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Home range and habitat use of free-ranging Przewalski horses at Hustai National Park, Mongolia

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Abstract

Przewalski horses (*Equus ferus przewalskii*), also known as takhi, were first re-introduced to the wild in Hustai National Park, Mongolia, in 1994. Since then the number of free harems increased to a maximum of seven; there are currently six (October 2000). The size of the home range of each of the harems changed among years and among seasons. The horses tended to settle in a home range close to where they were released although they explored the surrounding area. The use of the habitat within each home range changed through the day, with the horses grazing in the valleys during the morning and evening, and moving to higher places to stand rest and use as a refuge from heat and flies during the middle of the day. Range establishment and area, as well as habitat use are discussed.

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1. Introduction

Przewalski horses (*Equus ferus przewalskii*), also known as takhi, became extinct before they could be studied in the wild. This means that the only data on their behaviour and ecology have been obtained in captive conditions. Therefore, re-introduction efforts have been based on the assumption that they will behave like feral domestic horses when released. Knowledge of the home range and habitat use of Przewalski horses in the wild is essential for the success of re-introductions as it will give an idea of how many horses can be supported by a particular area of habitat and which are the best areas for their initial release.

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There are many factors affecting a horse's decision to settle in an area, but one of the most important is likely to be the availability of water. Studies on feral horses in America have shown that all home ranges include a water source. The home ranges will often overlap to enable all harems access to the water (Feist and McCullough, 1976; Pellegrini, 1971). However, other necessary requirements for a home range are sufficient grazing, refuges from flies and heat, and shelter from the wind (Keiper and Berger, 1982). Horses exhibit a preferential use of vegetation, tending to spend more time utilising the most nutritious (Duncan, 1983; Salter and Hudson, 1979; Pratt et al., 1986), and they use different parts of their home range at different times of the day, moving between grazing sites and refuges from flies (Keiper and Berger, 1982; Pellegrini, 1971).

The main question I wish to address in this paper is how re-introduced Przewalski horses established a home range and how they used it. This study was carried out in Hustai National Park (HNP). About 50 horses have been released at HNP since 1994, after spending 1–2 years acclimatising in enclosures. In 1998 there were five free-ranging harems, of which three had been free-ranging for 3 years or more. At the time of writing (October 2000) the population consisted of about 120 horses, including 20 horses in acclimatisation enclosures awaiting release.

2. Methods

2.1. Study area

Hustai National Park is situated about 100 km south-west of Ulaan Baatar, the capital of Mongolia. It covers 57,000 ha and its altitude is between 1100 and 1842 m. HNP has a mountain forest steppe habitat which consists of steppe, meadow, grassland, shrub and woodland communities. Silver birch (*Betula platyphylla*) and poplar (*Populus tremula*) forest covers 5% of the park and water flows down most of the valleys as streams (Wallis de Vries et al., 1996). In addition to re-introduced Przewalski horses there are other large ungulates in the park, including red deer (*Cervus elaphus*), wild boar (*Sus scrofa*), Argali sheep (*Ovis ammon*) and Mongolian gazelles (*Gazella guterosa*). There are also several species of carnivore, such as various mustelid and fox species, lynx (*Felis lynx*), Pallas' cat (*Felis manul*) and wolves (*Canis lupus*). Wolves are the only real threat to the horses.

2.2. Field observations and data analysis

The data presented here have been pooled from two sources. For the 1998 home range and vegetation use data I located the harems at dawn and then watched them for the following 4 to 8 hours. The same harem would be found at 14.00 h the next day and followed until dusk. In 1998, I recorded the location of the horses on a map and using a global positioning system (GPS) every 10 min, and, at the same time, recorded the activity of the group and the weather conditions. Four harems were observed for a total of 227 h. The home range data from 1995 to 1997 were collected by Mongolian biologists and rangers who located the harems once each day.

The range data have been analysed using the Geographical Information System (GIS) program Arcview using 100% and 75% Minimum Convex Polygons (MCPs). For the 75% MCP, the outer 25% of fixes were removed using outlier removal.

Non-parametric Kruskal–Wallis ANOVA was used to analyse time budget data as they were not normally distributed, and results were adjusted for ties.

Habitat utilisation has been examined using a grazing preference index based on observations of the horses' feeding locations:

$$PI = \frac{U_i}{A_i}$$

PI = preference for a vegetation type, U_i = use (percent of grazing observations in vegetation type 'i'), A_i = area (percent of study area covered by vegetation type 'i'). The index ranges from 0 (total avoidance) to 1.0 (no preference) to values >1.0 which indicate increased degrees of preference. For example, PI = 2.0 indicates that the horses use that vegetation type twice as much as the percentage of area that it covers (Duncan, 1983). Vegetation types and abundance were taken from a vegetation map of HNP (digitised by the Information and Computer Centre, Mongolian Ministry of Nature and Environment, 1999).

2.3. Study animals

All horses brought to HNP came from reserves and some were already bonded into harem groups before they arrived in Mongolia. Upon arrival the horses were released as a harem into acclimatisation enclosures of about 40 ha which were visually separated from each other. The horses were allowed to acclimatise for up to 2 years before being released from the enclosures. Harems are referred to by the name of the dominant stallion and the composition of the harems mentioned in this paper is shown in Table 1.

This paper will focus on the three harems that have been free-ranging for 3 years or more: Patron's, Khaan's and Paritet's harems. However the harems of Bayan and Ares will also be mentioned. These harems were released in May and August 1998, respectively. The number of harems free-ranging at HNP reached a peak of seven harems in 1998. The current number of harems (October 2000) is six. The difference in numbers has occurred because of fights between stallions for mares and mortalities.

Table 1
Composition of free harems at HNP, August 1998

Year released	Stallion	Adult mares	1–3 years old	Foals	Total
1994	Patron	8	One male	5	14
1994	Khaan	8	Three male, two female	5	18
1995	Paritet	5	One male	1	7
1998	Bayan	5		1	6
1998	Ares	4	One female	3	9

3. Results

3.1. Home ranges

Fig. 1 shows the 1998 100% use of Minimum Convex Polygons of the home ranges of the harems released from Enclosure 1 since 1994. The ranges show little overlap, indicating that each harem used a more or less exclusive area and suggesting that harems tend to avoid each other. Despite the fact that Khaan and Paritet's harems had been free-living for several years they still remained in an area near where they were released. It was expected that Bayan's harem would stay near the release enclosure as Khaan and Paritet's had, but within a month they moved to the west. However they continued to make forays towards the enclosure.

Patron and Ares' harems (not shown) were released from Enclosure 2. Ares' harem remained very close to the enclosure and his home range overlapped with Khaan's. Patron's harem has moved more into the forest area since their release and showed little overlap with other harems.

Paritet's harem stayed very close to their enclosure in the 3 years after their release (Fig. 2), but in 1998, and 1999 (not on map), they also spent some time farther north. After their release, Paritet's harem's home range increased in size from 75 ha in 1995 to 670 ha in 1998. The very small home range in 1995 is due to their being released in the autumn, so there was only a short time to collect data. Paritet's harem spent most of their time in the valley running almost north-south, only making occasional forays into the east-west valley which Khaan's harem was using.

Khaan's harem also settled in a home range next to the fence from which they were released (Fig. 1). The area they used changed in size less than Paritet's home range and appeared to decrease in size (738 ha in 1995 to 395 ha in 1998 for Khaan, compared with 75 ha in 1995 to 670 ha in 1998 for Paritet). Although Khaan's harem spent 75% of their time near the fence from which they were released, they also explored the surrounding area.

Patron's harem showed a similar pattern to Khaan and Paritet's and, like Khaan's, Patron's home range has got much smaller over time (1158 ha in 1995 to 331 ha in 1998), although the small home range in 1998 could reflect the smaller number of fixes collected in that year. This will be studied in due course. Patron's harem stayed close to the fence from which they were released in 1995, but in 1996 they moved to the forest more to the west, and this is the area in which they remain. They did the most exploring in 1996, moving to the east and west and have since settled in the middle of this range.

