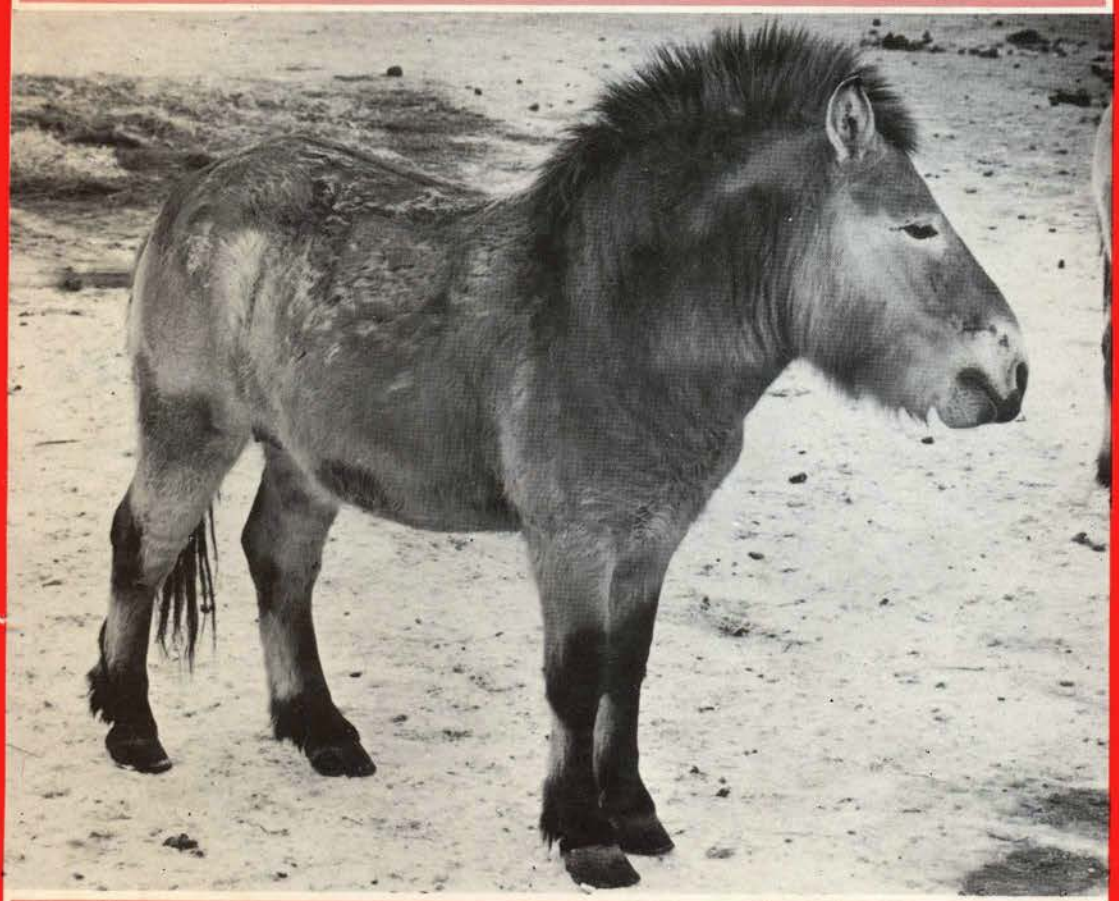
# The Przewalski horse

## and restoration to its natural habitat in Mongolia



FAO
ANIMAL
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PAPER

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FOOD
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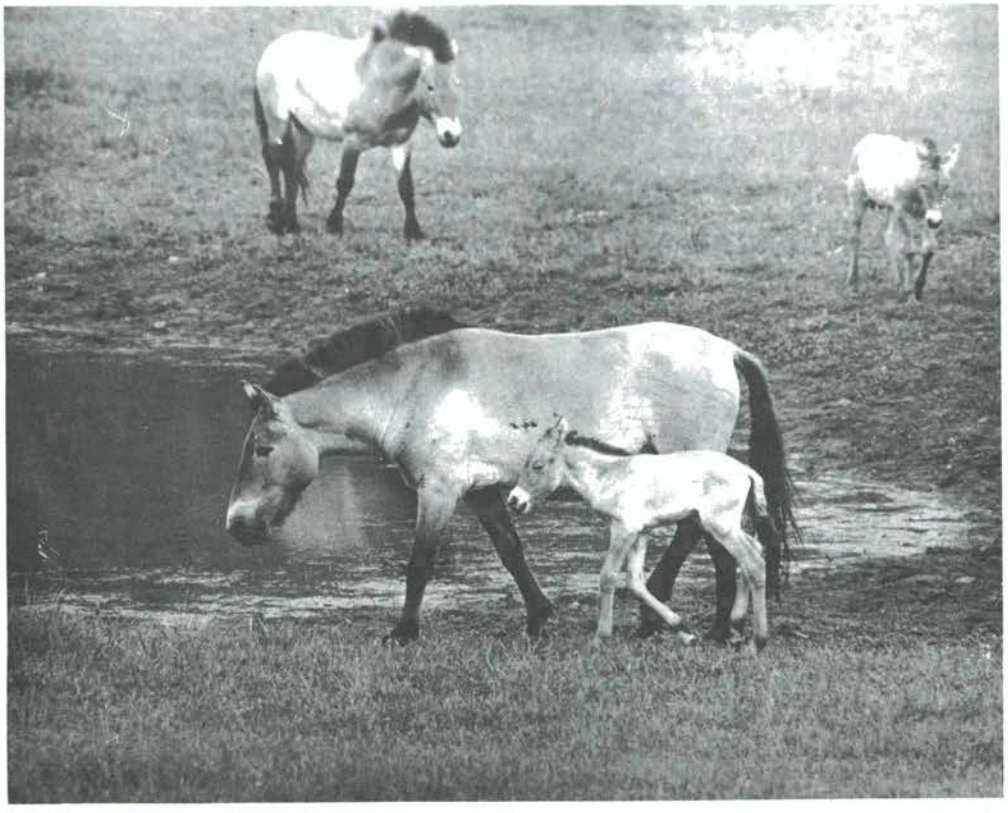

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FAO/UNEP Expert Consultation
held in Moscow, USSR
29-31 May 1985



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### SMALL POPULATIONS OF PRZEWALSKI HORSE

**REVIEW OF FERAL HORSES**



**TECHNIQUES FOR REINTRODUCTION**

# RECOMMENDATIONS BY FAO/UNEP EXPERT CONSULTATION ON RESTORATION OF PRZEWALSKI HORSE TO MONGOLIA

29-31 May 1985, Moscow, USSR

The Expert Consultation on the Restoration of the Przewalski Horse to Mongolia was arranged by The Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme (UNEP) in Moscow, USSR, by the kind invitation of the Government of the USSR. Local arrangements were made by the Centre for International Projects (CIP). The Consultation was attended by 35 Experts from 11 countries and lasted for 3 days (29-31 May 1985).

The objective was to draw up an Action Plan for the reintroduction of the Przewalski Horse to Mongolia. