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Long-Term Ecology of Asiatic Wild Ass (*Equus h. hemionus* Pallas) in Central Asia

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Long-term ecology of Asiatic wild ass (*Equus h. hemionus* Pallas) in Central Asia[1]

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Abstract

The main population of the nominate form *Equus hemionus hemionus* Pallas, 1775 occurs in the south-east Gobi desert of Mongolia. From 2003 to 2012 we studied the reproductive ecology and mortality of dschiggetajs or khulans (English also 'hulan'). During these years, the rate of reproduction was variable, ranging from 6.4 % to 23.0 % depending on climate, feeding conditions, and fitness of the mares. Our research shows that there appears to be a relationship between minimum temperatures in June (main foaling time) and rate of successful reproduction. The primary cause of decline in the numerical density of the population of *E. hemionus* was attributed to poaching. From the original range in Mongolia to the present known distribution, the area in which this species now occurs has decreased in size by about 50 % in the last 70 years. We recommend the development of new strategies for better protection, monitoring, and education of the people of Mongolia on the value of this rare species. Consideration should also be given to a re-introduction of the Wild ass to NE Mongolia and/or the Lake District in western Mongolia.

Key words: *Equus hemionus hemionus*, monitoring, Mongolia, reproduction, climate conditions

Introduction

Today the range of the nominate form of the Asiatic wild ass, *Equus hemionus hemionus* Pallas, 1775 is located only in the Gobi region which encompasses southern Mongolia/northern China. Because of international engagement is necessary to effectively conserve for the future, this keystone "indicator species" of the arid zone of Central Asia. To enable this needed work on the kkhulan, we organized the International Asiatic Wild Ass Conference 2005 in Ulaanbaatar, Mongolia.

In the last years the live stock was evaluated with about 20,000 animals by Mongolian experts. *Equus h. hemionus* has adapted to survive in semi desert habitats. The species is listed in the Red Data Book of Mongolia as well as in the Appendix I of the Washington Convention (CITES).

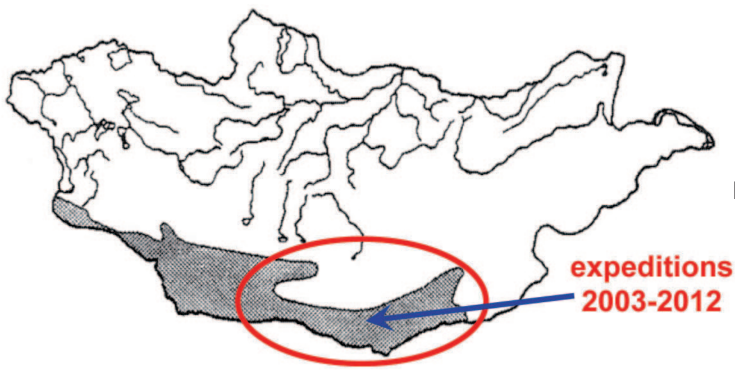

Fig. 1: Distribution of Wild Ass at the end of the 20th century (SOKOLOV et al. 1996).

[1] Results of the Mongolian-German Biological Expeditions since 1962, No. 313.

To try to achieve an firm understanding of the current distribution and make estimates of the numerical density of the populations of khulan in Mongolia, in 2003 we began a co-operative project combining the expertise of faculty from the Department of Zoology of the National University of Mongolia (NUM), Ulaanbaatar, the Martin-Luther-University Halle-Wittenberg/Ger-many, and the World Wildlife Fund (WWF), Mongolia. Our primary purpose was to launch and conduct a detailed study on the ecology of the Wild ass in the South Gobi Aimag (fig. 1) with the following objectives: (1) mapping of the northern distribution of the khulan in the South Gobi Aimag, (2) registration of the state or health of the population, (3) securing of skulls of dead animals for further analysis, (4) analysing the causes of mortality, (5) understanding the dispersion of feeding resources, (6) collecting of data on the rate of reproduction, (7) and providing local, national, and international governmental and NGO authorities with recommendations for protection and management of the khulan.

Results and discussion

Over the last century, and especially in the past 50 years, the known geographic range of the Wild ass has undergone a remarkable contraction in area in Mongolia. The first hunting law of the Mongolian People's Republic was established 1924. In the years 1930, 1962, and 1972 legislation on harvesting wild animals in Mongolia was revised and extended. In the last round of laws established in the 1972 session of the Mongolian Parliament 27 species of mammals and birds were given protected status. By 1926 hunting of Przewalski's horse [*Equus ferus przewalskii* (Poliakov, 1881)] and Wild ass was forbidden (ZEVEGMID, STUBBE & DAWAA 1974) with high monetary fines established for anyone caught hunting these animals illegally. Even though these fines exist, in the last few years poaching has been shown to be the main cause of mortality of *Equus hemionus* in Mongolia including areas that are designated "protected" (see fig. 2, 3).