In summary, the harems show different patterns in the change of home range size in the years since their release (Fig. 3). Paritet's harem showed an increase in range size, Khaan's harem showed a slight decrease and Patron's harem showed a greater decrease in home range size over the years. Unfortunately there are no data for Khaan's harem in 1997.

3.2. Habitat use

All home ranges contained a year-round water source and a patch of forest or rocky outcrop. This suggests that these features were important to the horses' choice of an area in which to settle.

In 1998, on average the harems spent 45% (S.D. = 6.50) of the daylight hours grazing, 38% (S.D. = 4.03) of the daylight hours resting and 16% (S.D. = 8.66) of the daylight

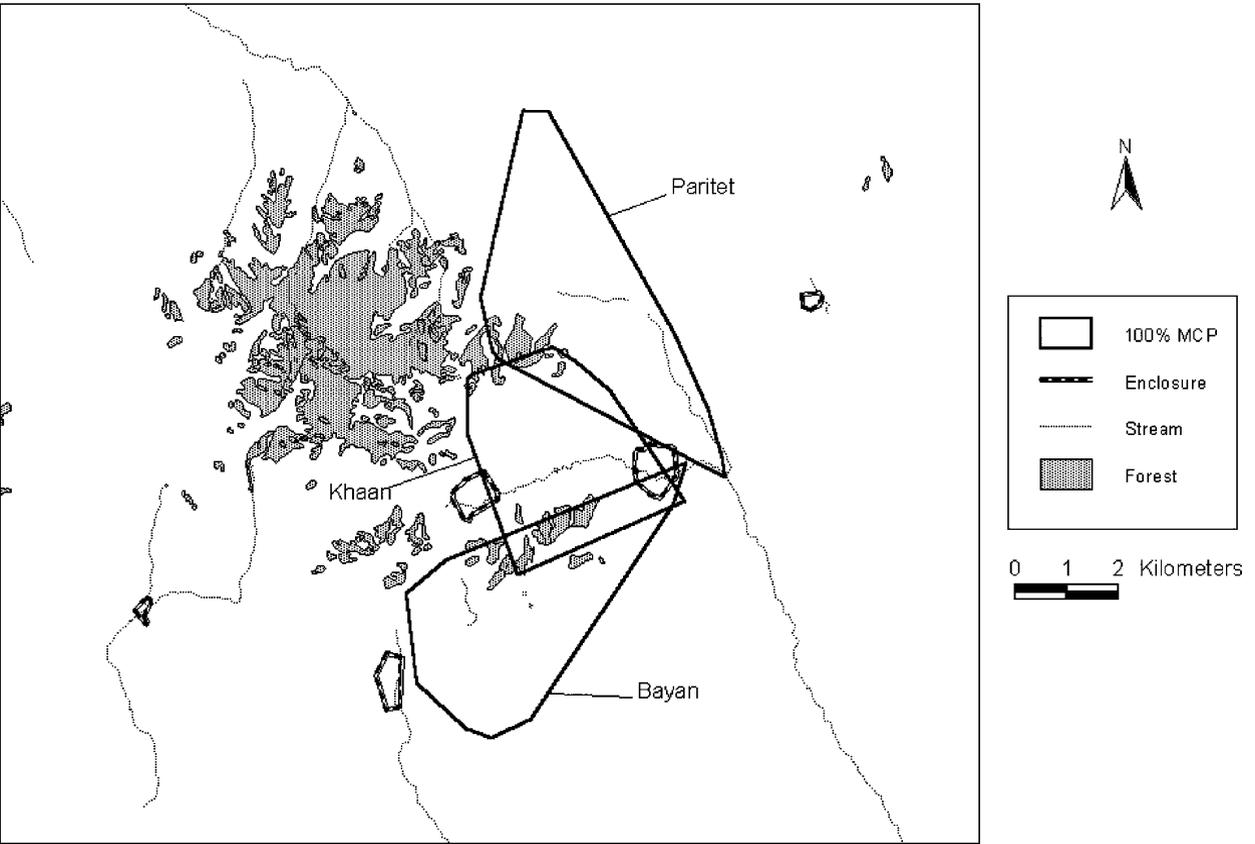


Fig. 1. 100% minimum convex polygons of harems released from Enclosure 1, 1998.

