10	1	9	90.0
2002	38	14	24	63.2
2003	29	15	14	48.3
2004	41	14	27	65.9
2005	42	25	17	40.5
2006	54	33	21	38.9
2007	56	32	24	42.9
2008	59	21	38	64.4
2009	68	24	44	64.7
2010	33	24	9	27.3
2011	61	22	39	63.9
Total	608	270	338	58.8

Table 6 Mortality of foals and its cause between 1993 and 2011.

Cause of foal mortality	Quantity	Percentage
Frozen	4	1.4
Captured by another mare	7	2.5
Strangles	6	2.2
Other disease	8	2.9
Injury	12	4.3
Stillbirth	21	7.6
Killed by stallion	25	9.0
Foal weakness	38	13.7
Unknown	48	17.3
Wolf attack	109	39.2
Total	278	100.0

unknown: it is not clear whether the foals were killed by stallions or simply became separated from their mothers. Deaths that occurred within the first day of life are assumed to be due to foals being born weak and with poor survival ability, although the foals may be born physically capable as measured by size and hair growth.

4. Discussion

Przewalski's mares are physiologically capable of conceiving as early as two years of age, however, most do not breed until the fourth year of life [4]. But the Hustai National Park mares, 24.7% of them first

gave birth at age 3, 55.6% of them first gave birth at age 4. It meant wild born mares gave birth at least one or two year earlier than captive mares. The reproduction rate of free-roaming mares in Hustai National Park was 25.0-89.0% on average. It is higher than the 38.7% Chen et al. (2008) of the Kalamaili Ungulate Protected Area in Xinjiang, China [5], 50% Feist and McCullough (1975) state for feral horses in the USA [6], but goes along with the 61% Keiper (1985) reports for feral ponies [7]. High percentage of reproduction rate may correlate with the even sex ratio of between stallions and mares. The low reproduction rate among released Przewalski's horses in Kalamaili

Ungulate Protected Area in China, caused by frequent alternation of the leading stallion and its infanticide, Ref. [5] suggests an even male-female ratio. Initially the sex ratio of horses transported to Hustai NP in Mongolia was 1 male: 2.5 female with actual numbers of 24 and 60 respectively.

The reintroduced Przewalski's horses gave birth to 608 foals in the wild from 1993 to 2011, and these foals were born in April (8.4%), May (48.6%), June (29.0%), July (9.7%) and August (2.6%). The number of newborn foals in May and June accounted for 77.6% of all the foals, and the main birth season of the reintroduced Przewalski's horse was confirmed to be in May and June. Ungulate seasonality is connected with the northern and southern hemisphere of the world. If Przewalski's horses are bred in the southern hemisphere, they are less adapted to the seasons of the northern hemisphere. But, Przewalski's horses of Hustai National Park show high seasonality and are already adapting to the new environment with long cold winters and short temperate summers.

The mortality rate among foals (40% in 1993-2011) is a matter of great concern since foals born in Hustai National Park are the only gain component after the active reintroduction period came to an end. However, Adams *et al.* (1995) found that caribou calf mortality in Denali National Park in Alaska was 39%, with 85% of the calves dying during the first eight days of life due to predation by wolf and grizzly bear. In Denali National Park predation was obviously restricted to a narrow age span [8]. As mentioned above the wolf seems to be the main reason for foal mortality in Hustai National Park. A total of 109 foals were killed by wolves in 1993-2011 but 52% of them were younger than one month.

5. Conclusions

Early first reproduction age among mares, high percentage of pregnancy of mares and seasonality indicate the Przewalski's horse has already

acclimatized to the new environment of long cold winters and short temperate summers at Hustai National Park. For the isolated population of Przewalski's horse the fecundity rate and survival of foals are important. In general 60% survival is enough of an index for the natural population, but for the reintroduced and defenseless population of Przewalski's horse, survival of foals must be focused on in the future.

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