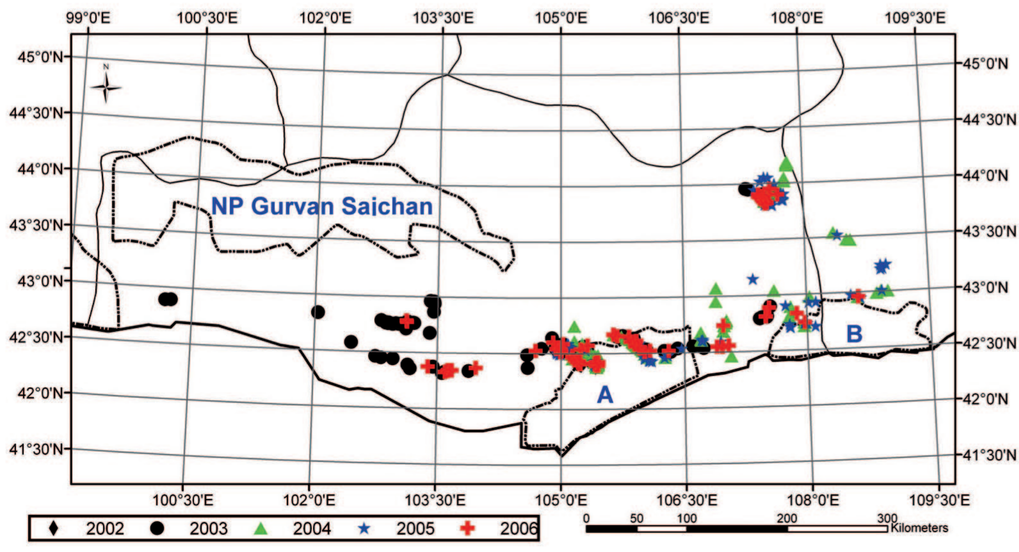

Fig. 2: The South Gobi Aimag with all localities of dead khulan between 2002 and 2006 and the Strictly Protected Areas Little Gobi A and B of this region.

The problems of an exact census of this species are discussed in various articles (see STUBBE et al. 2005). It was also a main point of discussion at the International Asiatic Wild Ass Conference in August 2005 in Hustai Nuuru National Park/Mongolia. In the South Gobi Aimag, over the last 20 years the Wild Asses have been more concentrated in the South eastern Gobi with the

Fig. 3: A herd of *Equus h. hemionus* near the monastery Ölgij, SE Gobi, in September 2012 (photo: A. &. M. STUBBE).

Fig. 4: Khulans in setting sun, September 2012 (photo: A. & M. STUBBE).

"Little Gobi Strictly Protected Areas A and B". We have a clear quantitative gradient of population density from the Dzungarian and Transaltai Gobi up to the Bordzongijn and Galbyn Gobi. This gradient is correlated also with the precipitation how v. WEHRDEN & WESCHE (2007) have shown.

WHERDEN & WESCHE (2007) have shown that in the desert steppe of the Gobi, quantity of precipitation annually determines the development of vegetation and the condition of forage. The annual migration of populations of khulan depends on these rains. Growth of vegetation in this region is locally determined by water input that occurs in geographically spotty areas and is provided by spring and summer monsoon thunderstorm rainfall activity. The spotty rainfall across large geographic areas of the desert steppe ecosystems of Mongolia creates large-scale mosaics of both productive and poor and pastures. Depending on the pattern of vegetation across the landscape, khulan disperse throughout the area concentrating in regions with better forage conditions and water sources. With the massive increase in private livestock numerical density that started especially since 1990, many, if not most, populations of khulan have now been largely excluded from areas with the best forage and best sources of water.

The importance of the Wild asses for the biocoenosis in the Gobi region of Mongolia is illustrated by the fact that in dry years, the behaviour of the Dschiggetaj enables other animals such as many species of birds and other mammals to obtain water. As noted, *E. hemionus* are adept at digging down for water in areas that have water below the surface (STUBBE et al. 2005). This water is used by many species of vertebrates that otherwise could become locally extinct during time of drought. In winters with deep snow accumulations, digging behaviour for food by populations of khulan provide opportunities to other species of mammals (and birds) to reach food. After KACZENSKY et al. (2010) khulans must drink in average every 1.5 -2.2 days.

During the past 10 years of this work, we recorded many dead individual khulan that were evidently shot, most with large calibre rifles, at or near "watering areas". Dead animals found included individuals that had both winter coats as well as those that had summer coats with much less dense fur. In addition, we discovered mares that were killed, together with their foals and some females were pregnant (STUBBE et al. 2007).

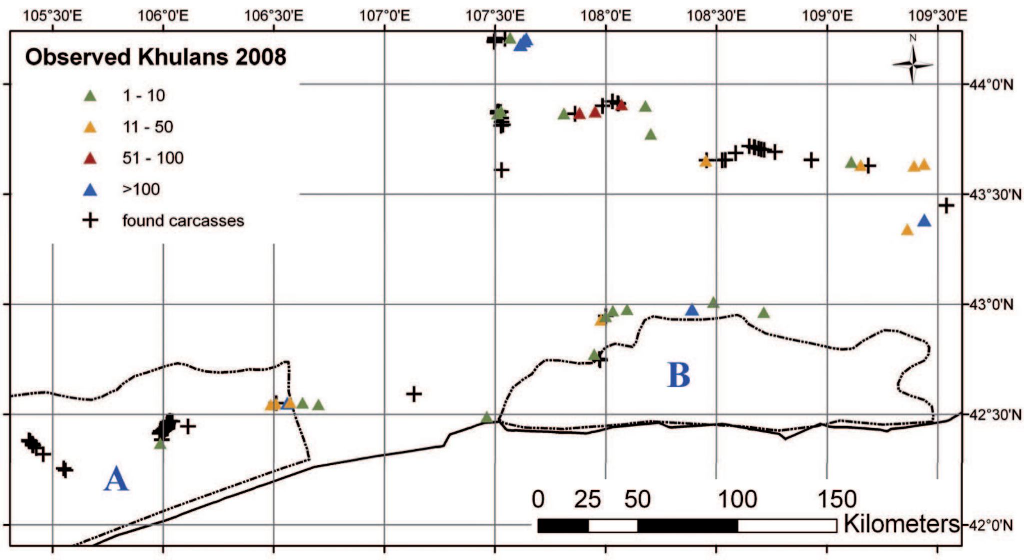

Fig. 5: The main distribution area of *Equus h. hemionus* in Southeast Mongolia in autumn 2008, with the Little Gobi Strictly Protected Areas A and B.