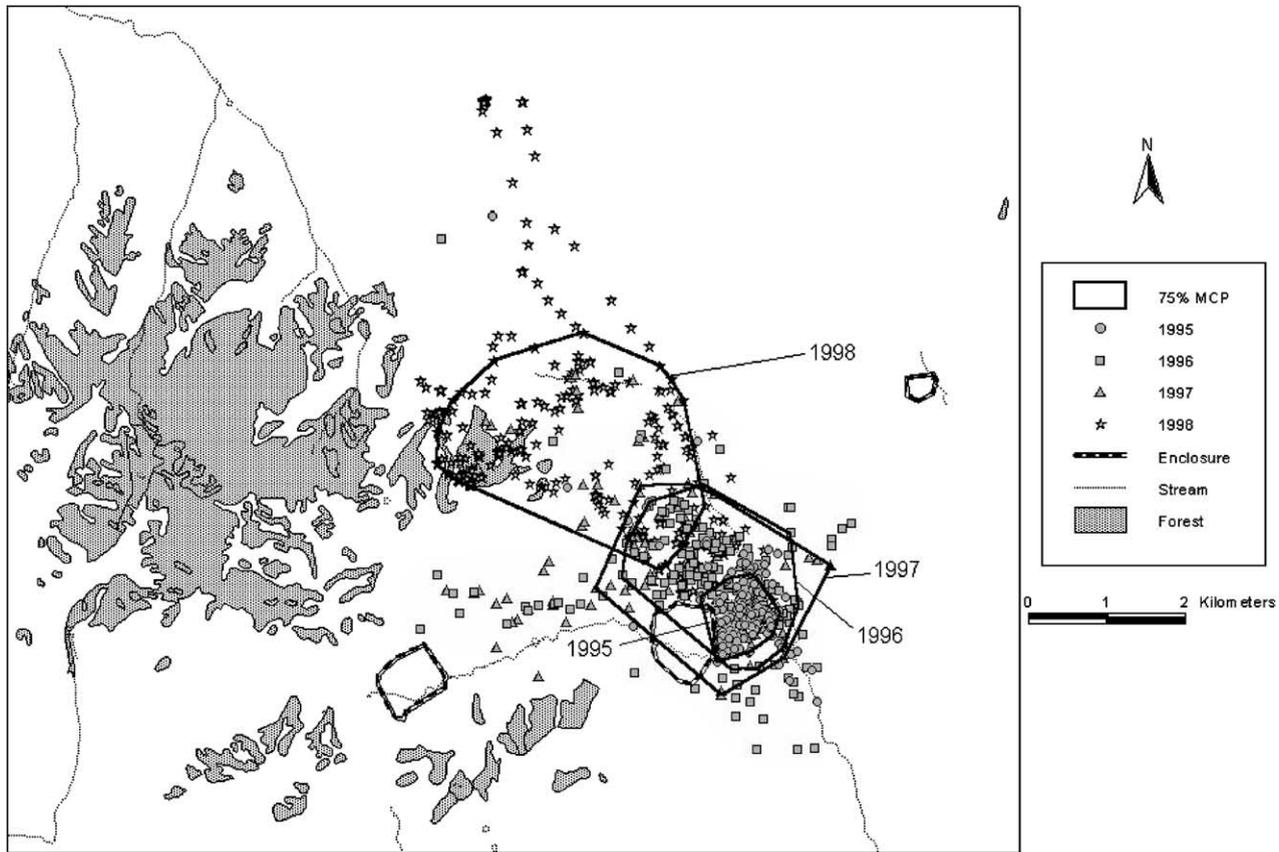


Fig. 2. 75% minimum convex polygons of Paritet's harem from 1995 to 1998.

