Mongolian Journal of Biological Sciences 2004 Vol. 2(2): 33-46

Methods and Routes of two German-Mongolian Zoological Expeditions through the Steppe, Semi-Desert and Desert Zones of Mongolia in 1995 and 2002

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Key words: Mongolian gerbils, mammals, Gobi desert, rodents, morphology, behaviour, ecology

Abstract

Routes, methods and key results of two mammalian expeditions undertaken by German and Mongolian zoologists in 1995 and 2002 are described. The 1995 expedition trapped a sample of Mongolian gerbils (*Meriones unguiculatus)* (n = 167) with high genetic diversity for further breeding of a new wild gerbil strain in Germany. The 2002 expedition collected 265 mammals from 23 species during an extended west-eastern survey from 96°to 113°E along the transient zone of the semi-desert to the Gobi desert near 44°to 45°N. Methods applied included dissections, behavioural experiments, vocalization recording, determination of dominant plants and livestock. New techniques were introduced to record surface activity of small mammals. Most mammals trapped in the steppe were Mongolian gerbils with an estimated density of 2400 - 6600 individuals per km^2. The highest diversity was found in the desert and semi-desert region and included *Hemiechinus auritus, Meriones unguiculatus, Salpingotus crassicauda, Pygeretmus pumilio* and *Cardiocranius paradoxus*, which were restricted to southern Mongolia. The need for further complex expeditions through the arid zones of Mongolia are discussed.

Introduction

The natural climate and landscape of Central Asia forms a broad band of arid vegetation, which extends west-easterly through Mongolia. Wild mammals in the steppe, semi-desert and desert zones live and reproduce relatively undisturbed by man, and have attracted zoologists from Mongolia, Russia, Germany and elsewhere for centuries (David 1867, Formozow 1931, Allen 1940, Stubbe and Chotolchu 1968, Sokolov and Orlov 1980). Recent checklists of Mongolian mammals were compiled by Mallon (1985), Reading *et al*. (1994) and Tinnin *et al.* (2002). Approximately 136 species of mammals are recorded in Mongolia (Tinnin *et al*., 2002). Mongolia provides the natural habitat for wild ancestors of several domesticated mammals, e.g. the Wild Ass (*Equus hemionus*), the Bactrian Camel (*Camelus bactrianus*) and the Mongolian gerbil (*Meriones unguiculatus*), but also give room to millions of sheep, cattle, goats and other livestock (Barthel 1990).

The rise of democracy and the transformations towards a market economy in Mongolia after 1990 affected both the basic conditions of biological research and the natural restrictions of wildlife and pastoral land use. The socio-economic transition has led to a rapid increase in livestock numbers, from 24 million in 1989 to 33 million in 1998 (Schickoff and Zemmrich 2000). Fundamental changes in nomadic pastoralism have taken place, and an increasing proportion of Mongolia is

Fig. 1. Survey area of the two zoological expeditions performed by German and Mongolian scientists in 1995 and 2002. Dotted lines = route of the *Meriones unguiculatus* Expedition 1995 (MU1995); solid lines = route of the Semi-Desert Mammology Expedition 2002 (SDM2002), dashed lines = supporting voyages and exchange of crew members (SDM2002). Stations are marked by roman numbers (I – IV, MU1995) or capital letters (A – 0, SDM2002), over-night camps are indicated by roman numbers (1 – 19, SDM 2002). The geographic positions of III, A and O are identical.

characterized by overstocking and overgrazing, in particular by Kashmir goats (Fernandez-Gimenez and Allen-Diaz 1999). Simultaneously, political changes hindered the traditional cooperation with biologists from former socialist states such as the USSR and the GDR. Other opportunities opened up through new international collaborations. Access to sophisticated methods facilitated studies in Mongolian life sciences, e.g. navigation and screening of vegetation via satellite (Naidansuren 2003), use of computer tomography for morphological investigations (Frey and Riede 2003) and molecular techniques.

Today, the gerbil is one of the most prominent mammals from Mongolia, known as a pet by millions of European and American children. Mongolian gerbils kept in laboratories since 1935 (strain Tum: MON) had become domesticated, and should be designated as *M. unguiculatus* forma domestica (LAB, for details see Stuermer *et al.* 2003). In June 1995, German and Mongolian zoologists undertook the first expedition focused on *Meriones* in Mongolia (Stuermer *et al.* 1996). To collect a representative sample of the species, wild *M. unguiculatus* (WILD) were captured east of the Changai mountain foothills, near the centre of their natural geographic distribution (see Fig. 1). Some gerbils were investigated morphologically (n = 68), others (n = 74) were taken to Germany alive and successfully mated (n = 60) to generate a new line of "wild gerbils" at the University of Goettingen (strain Ugoe: MU95) with sufficient natural genetic diversity.