As noted, the rate of reproduction of *Equus hemionus* depends on rainfall, food supply, and condition of the mares meaning that success at foaling is variable year to year. The rate of reproduction between 2003 and 2007 sows an important gradient (table 1). In autumn 2003 we found an optimal increase of 23 % whereas in 2006 it decreased up to 7.5 % and 7.4 % in 2007. But in 2007 the number of observed animals was small. In 2010 the reproduction rate was lowest in our 10 years of monitoring with only 6.4 %. In 2008 the reproduction rate again increased. Relative to recording data, the time of year and season of intense study is important because mortality after birth is a normal phenomenon and will reduce from month to month the relationship of young individuals to older individuals in the population under study. Thus, comparisons of censuses taken at different intervals after foaling has to take into account the time of census. During our study, we recorded data on reproductive rates in the populations between 2004 and 2006 in July. In 2008 we recorded data in the middle of October and in 2003 and 2012 the data were taken in late September early October (fig. 6).

Table 1: Monitoring of reproduction rate of Wild ass in Mongolia between 2003 and 2012 in the South and Southeast Gobi

observation time	**total**	**1+ / adult**		**foals**		**reproduction rate (%)**
	n	n	%	n	%	
21.09. - 07.10.2003	1830	1488	81.3	342	18.7	23.0
03.07. - 23.07.2004	3387	2776	82.0	611	18.0	22.0
07.07. - 27.07.2005	1399	1274	91.1	125	8.9	9.8
24.07. - 02.08.2006	1539	1431	93.0	108	7.0	7.5
10.07. - 16.07.2007	199	176	88.4	23	11.6	7.4
08.10. - 14.10.2008	1935	1704	88.1	231	11.9	13.6
29.06. - 09.07.2009	941	800	85.0	141	15.0	17.6
06.07. - 14.07.2010	718	675	94.0	43	6.0	6.4
22.07. – 28.07.2011	1280	1080	84.4	200	15.6	18.4
23.09. – 28.09.2012	1001	865	86.4	136	13.6	15.7
total (10 years)	14229	12269	86.2	1960	13.8	16.0

Our data show that the highest value increase was in autumn of records indicate that the summer of 2003 was very rainy and influenced an extraordinary development of vegetation across the desert steppe ecosystem. Also, in 2008 more rainfall was recorded than in previous years. It was a great impression in these two years to see a golden desert autumn with plants in rich colouring, in these areas and during this time, pastures for Wild asses and their resulting fitness were optimal. It is well-known that mares in bad physical condition at time of parturition may be accompanied by spontaneous abortion of foetuses or, after birth, the may experience reduced milk production and with concomitant increase in postnatal mortality of foals. It is assumed that predation pressure, especially by wolves remained the same over all years. In addition to predation and poaching as factors in decreased survivorship, a sudden fall in temperature can be fatal for foals of only a few days old. We recorded on the 17th of July 2006 an aberrant onset of cold temperatures in the territory of Manlaj Sum. The temperature fell to 12.9 °C and herdsmen and authorities in the region found dead khulan foals with simultaneous marked mortality of young goats and sheep.

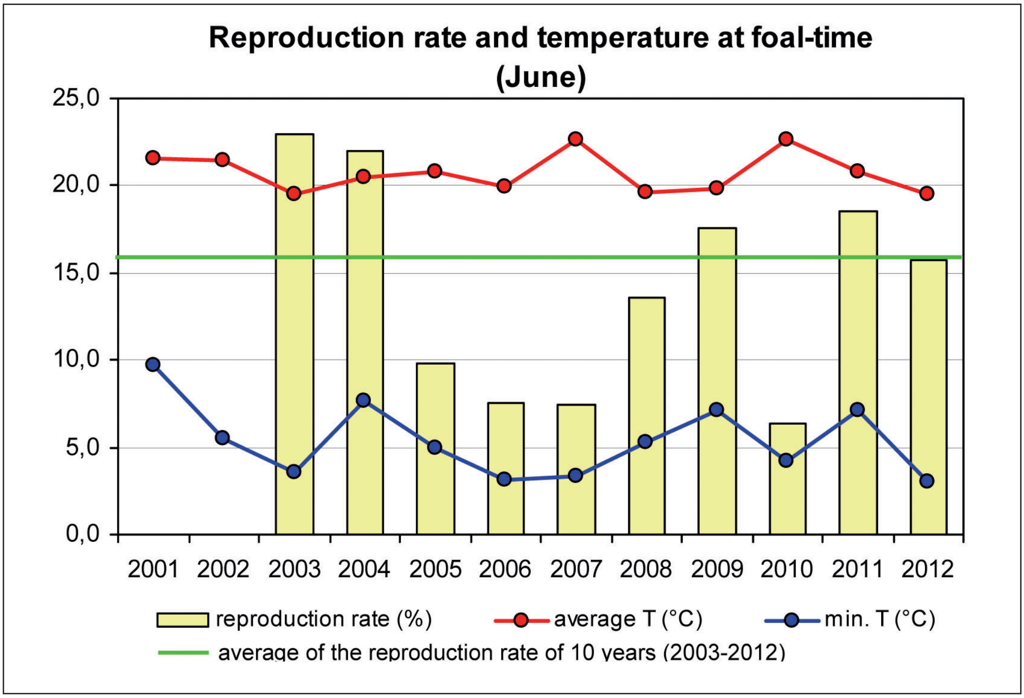

Fig. 6: Reproduction rate and temperature conditions in June, the main foaling time.