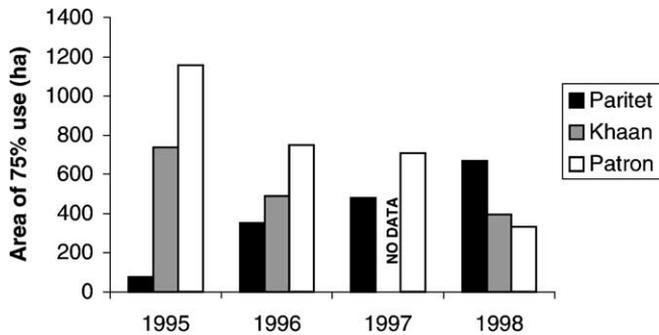


Fig. 3. Change in size of home ranges between 1995 and 1998.

hours moving. All harems grazed significantly more in the mornings and evenings (05.00–10.00 and 18.00–21.00), (Kruskal–Wallis for all harems combined: $H = 203.60$, d.f. = 17, $P < 0.001$), and rested significantly more through the middle of the day (11.00–17.00), (Kruskal–Wallis for all harems combined: $H = 256.51$, d.f. = 17, $P < 0.001$). This is reflected in the horses' use of different parts of their home range at different times of the day. Their temporal use of the habitat is also likely to be related to temperature, abundance of flies and vegetation.

3.3. Vegetation use

In 1998 Paritet's harem proportionally grazed significantly more on the vegetation type dominated by the needlegrass species *Stipa krylovii* significantly more than any other

Table 2

Grazing preference index (PI) of vegetation types used by Paritet and Khaan's harems, 1998

Vegetation type	Plant type	Home range					
		Paritet			Khaan		
		<i>U</i>	<i>A</i>	PI	<i>U</i>	<i>A</i>	PI
<i>Achnatherum splendens</i>	Grass	5.10	1.20	4.25			
<i>Stipa krylovii</i>	Grass	51.02	23.99	2.13	8.62	24.75	0.35
<i>Agrostis mongholic</i>	Grass				35.06	0.69	50.81
<i>Festuca lenensis</i>	Grass	9.69	36.36	0.27			
<i>Festuca sibirica</i>	Grass				21.84	7.92	2.76
<i>Filifolium sibiricum</i>	Grass	14.80	21.61	0.68			
<i>Poa attenuata</i>	Grass				6.90	6.19	1.11
<i>Amygdalus pedunculata</i>	Shrub	7.14	10.52	0.68	25.29	21.35	1.18
<i>Cotoneaster melanocarpa</i>	Shrub	2.55	0.27	9.44			
<i>Dasiphora fruticosa</i>	Shrub				2.30	0.57	4.04
<i>Betula platyphylia</i>	Tree	9.69	6.04	1.60			

PI = preference for a vegetation type (0 = total avoidance, 1 = no preference, 1+ = increased degrees of preference). *U* = use (percent of grazing observations in that vegetation type). *A* = area (percent of home range covered by that vegetation type).

vegetation type in their home range ($\chi^2 = 209.5$, d.f. = 6, $P = < 0.01$). However, in a preference index (Table 2) *Stipa* ranked third (PI = 2.13) with the shrub *Cotoneaster melanocarpa* (PI = 9.44) and the needlegrass *Achnatherum splendens* (PI = 4.25) vegetation types ranking higher. This can be explained by their low cover in Paritet's home range (0.27 and 1.2%, respectively) which biases the relative preference. However it does indicate that the plants growing in these vegetation types might be important species for the horses.

In the preference index Khaan's harem avoided vegetation type of the *Stipa* (PI = 0.35) despite the fact that it covered 25% of his home range. Khaan's harem had a strong preference for the bentgrass species *Agrostis mongholica* (PI = 50.81) over any other vegetation type, even though it covered <1% of their home range.

4. Discussion

4.1. Home range

The first harems released at HNP did not move far from their enclosures and, despite exploring the surrounding area, established a home range near their release site. Therefore, it appears that the horses will remain in an area with which they are familiar. The current home ranges are small when compared with those shown by feral horse populations in a similar environment in the mid-west of the United States. Miller (1983) recorded home ranges of 73–303 km² among eleven harem groups in Wyoming's Red Desert, and in the Granite Range of Nevada Berger (1986) observed home ranges from 6.7 to 25.1 km, depending on the season. As Paritet's home range appears to grow, and the other harems show no pattern in their change of size, it is possible that when the population is larger and more firmly established the home ranges will reach these sizes. However the current small size of range could be due to the fact that the horses can find all necessary resources in this area so have no need to travel farther.