The subsequent distribution of offspring, tissue and data among colleagues established a network of comparative gerbil research. Significant differences between WILD and LAB, e.g. lower brain weight (Stuermer *et al.* 1997), less genetic variability (Neumann *et al.* 2001), higher testosterone concentration and increased rate in spermatogenesis (Blottner *et al.* 2000) indicated domestication in LAB gerbil. Further studies on wild offspring investigated the size of different brain subdivisions (Gleich *et al.* 2000, Leybold 2000) and provided a method to determine age classes through skull characteristics (Tittmann 2002).

Despite the advantages of WILD gerbils kept in the laboratory, their natural behaviour and adaptation mechanisms to fluctuating food or aridity could not be investigated in captivity. Therefore, we investigated *Meriones* and other mammals of the steppe and semi-desert regions in their natural habitats during a second investigation in 2002, designated as the Semi-Desert Mammology Expedition (SDM2002). Animals were collected at 14 locations distributed over a west-east distance of 1300 km near the latitudes of 44°and 45°N, which mark the patchy transition of semi-desert areas into the Gobi desert. Additional traps were set out in July and August 2002 in the steppe zone at the location (near 47°N, 105,5°E) where founders of the Ugoe: MU95-strain had collected in June 1995. Methods applied included detailed morphometric dissections, food choice experiments, genetic and reproduction analysis, determination of dominant vegetation and quantification of livestock levels nearby. Additional new techniques were successfully implemented during this expedition, e.g. a new automatic device for measuring circadian activity, storage and transport of frozen tissue in battery-powered mobile freezers under desert conditions (Fig 4). In addition to the ongoing analyses of data, a species list of all mammals trapped in 1995 and 2002 along with useful information on the route and locations investigated are compiled here as a reference for further publications and a practical guide and overview for zoologists working in the arid zones of Mongolia.

Methods

Our first scientific expedition to Mongolia, the *Meriones unguiculatus* expedition was undertaken between 9th and 25ft June 1995 (MU1995) aimed to collect Mongolian gerbils with high genetic diversity for further breeding in Germany to establish a new wild gerbil strain (named Ugoe: MU95). The *Semi-Desert Mammology* expedition 14th July to 25th August 2002 (SDM2002) was intended as a collecting survey of the biodiversity of small mammals on the transient border of the semi-desert zone and the Gobi Desert. Both expeditions were led by the first author and undertaken as a joint venture with the National University of Mongolia in Ulaanbaatar. The expeditions were organized either by the Leibniz Institute for Neurobiology (IfN) at Magdeburg (MU1995) or by the University of Goettingen (SDM2002), together with the Leibniz Institute for Zoo and Wildlife Research (IZW) at Berlin (SDM2002).

The position of trapping localities (stations I to IV in 1995, stations A to O in 2002), their vegetation zone classification and the routes of both expeditions are shown in Fig. 1. The range of MU1995 (740 km) was restricted by the necessity of keeping all trapped rodents alive during the trip. The extended range (5400 km) of SDM2002 included behavioural experiments and transport of frozen tissues.

Morphological examinations and behavioural experiments. Mammals were live trapped in Sherman Traps of medium (76 x 89 x 229 mm, n = 150) or small size (51 x 64 x 165 mm, n = 80). Larger Sherman traps (375 x 102 x 114 mm, n = 10) were used occasionally at trapping stations A – C and K - O. Small vertebrates were anaesthetized and killed with Halothane (Eurim) or with T 61® (Hoechst). Four hoofed animals were killed at Station J by local hunters with buckshot (for details, see Frey and Gebler 2003). Skulls or carcasses of dead mammals were collected occasionally during transit. Taxonomic names were used following Wilson and Reeder (1993), Nowak (1999) and Tinnin *et al* (2002). For a current review on the phylogenetic relationships of Sciuridae, see Herron *et al.* (2004).