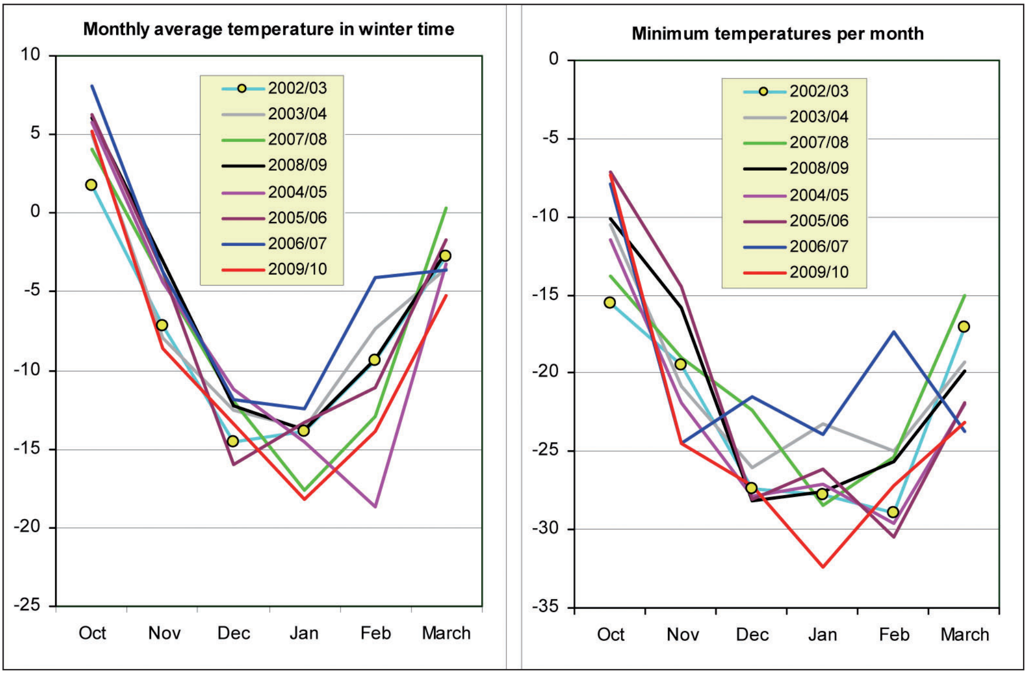

Fig. 7: Monthly average and minimum temperatures in the winter time in the area of Manlaj Soum.

In addition to our remarks on reproduction of Wild asses in volume 10 of “Explorations into the Biological Resources of Mongolia” (STUBBE et al. 2007) we here summarize data from RAŠEK (1973) and SOLOMANTIN (1973) in ŽIRNOV et al. (2005) on Turkmenian khulan. Females reach sexual maturity with 2-3 years, in drought years and after heavy snow winters one year later. Males are sexual active within 4–5 years. Males lead a harem not longer than 5 years. Reaching an age of 9-10 years, males will be replaced by younger stallions (RAŠEK 1965). Interviews with Mongolian herdsmen indicate that the rutting time of khulan in Mongolia is in the second half of July and August. In the second half of July 2004 we observed high sexual activities of stallions (STUBBE et al. 2005). In contrast, in Turkmenistan, the rutting time was earlier (SOLOMANTIN 1973), extending from the middle of April to the end of May, and in the Barsakelmes Reserves, from May through July.

Mares are in heat from 3-7 days, rarely 9 days, and mostly from 6-7 days. A further cycle is possible after 17–28 days. The mating habits were described in detail by RAŠEK 1973. In Turkmenistan khulans the gestation time is 342 ± 13–27 days. Twins are unknown up to day. In optimal years for climate, mares have one foal yearly. In the region of the lake Barsakelmes in Turkmenistan, 74 mares had 0.66 foals/year, in 7 years of observation time. The highest reproduction rate was found in the age of 4-13 years (0.75–1.0 foals/year), and with an age of 15 years only 50 % of mares had offspring. With 16–17 years no births were recorded. In three year old mares 67 % had foals. In the region of Barsakelmes RAŠEK (1973) recorded over seven years, the mean value of reproduction was 21.4 % (14.7–38.1 %). BANNIKOV (1981) registered 18.6 % for the Wild ass in Mongolia. ŽIRNOV & ILINSKIJ (1985) found in 1974 in the Transaltai-gobi a value of 10.9 %, and between 1980 and 1982 the value was 6.3 % (average 7.8 %).

Fig. 8: Khulan mares with foals at a water place in July in the Galbyn Gobi (photo: M. STUBBE).

The causes for the differing reproductive rates between the years 2003 and 2012 are probably a combination of climate (local weather) and thus range condition. The following first analysis is based on temperature and precipitation records of the meteorological station of the somon Manlaj. Precipitation in the years 2001 through 2010 shows values between 48 mm and 166 mm per year. As noted, in summer months, monsoon rains arrive and rainfall is mostly strong localized and comes down mostly as thunderstorms, therefore conclusions for large-scaled surroundings or correlations with the reproduction rate are not possible.

For the distinct continental climate in the south-eastern Gobi are the very cold and snow-poor winters characteristically. These strong winters and drops of temperature during the foal-time in time of middle of May to the end of June seem to be mainly for the fitness and the energy budget. Within the 8 years of observation time (2002/03 – 2009/10) were 5 years with a reproduction rate of less then 14 %. In these 5 years declined the monthly average temperature between October and March under -15°C. Only the winter 2006/07 was an outlier. In table 3 (Appendix) and fig. 6 and 7 the monthly minimum temperatures are given. They can fall below -30 °C.

