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Erforschung biologischer Ressourcen der Mongolei / Exploration into the Biological Resources of Mongolia, ISSN 0440-1298

Institut für Biologie der Martin-Luther-Universität Halle-Wittenberg

2012

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Schöpke, Kati; Stubbe, Annegret; Stubbe, Michael; Batsaikhan, Nyamsuren; and Schafberg, Renate, "Morphology and Variation of the Asiatic Wild Ass (*Equus hemionus hemionus*)" (2012). *Erforschung biologischer Ressourcen der Mongolei / Exploration into the Biological Resources of Mongolia, ISSN 0440-1298*. 10.
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Erforsch. biol. Ress. Mongolei (Halle/Saale) 2012 (**12**): 77– 84

Morphology and variation of the Asiatic wild ass (*Equus hemionus hemionus*)[1]

K. Schöpke, A. Stubbe, M. Stubbe, N. Batsaikhan & R. Schafberg

Abstract

A collection of recent skeletal remains from the Asiatic wild ass (*Equus hemionus hemionus* PALLAS) was prepared and stored in the Museum of Domesticated Animals "JULIUS KÜHN" in Halle, Germany.

The collection is based on carcass remains sampled between 2001 and 2006 under the leadership of M. Stubbe during joint Mongolian-German Biological Expeditions.

Skeletal remains of 43 individual specimens were studied (18 mares, 15 stallions, and 10 juvenile asses). The determination of sex and age was initially based on carcass information from observations made *in situ* in the field. Subsequently, skull traits, including dentition and development of canine teeth were included to determine the ages of individuals. All animals were classified by age using histomorphological sections and observations of the tooth structure. During this study, Individual ages ranged from a foal under one year to an 18-year old stallion.

The osteometric measurements of the fully grown long bones (Humerus, Radius, Femur, Tibia, and Metacarpalia) were performed according to A. von den Driesch, 1976. The quantitative analysis of size and shape of long bones allows a description of the morphology of the species. Commonly, this method is used for archaeozoological remains. Here the same method is applied to the largest preserved set of skeletons of the recent population of Wild asses from the southern Mongolian Gobi.

As expected, morphometric traits studied show no differences between left and right hand side and comparisons of standard morphometric traits predominantly show no sexual dimorphism with one exception: A highly significant difference is found in the length of the humerus between sexes.

It may be hypothesized that this sexual dimorphism is linked to an elaborate anti-predator defense strategy against wolves. Apparently differences in the length of the humerus cause a small shift in the proportion of the forehand.

Key words: Asiatic wild ass, *Equus hemionus hemionus,* Mongolia, morphology, osteometry

Introduction

Although programs for protection and special reserves have been created for them, the Asiatic Wild Ass in the southern Gobi of Mongolia is still in danger of extinction (CLARK et al. 2006). Several recent studies have demonstrated strong hunting pressure in this area by documenting the presence of many carcasses of animals that were killed by poachers (DUNCAN 1992, STUBBE et al. 2005). The documentation of these facts is undoubtedly frightening (STUBBE et al. 2007); however, the collection of dead animals, via salvage, has proven to be very interesting to science. The study of these skeletal remains can lead to new knowledge of morphology, because these data allow the application of other methods of study to such material. The morphological characteristics of these wild animals is difficult to study in field, but various relationships are possible to study via analysis of osteometric traits.

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[1] Results of the Mongolian-German Biological Expeditions since 1962, No. 314.

BANNIKOV (1958) showed that the withers of *E. hemionus hemionus* ranges from 110 to 128 cm high. But even if the diversity of the withers is low, individual animal observations never represent the dynamic population in the wild. The skeletal collections will be of increasing importance with respect to the morphology of the Wild ass. This is shown clearly by the first results of this series from STUBBE et al. (2007). These results, based on a sample of 50 stallions and 57 mares, demonstrate great variability of individuals within one region of the Gobi desert. Morphometric data collected in the field between 2005 and 2006 from carcasses found in the field provided preliminary information about head-body length, leg length, and hoof shape.

Further studies on these same specimens in the laboratory have provided many more details of morphometric variation in these animals. GASCHE et al. (2010) showed that the hooves of *E. hemionus hemionus* are predominantly flat and wide and are large relative to general size of the animals. This size variation appears to correlate to the morphological characters of hooves possessed by animals that live in plains and grasslands on soft and wet soils.