Our standardized methods for morphological measurements and dissections performed on trapped mammals in 1995 and 2002 are described in detail in Stuermer *et al.* 2003. Techniques improved or innovated during SDM2002 included the following methods: (1) frozen tissue for further morphological, genetic, spermatogenetical and parasitological analyses was collected and stored in two low energy upright freezers (Privileg Typ 105, 97 litres each – Fig 4f). Temperatures were maintained between – 10 and – 24 °C. Freezers were powered either by generator (Eisemann P2900, 2.8 kw, IP54) or 6 car batteries with an overall capacity of > 500 ampere-hours. DC was transformed to AC with the help of 2 Sine-Inverter (Typ HS 400, Conrad Electronic) with 400 VA continuous consumption each. (2) Activity patterns of Mongolian gerbils were registered with the Rodent Activity Logger (RAL), a new system to analyze surface activity of small mammals under outdoor conditions (Fig 4g). The self-constructed systems (n = 24) developed at the University of Cologne allowed simultaneous and continuous data recordings of surface activity at different entrances of one rodent burrow. The RAL was shielded against dust and rain. The sensory system was based on a magnetic field sensor, which detects soil vibrations above the data logger unit in a detection range of 220 cm^2. Its restricted size enabled us to bury it below the surface in front of the burrows' entrances (Fig 4g). (3) Spontaneous locomotion behaviour and frequencies of grooming and rearing were measured in Mongolian gerbils trapped at Station K and M and exposed to a standardized environment in an Open Field Area optimized for mobile use (Fig 4h). The experiments were performed for 20 min on a clean square Plexiglas (5 mm) platform (1 x 1 m) restricted by 4 vertical faces (1 x 1 m, Fig. 4h). Each sequence was recorded by a video camera mounted above the arena. (4) Some Mongolian gerbils trapped alive and kept in the camp for a few hours were exposed to a new behavioural device called Rapidometer to quantify rapid escape reactions and to measure the animals running speed. The Rapidometer consisted of a small start box (115 x 92 x 92 mm), which could be opened to a transparent tunnel (300 cm length, 30 cm width, 25 cm height) erected above natural ground. Its final section (280 cm) just opposite the start box was covered by semi-opaque Plexiglas and equipped with an artificial hole (diameter 68 mm) dug into the ground. (5) Head-and-neck specimens of 4 *Procapra gutturosa* (3 male, 1 female) were deeply frozen immediately after death and transferred frozen to the Leibniz Institute for Zoo and Wildlife Research in Berlin. A combination of classic macroscopic dissections with modern computer tomographical scanning (GE Lightspeed 4-Slice Spiral CT) together with volume-rendering imaging techniques was applied to obtain as instructive information as possible on the anatomical structure of the highly specialized larynx and vocal tract of the male Mongolian Gazelle (for details see Frey and Gebler 2003). The reproductive organs of 1 male *Ochotona dauurica* were dissected and drawn by Christine Hellwag at the same Institute (Frey *et al.* 2004). (6) Natural vocalizations of *Meriones unguiculatus* and *Procapra gutturosa* were recorded by means of a DAT (digital audio tape) recorder (Sony TCD - D 100) and a directional microphone with wind cover (Sennheiser ME 80 including a pre-amplified K3U) at Stations L and K (see vocalizing gerbil at Fig 4a).

An interdisciplinary approach to assess biodiversity. Methods focused on mammals were supplemented by an interdisciplinary approach, which related the analyses of mammalian biodiversity and abundance to their physical state (Stuermer *et al.* 2004) and behaviour (Tittmann *et al.* 2004), to climate data, vegetation community and the distribution of domestic animals. Continuous measurements of air temperature and humidity over a time period of more than 24 h were done simultaneously at two different distances above ground level at Stations A, B, C, K, and O. One sensor was fixed 10 cm above ground to register the daily changes within the microclimate of small mammals. The second sensor was put up 200cm above ground to match our measurements with standardized meteorological data. At most trapping sites, the percentage of soil covered by vegetation was estimated. Characteristic and dominant plants were documented through herbarium material (n=200) and photographs (n=600) at every station, identified (Grukov 1982) and designated to characteristic vegetation zones according to the classification of Hilbig (1995).

Observations and estimations of wild and domestic mammals. The casual sighting of a wild mammal was appointed a successive three-digit number and registered along with the date, time, position, genus or species, number of specimens and the observer's name. All observations (abbreviated as OB#, e.g. OB#508) were made at different locations at least 500 meters apart (or 2 min apart, if travelling in a vehicle). Animal tracks and burrows are not included in the record, if not otherwise mentioned. Systematic observations of nomadic settlements, domestic mammals and an estimation of livestock size were performed during the central part of SDM2002 through the semi-desert and desert zones south of 46°N (see Fig. 2). The number of nomadic tents (called ger) and the size of horse, camel, cattle, sheep and goat herds were recorded during transit with the naked eye or low magnification on both sides of the route. Therefore, reliable observations were obtained up to a distance of approximately 1.5 km on both sides of the routes.

Results

The greatest amount of time during SDM2002 was spent in the steppe zone (26 %, 4 stations, Fig 3a). Similar periods were spent in the semi-desert (19 %, 4 stations, Fig 3b) or mountain steppe zone (18 %, 3 stations, Fig 3d), less time in the Gobi desert (6 %, 3 stations, Fig 3c). Additional observations were done in transit, which required 15 % of the expedition time. MU1995 was performed in the steppe zone south and north of the river Tuul (see Fig. 1).

A total of 471 vertebrates were collected by both expeditions during nearly two months. Most vertebrates collected belong to the subclass Mammalia (93 %) and the order Rodentia (89 %). Mongolian gerbils make up two thirds of all vertebrates investigated. Records of 23 different mammalian species were compiled (see Tab. 1). Almost half of the traps were set out near burrows assumed to be inhabited by *Meriones*. (see Fig. 4a). Therefore, we re-calculated the diversity of mammals for all traps that were set out without the intention of collecting gerbils. These traps also contained mainly mammals (89 %) and rodents (85 %), and every second vertebrate captured (54 %) belonged to the same species (*Meriones unguiculatus*).

The number of individuals and biodiversity of mammals collected differed between vegetation zones (see Tab. 1). Summed up for each zone, we collected 152 mammals / 9 species in the steppe, 21 mammals / 8 species in the mountain steppe, 67 mammals / 11 species in the semi-desert and 14 mammals / 4 species in the desert. Normalized to 100 traps set over a 24-hours period, we trapped on average 13 mammals / 0.8 species in the steppe zone, 3 mammals / 1.0 species in the mountain steppe, 5 mammals / 0.8 species in the semi-desert and 6 mammals / 1.6 species in the desert.

Observations on domestic mammals and overgrazing. Domestic mammals and pasture activity were registered at 367 different locations over a distance of approximately 4000 km (see Fig. 2). Pasture was associated with 553 gers registered at 185 different locations (Fig. 2a). The total sums of domestic animals estimated (within n herds observed) were 1542 camels (n = 81), 2356 horses (n = 92), 1763 cattle (n = 55), 4153 sheep (n = 62) and 6748 goats (n = 77). The average (and maximum) size of each herd was 19 camels (200), 26 horses (300), 43 cattle (200), 66 sheep (400) and 124 goats (900).

Significant numbers of dead livestock were found at the end of July at the northern downward slope of the Gobi Altai and in its saddle region above 2500 m. For example, we registered the cadavers of 40 goats and 20 sheep in an abandoned nomadic camp near 45,5°N and 98°E in the mountain steppe zone, dominated by *Artemisia sp.* and *Arenaria meyerii* (see Fig. 4e). Overgrazing was mainly observed in the semi-desert region around lake Orog Nuur, in the mountain steppe zone of the

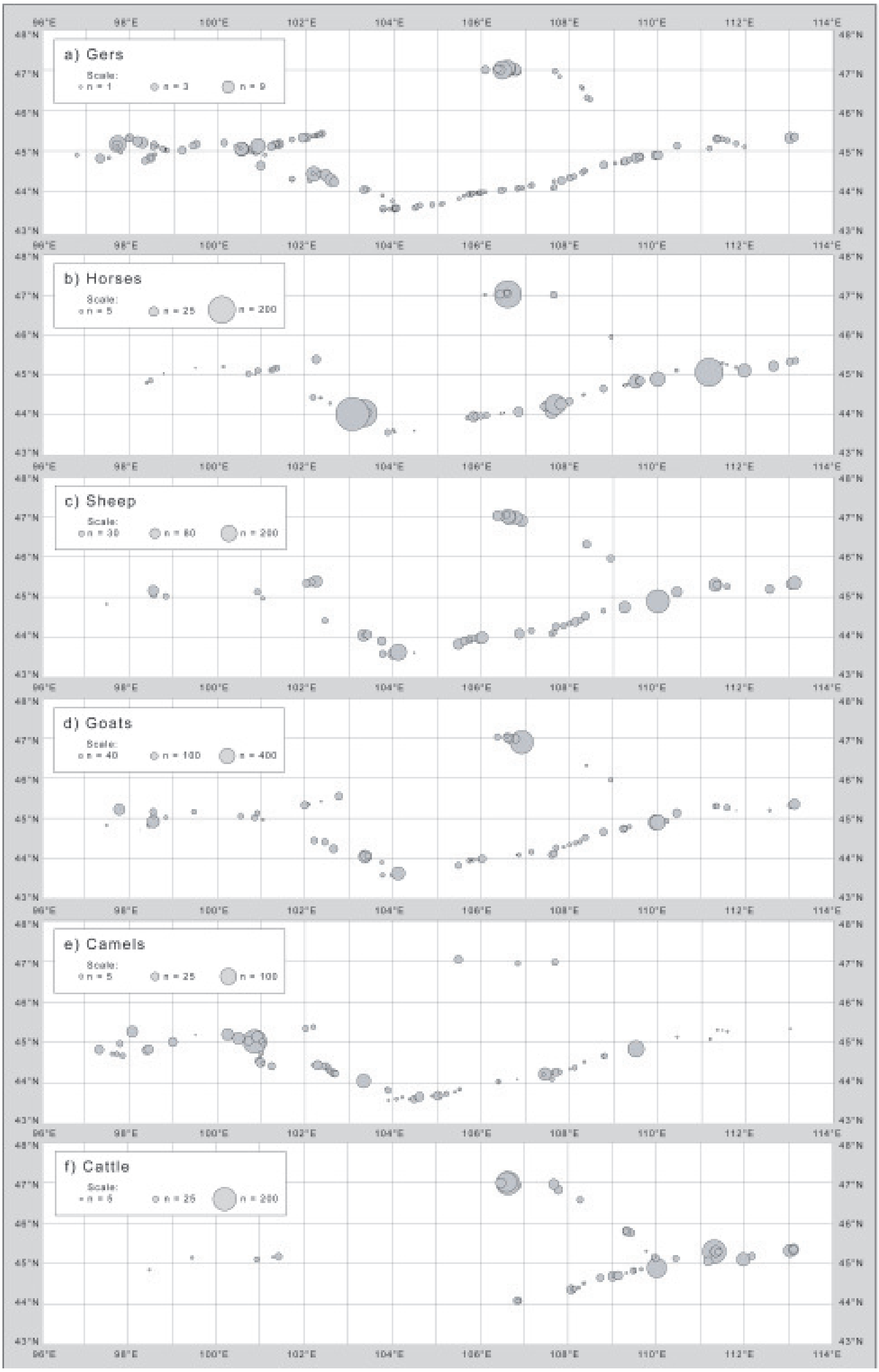

Fig. 2. Pasture activity of nomads registered along the route of SDM2002 in the arid zones of Mongolia south of 46°N. (a) Gers (b) Horses (c) Sheep (d) Goats (e) Camels (f) Cattle. The number of gers and livestock were given by the area of each circle, its centre indicates the geographic position of each observation.