For the energy budget of the Dschiggetaj, of great importance are the thick woolly winter coat and the storage of fat in bones and other tissue structures. Skulls of khulan illegal killed in the winter months appeared to contain much fat; such animals poached in the summer month did not demonstrate this. The fine structure of the pelage as well as lipid metabolism should be fields of investigation in the future. The postnatal mortality of newborn foals seems to be strong influenced by very cold days and nights within the first few days of life. That can lead to strong hypothermia and a decrease of the body core temperature ending in death. From fig. 5 can be deduced a correlation between the minimal temperatures in June and the reproduction rate among different years. Only the year 2003 seems to be an outlier. In 2003 the first part of June was very warm, after the 11th of June the night time temperature declined to 3.6 °C. Unfortunately it was not possible to recover the exact dates of the main foaling time of this year. Without the 2003 data, a regression shows that the correlation between minimal temperature of June and reproduction rate is 80 % (r = 0.8).

Further analyzes are necessary to estimate the multi-attributed impact of climatic parameters. Also wind regime, sunshine duration, and snow depth and duration of snow layer are probably correlated with survivorship.

Fig. 9: Young khulan stallion driving its harem of two mares (photo: Scott L. GARDNER).

Conclusions and prospects

The geographic area now inhabited by *E. hemionus* in Mongolia is about one half of the size of the original range. BANNIKOV (1954, 1981), ZEVEGMID & DAWAA (1973), SOKOLOV et al. (1996), STUBBE et al. (2005) have documented this change. At the present time, we are of the opinion that the khulan, previously occupying the steppe habitats of Mongolia have been forced from these optimal habitats by humans and their domestic animals. The continued development and growth of the human population, occupation and exclusive use of water resources for domestic animals, motorization of herdsmen, the enormous increase in numerical density (indeed over population beyond the carrying capacity and no regulation of this by the government) of livestock, concomitant with recorded changes in agriculture, industrialization, and mining continues apace.

We hope that the established bio-reserves in the Gobi desert and desert steppe ecosystems can stand up to this pressure. New and further disruptions in the geographic areas now occupied by populations of *E. h. hemionus* include: (1) the blockage of migration routes of khulan and other wildlife by a newly established and impassable fence on the Mongolian-Chinese border, built by the Chinese government, (2) cutting of migration routes by highways, (3) cutting of migration and ranges of Dschiggetajs by impassable railways lines. These challenges are taking place now and will continue to occur in the future as mining and other infrastructure development continues to occur in Mongolia.

A list of the sources of all published records we could locate on the rare and beautiful *Equus hemionus* are included in the Mongolian Red Books (SHAGDARSUREN et al. 1987, SHIREVDAMBA et al. 1997, ŽIRNOV et al. 2005, DULAMTSEREN et al. 2006) as well as by STUBBE et al. (2005) and further passages in the Conclusions/Recommendations of the Asiatic Wild Ass Conference (STUBBE et al. 2007) and in the Conservation Action Plans for Mongolian Mammals (CLARK et al. 2006).

The actual situation of the Mongolian Wild ass or khulan (*Equus hemionus hemionus*) in Mongolia can be summarized by the following main points and questions:

- We show that for the last 12 years, poaching of Wild asses appears to be the main source of mortality. Therefore control, registration, and responsible use, and enforcement of all firearms in Mongolia are necessary.
- National laws protecting the khulan need to be strengthened.
- An international cross border monitoring system for endangered species in the Gobi region of Mongolia and China needs to be implemented. Additional funding for research is urgently needed to study the social and population structure, natural mortality under the influence of carnivore pressure, migration behaviour, interactions with the plant biodiversity (feeding grounds), global change of climate and landscape of the region.
- We urge the development of a programme of re-introduction into two areas: (1) the western the Mongolian basin of the Great Lakes region and (2) on the east side of the railway line from Ulaanbaatar to Beijing.
- A review of the network of protected areas to determine level of coordination and concept. Are the protected areas working and can the coordination among them be increased to further the common goals of conservation of biodiversity?

We feel it is time to realize the demands and aims of protection outlined in the documents of the International Asiatic Wild Ass Conference 2005 in Ulaanbaatar. During this meeting, the participants recorded all pertinent knowledge and presented results of available research on Mongolian khulan. These results and the knowledge generated from this meeting should be transformed into practice. We urge the people of Mongolia and the region, indeed the world, to push hard to establish a new strategy to manage the biodiversity of this last and majestic great wild mammal which is a symbol of the Mongolian wilderness. This represents a great challenge for international protection of nature! The people of Mongolia can decide their bright future with biodiversity playing a great part in this.

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Appendix

Table 2: Monthly average temperatures (°C) of the meteorological station in Manlaj Sum 2001–2010

year	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
2001	-15.2	-10.0	-2.3	6.8	14.7	21.5	24.1	21.1	16.2	6.9	-4.3	-15.2
2002	-9.7	-5.7	-0.6	5.4	14.5	21.4	24.3	23.1	13.8	1.8	-7.2	-14.5
2003	-13.9	-9.4	-2.8	6.3	13.6	19.5	21.5	18.5	15.0	5.0	-7.9	-12.5
2004	-13.7	-7.4	-3.5	9.9	14.2	20.5	22.9	19.6	14.0	5.8	-4.4	-11.2
2005	-14.5	-18.7	-3.2	7.2	13.5	20.8	24.1	21.8	14.9	6.3	-3.7	-16.0
2006	-13.3	-11.1	-1.7	5.2	13.4	19.9	21.8	22.8	15.2	8.1	-3.7	-11.9
2007	-12.4	-4.1	-3.6	6.6	15.4	22.6	23.4	22.5	16.9	4.1	-4.3	-12.0
2008	-17.6	-12.9	0.3	8.6	12.6	19.6	23.5	20.8	15.1	6.1	-3.0	-12.2
2009	-13.8	-9.3	-2.5	9.5	15.5	19.8	23.5	21.2	14.2	5.2	-8.6	-13.4
2010	-18.2	-13.9	-5.2	1.5	13.8	22.6	25.2	19.9	15.2	5.4	-3.4	-12.7

Table 3: Monthly minimum temperatures (°C) of the meteorological station in Manlaj Sum 2001–2010

year	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
2001	-29.6	-27.7	-21.4	-9.0	-4.9	9.7	10.8	8.0	3.1	-8.5	-18.2	-25.1
2002	-20.5	-16.2	-18.7	-12.3	-1.2	5.5	14.0	8.0	-1.6	-15.5	-19.5	-27.4
2003	-27.8	-28.9	-17.1	-7.5	0.1	3.6	9.6	7.5	1.1	-10.5	-20.8	-26.0
2004	-23.2	-25.0	-19.3	-8.7	-4.0	7.6	8.1	6.1	-11.1	-11.5	-21.9	-27.9
2005	-27.1	-29.6	-22.0	-9.5	-6.0	5.0	12.5	7.6	-0.5	-7.1	-14.5	-28.1
2006	-26.1	-30.5	-21.9	-10.3	-3.0	3.1	10.7	8.4	-1.4	-7.9	-24.5	-21.5
2007	-23.9	-17.4	-23.7	-10.7	0.2	3.3	12.9	9.4	2.4	-13.8	-19.0	-22.4
2008	-28.4	-25.4	-15.0	-7.0	-1.9	5.3	12.1	5.5	0.1	-10.1	-15.8	-28.2
2009	-27.6	-25.6	-19.9	-6.0	-0.9	7.1	11.9	9.6	-2.4	-7.3	-24.5	-27.2
2010	-32.4	-27.2	-23.1	-14	-1.1	4.2	11.8	6.0	-0.7	-9.1	-18.0	-29.0

Table 4: Monthly maximum temperatures (°C) of the meteorological station in Manlaj Sum 2001–2010

year	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
2001	-0.5	8.0	19.5	25.0	33.0	32.2	36.2	33.0	31.0	21.2	9.5	-1.5
2002	4.5	13.0	22.0	22.4	33.0	35.6	35.8	34.0	29.2	21.0	12.5	6.5
2003	0.5	5.0	21.5	29.5	30.5	31.5	33.5	30.5	30.0	19.8	13.5	0
2004	-0.2	8.8	15.5	29.1	33.7	32.7	36.0	34.4	28.0	21.7	15.4	5.2
2005	-0.7	-0.4	16.1	28.0	28.8	39.1	37.8	34.3	32.5	23.4	14.3	0.6
2006	2.1	8.0	18.0	24.0	31.3	32.0	33.5	34.8	30.0	23.5	13.2	4.1
2007	1.8	10.7	15.9		30.1	34.7	35.0	34.0	29.0	21.9		1.2
2008	-3.8	5.6	14.9	26.0	31.9	34.7	35.0	36.9	30.0	22.8	12.6	2.2
2009	1.5	10.3	20.3	25.1	32.2	36.4	35.5	34.6	29.3	21.0	15.0	3.0
2010	1.5	7.7	18.0	23.5	29.4	36.0	38.4	32.0	30.9	26.0	13.0	7.4

Table 5: Monthly rainfall (mm) at the meteorological station in Manlaj Sum 2001–2010

year	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.	total
2001	2.4	0.6	3.8	0.2		50.3	27.2	7.2	2.9	10.7	3.0	0.0	**108.3**
2002		0.0	3.1	2.4	9.8	32.1	23.1	7.7	4.6	0.2	0.4	8.3	**91.7**
2003	0.2	0.2	0.4	0.9	50.5	9.0	57.1	37.7	7.1	0.2	2.8		**166.1**
2004	0.3	0.3	0.2		6.8	12.2	0.8	22.2	10.2	0.2	0.6	0.0	**53.8**
2005		3.9	0.3	0.0	9.9	1.6	12.8	16.0	0.0	2.6	0.8	0.0	**47.9**
2006	1.8	0.6	0.8	0.3	0.7	6.8	78.8	2.7	9.7		1.4	0.5	**104.1**
2007	0.3	3.6	3.1	0.0	4.6	0.0	28.0	1.1	0.0	10.0	1.4	2.3	**54.4**
2008	1.8	0.4	2.7	0.6	0.6	37.2	22.0	35.8	5.0	0.5	1.2	2.0	**109.8**
2009			0.0	1.0	7.3	8.3	13.5	24.6		3.0	5.1	0.5	**63.3**
2010	9.2	0.7	2.5	7.4	33.1	20.5	21.3	2.3	30.4	1.4	1.6	0.5	**130.9**

Fig. 10: Meteorological station in Manlaj Sum, Ömnögov Aimag (photo: A. Stubbe).

Fig. 11: Office of the meteorological station in Manlaj Sum (photo: A. STUBBE).