Material and methods

Skeletal remains were gathered in the southern Gobi desert region during the Mongolian-German Biological Expeditions from 2001 to 2006 (STUBBE et al. 2007). During these expeditions 794 skeletons of *E. hemionus hemionus* have been documented. More than 95 % of the carcasses had clear traces of gunshot wounds clearly demonstratingpoaching (STUBBE et al. 2007).

All collected skeletal remains were prepared and stored either in the Museum of Domesticated Animals “JULIUS KÜHN” in Halle, Germany or in the Natural History Museum of Görlitz, Germany. Each individual sample consists mostly of the complete skull with the corresponding first cervical vertebrae. In exceptional cases the bones of the postcranial skeleton were sampled; only a few complete skeletons were collected. The conservation status of the bones is very good and probably because of the dry conditions present the desert.

Age and sex were determined in the field (STUBBE et al. 2007) and verified by R. MÜLLER (see MÜLLER & WUSSOW 2010). Data on determination of the age of individual specimens from MÜLLER & WUSSOW (2010) were combined with data obtained by STUBBE et al. (2007). Methods for determination of age in this study are commonly used in paleontology and include data abrasion of dentition and extent of ossification of the skull (HABERMEHL 1975, 1985). Determination of age via analysis of extent of cementum was supplemented by assessment of histological preparations of teeth (ANSORGE et al. 2007, LKHAGVASUREN et al. 2012).

In total, our study was based on a collection of 43 individuals including: 18 mares, 15 stallions, and 10 juveniles of unknown sex. The animals varied in age between a foal of less than one year to a stallion of more than 18 years.

For a description of the measurements taken during this study, see table 1. All morphometric traits were taken on completely ossified long bones of the postcranial skeleton. They are based on a total of 43 individual asses and all of the archival bones belong to the collection at the museum in Halle. Measurements were taken as part of the work toward the Diploma of Agriculture by Yvonne LESSER in 2010. All measurements taken were defined previously and are standard for investigations in osteoarchaeology (see A. von den DRIESCH 1976). Measurements were taken with a vernier scale caliper or measuring bord with an accuracy of 1 mm.

All steometric data were recorded using Microsoft Excel (2007) spreadsheets, followed by processing and analysis using the program package SAS 9.2 (Copyright (c) 2002–2008 by SAS Institute Inc., Cary, NC, USA). Univariate statistical analyses include group means and analysis of variance. Statistical significance was set a-priori at $p \leq 0.05$ and tests of significance were made using t-tests.

Table 1: Morphometric characters taken on samples of *E. hemionus hemionus* from the Gobi of Mongolia. Abbreviations and definition follow A. von den DRIESCH (1976)

humerus	
GLl	greatest length lateral
GLC	greatest length from caput
Bp	greatest width proximal
Bd	greatest width distal
KD	lowest width diaphysis
BT	greatest width trochlea
radius	
GL	greatest length
Ll	length lateralis
PL	physiological length
Bp	greatest width proximal
Bd	greatest width distal
BFp	greatest width of Facies articularis proximalis
KD	lowest width diaphysis
femur	
GL	greatest length
GLC	greatest length caput
Bp	greatest width proximal
Bd	greatest width distal
KD	lowest width diaphysis
TC	greatest depth caput
tibia	
GL	greatest length
Ll	greatest length lateral
Bp	greatest width proximal
Bd	greatest width distal
KD	lowest width diaphysis
Td	greatest depth distal
metacarpus/metatarsus	
GL	greatest length
GLl	greatest length lateral
Ll	length lateral
Bp	greatest width proximal
Bd	greatest width distal
KD	lowest width diaphysis

Results

There were no detectable differences between the two sides of the body. Consequently the right side was used if the animal had bones from both sides. The differentiation between the sexes was inspected for some measurements for adult animals (table 2).

The humerus proved to be the only significant character that allowed separation of males and females. For females it is significantly longer and the distal end of the joint is narrows more completely. The other long bones of the fore-legs did not differ substantially and the sex differences can only be found in the humerus.

The differences in width, found in the distal humerus, also exist in other long bones. It is even significant, if increasing the level of significance ($p < 0.10$) is allowed because of the small sample size. The radius of the facies articularis proximalis and the metacarpus at the distal joint is wider for mares than it is for stallions. Concerning the hind leg, the mares' diaphysis of the tibia is wider ($p = 0.09$). Consequently it can be shown that there are interesting morphological gender differences in *E. hemionus hemionus*.

At least the gender differences concern only a few measurements. All mean values of measurements showing significance are shown together in table 2.