Aimag Govi-Altai and Bayanhongor (see Fig. 3d) and in the surrounding areas of Ulaanbaatar, Saynshand and other densely populated centres. Intensive pasture between 98°E and 101°E, around Dalanzadgad and north of Saynshand goes along with an obvious lack of predator birds. Additionally, we collected conspicuous much carcass of Mongolian gazelles in the overgrazed steppe on the western side of the railways north of Dalanzadgad.

Discussion

Domestication of Mongolian gerbils proved by the MU1995 expedition. Wild gerbils trapped and dissected by MU1995 (n = 68) provided the most comprehensive set of morphological measurements since Allen (1940) and Stubbe and Chotolchu (1968) published data on this species. In addition, brain and eye weights in WILD compared to LAB allowed us to scrutinize our hypothesis that the laboratory strain had become domesticated as a consequence of genetic isolation and controlled selective breeding since 1935 (Stuermer *et al.* 1996). Allometric brain weight reduction of 17.6 % in LAB marks the highest value found among rodents, and eye weight reduction of 26.0 % may point to serious reductions of sensory capabilities (Stuermer *et al.* 2003). The well-known history of the laboratory gerbil breeding line (Rich 1968) indicated that they were subjected to severe genetic population bottlenecks in 1935 and 1954 (Stuermer, 2003). This assumption is backed up by recent data on natural high microsatellite variation in our samples of MU1995 gerbils, and reduced genetic variability in LAB (Neumann *et al.* 2001).

The successful breeding of wild gerbils taken by the MU1995 expedition stimulated further investigations on reproductive physiology, brain morphology and behaviour in Ugoe: MU95 (Stuermer *et al.* 2002). Offspring of wild gerbils (F_1) raised under identical conditions as LAB showed reduced rate in spermatogenesis and a significantly lower testicular testosterone concentration than domesticated gerbils (Blottner *et al.* 2000). Volumetric changes in the central nervous system due to domestication differed among subdivisions of the brain. Reduction is greater in the cerebellum as in the forebrain (Leybold 2000). A reduction was also observed in the dorsal part of the cochlear nucleus (CN), whereas the size of its anteroventral part increased (Gleich *et al.* 2000). Several reports (reviewed by McGinn & Faddis 1994) indicated that species-specific neurodegenerations in the CN increased with age and auditory experience, but it was unknown if wild gerbils show similar microlesions. A recent investigation of CN in Ugoe: MU95 revealed corresponding degenerations, but a later onset of degenerative processes (Stuermer *et al.* 2001) in offspring of wild gerbils. Apart from the maintenance of the master breeding line at Goettingen University, Ugoe: MU95 breeding pairs are established at Munich University, Frankfurt University and at the IfN Magdeburg. Wild gerbils open up new opportunities, e.g. in behavioural and auditory research, or in the understanding of reproduction changes due to domestication.

Mammal biodiversity and abundance determined by the SDM2002 expedition. The results on biodiversity obtained in 1995 and 2002 must be interpreted separately. The sample of mammals collected by MU1995 was biased by our focus on gerbils. It provided information on their abundance (see below), but was not suitable for the estimation of biodiversity. In contrast, 23 species of wild mammals collected by SDM2002 could be used for biodiversity assessments. In the summer of 2002, the highest diversity of mammals was found in the desert and semi-desert region, where 1 - 2 new species were trapped per day. Some mammals, e.g. *Meriones meridianus*, *Salpingotus crassicauda, Pygeretmus pumilio, Cardiocranius paradoxus*, *Hemiechinus auritus* (see Fig. 4b) were obviously restricted to southern Mongolia. The high diversity recorded was in accordance with the general finding that endemic animals are found primarily in the desert steppe and Gobi Desert (Finch 1999). Interestingly, three Korean Field Mice (*Apodemus peninsulae*) were trapped in the semi-desert at Station K (near 44°N and 107,5°E), even though the site was located at the northern edge of the Great Gobi Depression and one of the hottest and lowest spots (1070 m above sea level) of our expedition. The number of *A. peninsulae* subspecies is still under discussion (Koh *et al.* 1996)

The daily trapping record of 2 to 3 mammals in the mountain steppe was a remarkable minimum. The low abundance of wild mammals in the western part of SM2002 matched with data of the United Nations (www.un-mongolia.mn, http://www.un-mongolia.mn/archives/disaster) on livestock lost due to an extraordinarily hard winter (zud) in 2001-2002.