Table 6: Daily average temperatures (°C) in June at the meteorological station in Manlaj Sum 2002–2012

day \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
01.06.	26.1	22.8	22.7	17.0	12.1	23.4	12.6	21.9	23.4	19.4	11.7
02.06.	28.6	21.1	16.4	22.4	13.4	24.1	14.4	21.5	24.2	18.6	16.8
03.06.	24.4	21.8	15.3	23.6	17.1	11.7	14.7	22.5	24.1	17.2	15.8
04.06.	25.2	19.0	15.2	19.1	23.9	19.8	14.2	22.6	22.7	19.0	18.7
05.06.	28.2	19.2	15.5	12.8	25.4	24.2	14.0	19.6	22.1	20.6	20.6
06.06.	20.0	21.2	17.6	15.3	16.3	26.7	20.2	15.2	23.8	21.5	18.3
07.06.	15.1	17.5	21.5	14.4	14.2	27.2	25.0	11.0	20.3	16.4	20.2
08.06.	15.5	17.7	22.7	16.7	17.0	28.2	27.2	12.4	10.7	18.3	22.1
09.06.	12.6	13.6	23.8	18.8	17.7	27.1	24.3	14.1	14.5	17.9	13.5
10.06.	13.6	13.0	25.1	20.6	19.6	26.0	24.0	19.2	16.3	15.8	13.7
11.06.	18.4	13.2	25.0	23.6	18.0	17.9	26.0	20.9	19.9	18.5	17.4
12.06.	20.6	16.4	24.8	17.7	11.6	20.6	23.2	18.4	21.7	23.1	17.6
13.06.	22.4	20.2	18.8	17.2	14.9	21.1	14.9	20.6	19.0	25.1	12.8
14.06.	23.0	22.7	21.0	19.5	17.4	23.0	17.3	23.0	23.8	26.9	16.0
15.06.	24.8	22.9	18.1	21.3	21.8	16.5	22.1	23.3	20.6	23.6	21.4
16.06.	24.8	23.8	16.3	21.3	22.0	19.1	20.2	20.5	11.9	24.2	25.4
17.06.	27.8	22.4	15.6	22.5	22.6	19.8	19.1	25.6	17.2	24.4	27.7
18.06.	21.6	22.5	20.4	24.0	21.0	19.1	23.0	23.3	21.5	26.5	25.7
19.06.	19.6	21.3	23.2	23.0	22.5	19.2	25.0	16.3	23.8	23.7	23.6
20.06.	21.8	21.6	22.0	27.5	23.8	21.3	22.7	14.5	25.7	23.4	18.8
21.06.	17.5	24.2	18.7	31.0	24.7	25.8	18.7	14.0	24.3	20.1	21.6
22.06.	18.4	20.4	16.0	23.3	24.3	25.1	17.5	16.1	25.5	17.9	26.0
23.06.	19.6	19.1	17.4	18.0	18.2	22.4	15.2	22.8	27.6	15.8	17.4
24.06.	17.2	21.8	21.1	19.5	19.0	25.2	18.0	24.1	29.6	18.7	18.4
25.06.	18.6	17.6	24.8	23.1	21.8	23.9	19.0	27.8	29.4	19.5	16.5
26.06.	22.5	14.4	27.1	26.0	23.5	26.8	18.5	25.2	29.1	20.9	16.8
27.06.	24.0	12.8	25.9	23.4	23.2	22.8	18.9	17.8	29.0	22.6	19.5
28.06.	25.5	15.1	22.1	21.5	22.5	22.0	19.6	17.5	27.8	24.8	20.7
29.06.	25.6	21.6	20.6	20.8	22.5	21.8	18.5	19.3	23.5	18.2	22.1
30.06.	20.0	24.4	21.4	20.3	23.5	24.7	19.9	22.2	23.4	19.9	27.5

Table 7: Daily minimum temperatures (°C) in June at the meteorological station in Manlaj Sum 2002–2012

day \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
01.06.	17.2	15.2	13.6	7.5	9.1	12.0	5.3	12.8	15.1	8.0	3.0
02.06.	22.5	13.6	10.5	14.6	3.1	17.6	8.3	15.6	15.3	11.5	10.6
03.06.	18.4	13.1	10.7	16.4	6.5	3.3	6.3	16.1	15.6	10.7	7.3
04.06.	15.9	13.1	9.4	15.7	16.1	8.1	11.3	15.7	16.1	8.2	10.5
05.06.	23.4	10.1	10.9	5.0	16.6	14.7	9.5	16.2	13.6	13.0	15.3
06.06.	14.6	17.1	7.6	8.9	11.1	17.3	11.8	8.3	17.2	10.9	10.2
07.06.	9.1	11.6	14.6	6.7	7.5	18.5	16.4	7.6	14.4	9.5	13.4
08.06.	11.5	13.4	13.8	10.7	9.1	19.0	20.7	7.5	4.2	9.7	15.5
09.06.	11.0	7.1	13.5	10.6	12.1	19.9	17.6	7.1	7.5	11.5	3.6
10.06.	5.5	8.9	17.0	11.2	12.9	19.2	17.1	12.6	11.1	9.8	5.1
11.06.	9.6	3.6	16.1	14.5	12.0	11.8	22.4	13.5	106.0	7.1	9.8
12.06.	12.9	10.1	19.4	12.9	5.1	14.6	19.9	12.5	17.6	15.1	11.1
13.06.	15.0	12.1	14.1	9.8	8.6	16.3	8.4	14.2	12.5	16.1	6.6
14.06.	16.5	17.6	15.1	12.8	7.4	18.2	12.1	16.8	15.0	17.9	7.6
15.06.	15.4	15.1	14.4	13.6	11.2	14.2	14.6	19.1	16.0	15.5	11.7
16.06.	21.8	18.6	9.7	13.3	14.6	12.7	15.8	12.1	8.3	14.3	17.7
17.06.	16.6	15.6	12.1	13.5	14.5	15.7	13.5	17.8	11.4	16.3	18.9
18.06.	12.5	15.3	12.8	16.3	15.9	12.1	16.3	16.5	13.9	17.8	19.3
19.06.	17.8	16.6	17.0	14.1	14.6	11.0	17.6	8.3	17.7	18.6	19.1
20.06.	16.5	15.1	14.4	20.7	14.6	13.4	17.7	8.3	19.5	15.0	12.6
21.06.	14.0	17.1	14.0	21.1	17.3	17.1	10.6	7.6	19.6	15.1	12.3
22.06.	12.0	14.6	11.0	17.4	19.7	18.3	12.5	8.5	17.7	14.4	19.6
23.06.	14.5	11.9	13.0	15.1	13.9	16.4	11.2	11.5	20.2	9.9	11.9
24.06.	12.4	13.6	14.6	12.7	11.7	17.2	10.2	16.7	22.5	9.5	12.6
25.06.	13.0	13.1	16.3	13.6	13.3	18.0	13.7	18.6	20.4	14.1	9.7
26.06.	18.3	9.4	18.9	16.4	17.1	19.4	13.3	18.3	19.7	12.0	8.8
27.06.	16.9	8.6	22.6	19.1	17.2	15.2	12.1	11.4	22.1	12.4	13.6
28.06.	19.9	7.1	15.8	16.6	16.4	14.7	15.1	10.1	21.5	16.6	14.2
29.06.	20.5	13.6	17.6	12.9	15.8	13.0	14.1	8.8	16.7	12.5	13.1
30.06.	13.0	17.3	14.4	13.4	15.9	16.1	14.1	14.8	16.1	12.5	17.6