Discussion and outlook

Like other equines, *E. hemionus hemionus* from the Gobi of Mongolia has long extremities. This is a prerequisite for their excellent running performance and long legs are assumed to be an adaptation to their large territories of far more than 20 km^2 (KLINGEL 1998).

The significant sex differences in the length of the humerus, together with the same length of the adjacent bones in the extremities, causes a shift of proportion in the skeletal system of the forehand. In modern horse breeding, the variation in length and location of the foreleg-bones is a criterion for performance in running and movement. A longer humerus leads to dislocation of the scapula, which makes the angle between scapula and humerus more obtuse.

The herein documented change in proportion in these bones can considerably improve the running performance of the animal: the longer the humerus – the bigger the scope to the ass' gait. That is, greater reach, arc, and lateral movement. The animals can cover more ground with a longer stride length. Such a kind of morphological change goes along with a displacement of the balance point which might be shifted forward. A more laid back shoulder will probably result in a higher neck.

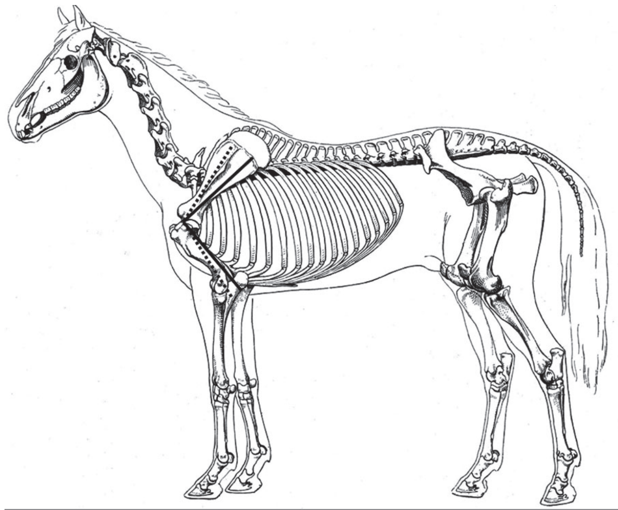

Fig. 1: Skeletal schema of a Horse (following Ellenberg & Baum 1926, modified) with marked Humerus-Scapula-complex for long (continuous line) and short humerus (broken line).

For *E. hemionus hemionus* the discovered gender differences show that mares have better running performance compared to stallions. But the animals are living in the same habitat. Consequently, the different development may be combined with behavioral differences.

As BANNIKOV (1958) and FEH et al. (1994, 2001) showed, the E. hemionus hemionus of Mongolia is comparable to wild horses (*E. przewalski*) in their social behavior, further comparisons to other equines should also be made.

For equines, sex specific behaviors are well documented (VOSSWINKEL 2009). BOYD (1988) showed that mares are more often exposed to conflicts and stallions spend much more time in movement. These patterns are already evident among young animals, since the filly trains mostly running skills and the colt prefers to coach itself in ranking battles.

These differences probably result in the preferred defensive patterns. Stallions tend to a rise and attack behavior in case of danger. Mares instead flee from violence and avoid confrontations. In conflicts mares are likely to kick an aggressor.

As for *E. hemionus* hemionus the difference between sexes long bones could be compliant with the particular avoidance strategy against wolves (FEH et al., 1994, 2001), if that difference is only documented within this population. On the other hand, better running characteristics seem to be plausible in the behavioral patterns of all female equines.

The subject of ongoing investigation will show, whether the results can be applied to other populations of equines. Here, the entire data set should also be compared to modern as well as historical documents. Promising approaches appear (like BECKER 2007), where the indices of the extremities in relation to each other were compared. So with additional studies, we expect new discoveries in correlations between behavior and morphology in populations of *E. heminous hemionus*.

Table 2: Least square-mean of Sex (se = standard error) of morphometric characters of *E. hemionus hemionus* from the Gobi of Mongolia