Table 1. Species and number of mammals collected by the expeditions in 1995 and 2002. Camps marked by roman numbers (I – IV, MU1995) or capital letters (A – 0, SDM2002). Each position is assigned to one vegetation zone, either steppe (S), semi-desert (sD), mountain-desert (M) or desert (D). Material marked with * indicates skulls collected from dead animals. One animal marked with ** was trapped 74 km northwest of station E in the mountain steppe between Ikh Bogd and Baga Bogd. Scientific names are used in accordance with the taxonomy of the most recent Edition of "Mammal Species of the World" (Wilson and Reeder, 1993).

	Expedition :	***MU1995***			***SDM2002***														
	Station :	**I**	**III**	**IV**	**A**	**B**	**C**	**D**	**	**E**	**F**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**O**
	Vegetation Zone :	**S**	**S**	**S**	**S**	**sD**	**M**	**D**	**M**	**D**	**M**	**M**	**D**	**sD**	**sD**	**sD**	**S**	**S**	**S**
Genus	species																		
Allactaga	*sibirica*		1			4						2				1			
Pygeretmus	*pumilio*														3				
Alticola	*argentatus*																		2
Apodemus	*peninsulae*														3				1
Cardiocranius	*paradoxus*														1				
Spermophilus	*dauricus*								1										
Cricetulus	*longicaudatus*																1		
Cricetulus	*migratorius*														1		3		2
Hemiechinus	*auritus*									2			1		1				
Marmota	*sibirica*				1*														1*
Meriones	*meridianus*							2		3					18	4			
Meriones	*unguiculatus*		163	4	98	1		2			5	4			6		3	5	30
Lasiopodomys	*brandtii*	5					3											4	1
Mus	*musculus*																1		
Ochotona	*dauurica*						1												
Phodopus	*roborovskii*									2			2		19	1	1		
Phodopus	*sungorus*		2									1							
Procapra	*gutturosa*													4		4*			
Salpingotus	*crassicauda*														1				
Stylodipus	*telum*																2		
Spermophilus	*alashanicus*											1							
Spermophilus	*erythrogenys*											2							
Vulpes	*corsac*		1*																1*
	Number of specimens trapped :	**5**	**167**	**4**	**99**	**5**	**4**	**4**	**1**	**7**	**5**	**10**	**3**	**4**	**53**	**10**	**11**	**9**	**38**
	Number of species trapped :	**1**	**3**	**1**	**1**	**2**	**2**	**2**	**1**	**3**	**1**	**5**	**2**	**1**	**9**	**3**	**6**	**2**	**5**

This zud most severely affected the western Aimags, e.g. Gobi-Altai and Bayarhongor, and could had an impact on rodent reproduction during the spring of 2002, a time when most rodents must maintain themselves by hoarded seeds, and are susceptible to poisoning. In 2002, the Mongolian Ministry of Agriculture distributed a rodenticide (Broma-diolone) against *Lasiopodomys brandtii* (Brandt's Vole) by airplanes and land machines (Gombobaatar *et al.* 2003). Poisoning of voles likely affected other rodent species, and caused an increased mortality on predatory birds, which prey mainly on Brandt´s vole and gerbils (Gombobaatar *et al.* 2001, 2003). Nevertheless, the steppe zone revealed few species but high abundance of rodents in the summer of 2002. We trapped 13 – 14 small mammals per day at Station A, M, N and O, but nearly 90 % of all mammals collected there belong to one species, *Meriones unguiculatus*. Therefore, Mongolian gerbils should be regarded as the dominant mammal species of the steppe zone, at least in July and August of 2002.

Traps (n = 156) distributed within a circle (radius = 100 m) at Station A (or O, respectively) collected 56 (26) Mongolian gerbils during 72 (24) hrs in July (August) 2002. If these samples represent 50 - 100 % of the total population within the area, the density of the species may be estimated as 2400 – 6600 individuals per km^2. This is slightly higher than the 600 – 1500 gerbils per km^2 calculated by Lavrinenko and Tarasov (1967) for wormwood steppe and salty soils, but our range was close to other estimations, e.g. 4200 gerbils per km^2 in *Caragana* vegetation and grain fields (Bannikov 1954), 5000 gerbils per km^2 in northwest Mongolia (Nekipelov 1959), 4200 – 9100 gerbils per km^2 in short grass steppe of northern China (Ågren *et al.* 1989). Higher densities were reported in preferred habitats such as agricultural fields or near human settlements (Pavlinov *et al.* 1990). Indeed, we trapped > 20

Fig. 3. Typical sites of the four different vegetation zones examined by SDM2002 (a) Steppe zone near Station N. (b) Semi-desert zone near Station B. (c) Gobi Desert (oasis) near Station E. (d) Mountain steppe zone between Station D and C near Bayan-Ondor, Gobi-Altay.

adult specimens at different abandoned nomadic camps (radius=25 m) during both expeditions.

It might be reasonable to assume that the average density of gerbils in the Mongolian steppe exceeds the occurrence of other rodents, e.g. the density of Brandt's Voles (*Lasiopodomys brandtii*), at least in 1995 and 2002. Some gerbils were found in former burrows or close to colonies of Brandt's voles, as reported by Heptner (1949) and Naumov and Lobachev (1975). A long-term survey of the interrelationship of abundance changes for both species may be warranted, and new techniques for standardized environmental measures of density estimation should be applied (for review, see Parmenter *et al.* 2003).