Table 7: Daily maximum temperatures (°C) in June at the meteorological station in Manlaj Sum 2002–2012

year / day	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
01.06.	34.5	28.8	31.4	25.0	21.5	33.0	20.1	29.5	30.2	27.8	20.0
02.06.	34.0	27.0	25.1	29.8	22.0	31.1	20.9	27.6	30.8	24.8	24.0
03.06.	33.0	28.0	18.5	31.5	26.9	23.2	22.0	27.7	30.4	22.6	24.2
04.06.	34.3	27.0	19.1	24.8	30.6	28.9	20.1	28.1	30.3	26.1	25.2
05.06.	35.6	28.0	18.5	18.7	32.0	31.7	20.3	24.9	29.5	26.9	26.2
06.06.	27.0	27.5	26.0	21.4	28.1	34.0	28.7	22.1	30.7	29.8	25.4
07.06.	21.5	22.8	28.0	21.0	19.6	33.8	32.7	18.9	27.7	26.8	26.6
08.06.	20.0	22.7	29.0	21.8	23.5	34.0	34.7	17.8	18.2	25.2	29.5
09.06.	14.6	21.5	31.0	25.5	22.3	33.7	31.2	20.7	22.5	24.0	26.9
10.06.	21.6	19.0	31.7	28.6	26.0	30.8	31.6	26.5	22.9	20.2	22.2
11.06.	27.0	22.3	31.5	32.2	26.6	27.8	32.1	26.7	29.5	27.7	25.9
12.06.	28.4	22.2	29.0	24.8	18.1	28.8	29.2	24.7	27.7	30.5	25.6
13.06.	28.0	27.0	26.6	23.9	18.8	28.1	22.0	26.1	26.8	33.4	20.0
14.06.	30.0	29.0	28.0	26.7	26.5	28.7	22.6	29.1	31.7	33.8	23.6
15.06.	31.5	30.0	25.0	28.8	31.6	23.4	29.6	28.7	27.9	30.0	31.3
16.06.	32.0	29.5	20.9	28.3	28.1	25.4	28.4	27.8	17.9	29.5	32.4
17.06.	34.3	30.0	22.6	29.4	30.0	25.5	25.3	33.0	25.0	30.8	35.0
18.06.	30.5	30.5	27.5	31.6	28.2	23.7	29.1	30.6	29.0	35.1	32.7
19.06.	25.0	26.3	27.5	29.5	29.9	26.2	31.5	25.8	30.0	31.8	29.2
20.06.	26.3	29.3	29.0	34.8	30.3	28.1	28.8	21.1	33.5	31.6	27.8
21.06.	25.8	30.5	26.0	39.1	30.8	32.5	26.5	22.6	29.7	29.5	30.0
22.06.	25.0	29.0	21.5	36.7	28.8	31.5	24.8	23.3	31.5	23.0	32.6
23.06.	24.5	25.5	22.7	25.8	22.8	29.5	21.6	33.1	34.0	21.4	25.0
24.06.	21.8	19.5	27.5	25.5	26.0	32.6	27.7	32.0	36.0	25.5	24.8
25.06.	24.7	19.8	31.6	31.0	28.5	30.6	24.1	36.4	35.3	24.0	24.6
26.06.	30.0	22.5	32.7	32.7	31.0	34.7	22.7	33.5	35.5	27.3	25.3
27.06.	31.0	30.0	31.5	29.8	26.6	32.6	25.2	27.3	34.4	30.0	25.3
28.06.	31.3	28.5	26.8	27.6	27.8	28.8	25.6	25.4	34.1	30.0	26.7
29.06.	31.7	25.5	25.4	27.2	29.2	29.2	22.2	28.1	30.3	21.7	29.8
30.06.	27.7	31.5	29.0	26.6	29.9	31.6	25.1	30.3	30.0	26.7	36.9