There was no evidence of defence of the home ranges, yet they appeared to be almost exclusive. Lack of defence of home ranges has been seen in almost all feral horse populations, but only four out of 21 populations studied showed evidence of exclusive range use (Linklater, 2000). The only populations that had discrete home ranges occurred on barrier islands (Rubenstein, 1981; Keiper, 1976), or were otherwise spatially constrained (Gates, 1979; Duncan, 1992). As the population at HNP had no restrictions to their movement it is likely that their current exclusive use of home ranges is only due to the low density of animals and will diminish as the population grows.

As more harems are released, the pattern of home range establishment may change as the harems compete for space and resources. The first harems were not constrained by previously established home ranges and so could select areas that were not already occupied. It is likely that after release they would have met each other and would then avoid that area. For instance, Khaan and Paritet's harems were both released from the same fence yet Khaan's harem went to the west and Paritet's to the north with little overlap between them (Fig. 1).

It will be interesting to see whether the mares will stay in their current home ranges even if there is a change in dominant stallion. There is some evidence that they will as the mares

of Khaan stayed in their home range (Fig. 1) even when another stallion replaced Khaan in 1999.

4.2. *Habitat use*

It seems likely that the horses selected areas that contained a reliable water source and places where they could shelter from flies and inclement weather as all home ranges contained these features. Also, all home ranges were established along valleys, suggesting that the horses select these for the more nutritious grazing along the streams, and also possibly for sight lines or ease of travel.

During the summer of 1998 the horses preferred to graze more in the mornings and evenings in the more lush vegetation in the valleys. In the middle of the day they moved up to either rocky outcrops or forest to rest as it grew hotter and the abundance of flies increased. This pattern of behaviour has been seen both in captive populations of Przewalski horses and in populations of feral horses (Boyd, 1988, 1998; Duncan, 1979; Keiper et al., 1980). The daily routine of movement up and down the mountains has also been seen in populations of feral horses in America (Keiper and Berger, 1982; Pellegrini, 1971). Keiper and Berger (1982) and Duncan (1979) suggest that this is due to flies having a strong effect on the horses, causing them to seek refuge through the hottest parts of the day. This will change according to the season.

4.3. *Vegetation use*

The home ranges of Khaan and Paritet's harems both covered a variety of vegetation types yet both showed particular preferences. As in other studies, the horses appeared to select the most nutritious vegetation in their home range. Khaan's harem, for example, showed a strong preference for the *Agrostis* vegetation type. The area near the stream where this was found had been burned in 1997 and so the new growth in 1998 was noticeably greener, and therefore more nutritious than the surrounding vegetation (Duncan, 1983). Other studies have shown that horses select the most nutritious vegetation in their home range (Salter and Hudson, 1979). Further work on the nutritional quality of the plants at HNP would be rewarding.

In the Camargue it was found that, although the horses were seriously affected by flies, the best predictor of their habitat use was the abundance of food, particularly green plant matter (Duncan, 1983). Khaan's harem selected *Agrostis* when it was most abundant and so this would imply that the horses at HNP were found most often where the best food occurred. This is probably the reason why the horses spent a lot of time in the valleys in the spring where the greenest vegetation grew near the streams.

5. **Conclusions**

The horses at Hustai National Park appear to be adapting well to their environment and have formed home ranges and selected vegetation in a similar manner to feral domestic horses. Further research is necessary to see how the home ranges change in size and how

much overlap occurs as future harems are released and naturally occur and the habitat 'fills up'. Currently there is much less overlap among the harems than Berger (1986) observed in America. Further analysis of the data presented here will show more patterns in the behaviour of the horses.

Future release efforts should bear in mind that horses are likely to stay in the area where they are released if there are sufficient resources, so enclosures should be constructed in areas where there are no previous home ranges and where it is suitable for the horses to remain.

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