Scientific means and needs of complex expeditions. It must be asked if our approach to an extensive scientific expedition in 2002 met the needs of modern zoology. SDM2002 covered 5400 km, but spent only 52 hrs on the average at each station (n = 14). Previous expeditions faced similar shortages of time. For example, two extensive joint expeditions undertaken in the summer of 1962 and 1964 by the University of Ulaanbaatar and Halle University put up 12 (or 45, respectively) camps along a route of 5500 km (7160 km) to collect animals during a time period of 37 (90) days (Piechocki and Peters 1966).

A recent expedition by the National University of Ulaanbaatar and the Museum of Southwestern Biology (New Mexico) collect 40 species (n = 340) from 15 localities throughout Mongolia (Tinnin *et al* 2002). The 1964 expedition of University of Halle investigated almost every geobotanical region within Mongolia, and collected 50 mammal species (n = 492), whereas the 1962 Halle expedition was restricted to southern Mongolia, and trapped only few mammals (Stubbe & Chotolchu, 1968). This correspond with a low record of SDM2002 (261 mammals from 23 species), which concentrated on the steppe, semi-desert and desert zones. Interestingly, the amount of "stationary time" available to collect animals (roughly two third of the total expedition time in 1962, 1964, 2002) and the distances covered per day (ETMAL means were 160 km in 1962, 140 km in 1962, 210 km in 2002) were quite similar. This points to general

Fig. 4. Methods applied and appearance of some animals in their natural habitat. (a) Mongolian gerbil (*Meriones unguiculatus*) at Station K. (b) Long-ear hedgehog (*Hemiechinus auritus*) trapped at Station E, an abandoned oasis in the Gobi desert. (c) Grasshopper at Station A. Countless numbers of these insects caused a slow devastation on the steppe vegetation and the textile equipment of the expedition, e.g. tents and clothes. (d) Female cricket at Station A. (e) Carcasses of dead goats piled up near a temporary campsite of nomads in the mountain steppe of the Gobi Altai. Picture was taken on 30th July 2002. (f) Mammals collected by SDM2002 could be frozen on the spot for subsequent dissections or the request of histological and genetic investigations. Freezers were transported in the rears of two UAZ2206 and maintained by car batteries (g) Activity recording of small mammals with the Rodent Activity Logger (RAL) system. The contour of one RAL, which is concealed in front of the hole, are given by a broken white line. (h) Open field arena with a camera mounted above, assembled for behavioural measurements of spontaneous activity at Station M.

difficulties in performing fieldwork due to the rough and demanding character of Mongolia.

Further research projects in semi-desert Mammology. Regarding the long-term effects of joint scientific expeditions, they could bring yields in two different ways. First, analyses and publication of data are the direct return. Secondly, preliminary observations and the personal involvement of scientists often initiate long-term research programs. For example, the expeditions of 1962 and 1964 were followed by 2 decades of fruitful cooperation between the National University of Ulaanbaatar and Halle University (Stubbe 1971). It culminated in the publication of a new scientific Journal (Erforsch. biol. Ress. MVR, 1981 – 1990). Therefore, expeditions are able to act as dopants within the scientific matrix to stimulate the cooperation between faculties and to favour the international exchange with scientists abroad.

Scientific insight may start through explorations, but most scientific outcomes are the result of repeated investigations at defined places over a longer period of time. We therefore try to initiate an interdisciplinary research program to evaluate biodiversity and its temporal changes between 2006 and 2010 at three distinct spots of the steppe, semi-desert and desert zone twice a year at the beginning and end of the vegetation period. The three research sites will be located on a north-southerly transect between 47°N and 43°N. Each of the sites will represent one of the three main vegetation zones. The program will apply most of the methods introduced and used by MU1995 and SDM2002 and will be open to all colleagues who are interested in participating in a long-term study on biodiversity changes in the arid zones of Mongolia.