morphometric traits		stallion		mare		p-value	significance
humerus	n	LSmean	se	LSMean	Se		
GLI	12	249.25	1.94	255.75	1.37	0.0209	**
GLC	12	222.50	2.40	235.00	1.70	0.0017	***
Bp	11	80.97	1.63	77.74	1.00	0.1257	
KD	12	30.03	0.61	29.48	0.43	0.4799	
Bd	12	69.85	1.69	65.21	1.19	0.0488	**
BT	12	62.96	1.95	59.93	1.38	0.2312	
radius							
GL	13	300.86	3.56	306.67	3.85	0.2918	
Bd	14	69.68	0.70	67.92	0.81	0.1252	
LI	14	293.50	3.21	297.00	3.71	0.4892	
PL	14	291.88	3.51	298.33	4.05	0.2511	
Bp	14	64.54	1.54	66.97	1.54	0.2852	
BFp	14	53.98	1.84	59.87	2.12	0.0577	*
KD	13	22.89	0.30	22.06	0.38	0.1164	
metacarpus							
GL	19	232.11	2.48	230.50	2.35	0.6428	
GLI	19	227.67	2.79	225.50	2.65	0.5808	
LI	19	226.11	2.41	224.30	2.28	0.5924	
Bp	19	43.38	0.79	45.52	0.75	0.0650	*
Bd	19	39.86	0.33	39.49	0.31	0.4347	
KD	19	18.71	0.29	18.86	0.28	0.7179	
femur							
GL	12	323.67	10.01	224.00	17.34	0.6170	
GLC	12	307.67	2.72	309.00	4.71	0.8114	
Bp	12	96.83	1.43	93.97	2.47	0.3388	
Bd	12	83.88	4.60	82.70	7.97	0.9007	
KD	12	31.92	0.65	30.63	1.12	0.3436	
TC	12	44.52	0.96	44.20	1.66	0.8697	
tibia							
GL	7	319.00	3.63	324.00	5.74	0.4950	
LI	7	293.40	6.08	284.00	9.61	0.446	
Bp	7	82.52	1.27	79.55	2.01	0.2678	
Bd	7	58.62	1.53	57.80	2.42	0.7862	
KD	7	25.50	1.99	33.15	3.14	0.0948	*
Td	7	41.44	1.17	38.45	1.86	0.2314	
metatarsus							
GL	15	270.25	4.71	260.14	5.04	0.1665	
GLI	15	267.75	4.83	256.43	5.16	0.1331	
LI	14	264.63	5.09	252.83	5.87	0.1549	
Bp	15	40.56	0.41	41.24	0.44	0.2797	
Bd	15	38.53	0.39	37.91	0.42	0.3066	
KD	15	21.70	0.63	21.13	0.68	0.5472	

Table 3: Population-mean (s = standard deviation) of *E. hemionus hemionus* from the Gobi of Mongolia

humerus	n	mean	s	minimum	maximum
GLl	16	251.81	10.39	217.0	261.0
GLC	16	228.94	10.78	198.0	243.0
Bp	15	78.24	4.63	65.4	84.1
KD	16	29.24	1.87	24.7	31.5
Bd	16	66.18	3.69	59.7	72.8
BT	16	60.95	3.67	53.9	65.9
radius					
GL	16	304.38	9.24	285	318
Bd	17	69.11	1.99	65.8	74.1
Ll	17	295.71	8.65	276	309
PL	17	294.65	10.0	271	309
Bp	16	65.12	4.20	60.4	74.2
BFp	17	56.14	5.98	49.3	67.7
KD	16	22.57	0.98	21.2	24.3
metacarpus					
GL	24	232.04	7.26	217	248
GLl	24	227.71	8.4	212	246
Ll	24	226.00	7.2	212	242
Bp	24	44.06	2.51	40.5	50.8
Bd	24	39.66	1.14	3.9	42.6
KD	24	18.79	0.89	17.1	20.5
femur					
GL	13	326.31	27.78	237	347
GLC	13	307.23	7.97	298	321
Bp	13	95.85	4.21	88.7	104.7
Bd	13	83.04	12.76	73.2	113.4
KD	13	31.61	1.86	28.6	34.7
TC	13	44.18	2.79	40.1	48.5
tibia					
GL	8	319.50	7.69	309	332
Ll	8	290.88	12.25	275	316
Bp	8	81.43	2.84	77.3	86.6
Bd	8	58.48	2.93	54.5	62.6
KD	8	27.18	5.30	23.6	40.1
Td	8	40.43	2.64	34.6	42.8
metatarsus					
GL	18	267.11	13.10	222	280
GLl	18	263.50	13.29	216	274
Ll	17	261.06	14.02	214	274
Bp	18	40.83	1.08	38.5	42.4
Bd	18	38.34	1.06	35.9	39.8
KD	18	21.36	1.60	18.4	25.7

Acknowledgements

We thank Mrs. Lesser for technical support.

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Long bones *of Equus h. hemionus* found in the southern Gobi, Mongolia (photo: A. STUBBE).