Acknowledgements

We thank the crews of the MU1995 and SDM2002 expeditions for their tenacity and support of our scientific work under lasting unfavourable conditions of desert heat, dust, storms, rain, shortage of sleep and mutton and during countless hours of cross country driving. Essential comments on water and animals were given by native nomads throughout Mongolia. We greatly appreciate their hospitality and helpfulness. We are especially grateful to our senior drivers Dong Tschin (MU1995) and Bazar Sodnomdorj (SDM2002) for careful transport of crews and equipment and experienced navigation. We would also like to thank our veterinarian, Tim Reefschläger, for exemplary precision during trap controls. We thank our expedition physicians Dr. Brigitte Weber and Dr. Karsten Plotz for medical treatment during her watch on the 1st half and his watch on the 2nd half of SDM2002 and his watch during MU1995. Expert technical instructions and assistance for the dissection of small mammals were received from Olaf Zinke at the Museum of Westlausitz during MU1995 and after both expeditions. Practical help was given by Batbold and Munkbayar (MU1995) and by Ganbot Tserennyam, Munkhchulum, Lhagvasuren, Angelika Mai and Henrik von Wehrden (SDM2002). We appreciate the hospitality of Halle University and Dr. Karsten Wesche at camp 10 and his helping hand with the satellite phone. Patient and invaluable help during customs clearance of goods, frozen and living animals was received by Prof. R. Samjaa, Vice President for Research Projects and International Relations at the National University of Mongolia, and the German Embassy at Ulaanbaatar, especially by Mrs. Spahl (Chargé d´ affairs), by Consul T. Scherer; Mrs. Oynzuren and Mrs. Tuga. We thank Iris Maletzki and Corinna Rehwald for dependable technical assistance at Goettingen University throughout and after the SDM2002 expedition. We greatly appreciate the careful reading of the manuscript and the helpful comments of Dr. Nigel Barton and two anonymous reviewers.

Crew of the *Meriones unguiculatus* Expedition 1995 included K. Plotz (zoologist, physician); I.W. Stuermer (zoologist, leader), Munkchulum (student), Danertscho (driver), A. Leybold (zoologist), Dong Tschin (driver), O. Kalberlah (botanist), J. Batbold (zoologist), O. Zinke (taxidermist, zoologist), Naraa (driver). Crew of the Semi-Desert Mammology Expedition 2002 included C. Tittmann (zoologist), T. Reefschläger (veterinarian), D. Lhagvasuren (student), H. v. Wehrden (student), R. Frey (zoologist), R. Tungalag (botanist), A. Mai (technician), C. Davaasuren (cook), O. Kalberlah (botanist, photographer), K. Plotz (zoologist, physician), I.W. Stuermer (zoologist, leader), G. Tserennyam, Munkchulum, B. Sodnomdorj (drivers), D. Surjo (zoologist), B. Weber (physician).

The *Meriones unguiculatus* Expedition 1995 was supported by a grant of the *Kultusministerium des Landes Sachsen-Anhalt* (1934K/0025). The Semi-Desert Mammology Expedition 2002 was supported by a grant of the *Bundesamt für*

Naturschutz (BfN 534 12-7/02). Financial assistance for SDM2002 was also given by the *Freunde der Naturkunde-Abteilung des Niedersächsischen Landesmuseums* at Hannover, by the *Museum Alexander König* (Bonn), Bayer Crop Science (Leverkusen) and Nomads Tours and Expeditions (Ulaanbaatar). The analysis of botanical data was supported by an award of the German Academic Exchange Service (DAAD A/04/12825).

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Хураангуй

Энэхүү өгүүлэлд 1995, 2002 онуудад хэрэгжүүлсэн Монгол, Германы хамтарсан хөхтөн судлалын экспедицийн замнал, арга зүй, судалгааны гол үр дүнгүүдийг тусгасан болно. 1995 онд хийгдсэн судалгааны явцад ХБНГУ-д лабораторийн шинэ үүлдэр (шугам) гарган авах зорилгоор генетикийн олон янз байдал бүхий 167 бодгаль Монгол чичүүлийг (*Meriones unguiculatus)* барьсан юм. Харин 2002 оны хээрийн судалгаа тус орны заримдаг цөл болон цөлийн бүсийг хамарсан (зүүн уртрагийн 96°-аас 113°, хойт өргөргийн 44°-аас 45° хүртэл) бөгөөд судалгааны явцад 23 зүйлийн 265 бодгаль хөхтөн амьтдыг цуглуулсан болно. Судалгаанд хэрэглэсэн амьтдын задалгаа, зан төрхийн ажиглалт ба туршилт, дуу авианы бичлэг, зонхилогч ургамал ба малыг тодорхойлоход хэрэглэгддэг арга зүйн талаар өгүүлэв. Мөн хөхтөн амьтдын газар дээрх идэвхийг бүртгэх шинэ арга зүйг туршсан тухай мэдээлсэн болно. Судалгааны явцад баригдсан хөхтөн амьтдын дийлэнх хэсгийг Монгол чичүүл (*Meriones unguiculatus)* бүрдүүлж байсан бөгөөд тэдгээр нь 1 км^2 талбайд 2400-6600 бодгаль нягтшилттайгаар тохиолдож байв. Заримдаг цөл болон цөлийн бүсүүдэд хөхтөн амьтдын зүйлийн олон янз байдал хамгийн их баялагтай байсан бөгөөд *Hemiechinus auritus, Meriones unguiculatus, Salpingotus crassicauda, Pygeretmus pumilio*, *Cardiocranius paradoxus* зэрэг Монгол орны өмнөд хэсгийн тархалттай зүйлүүд тохиолдож байв. Түүнчлэн Монгол орны хуурайсаг бүс нутгуудад хийх цаашдын иж бүрэн хайгуул судалгааны чиглэлийн талаар энэхүү өгүүлэлд дэлгэрэнгүй өгүүлсэн болно.

Recieved: 14 September 2004
Accepted: 26 February 2005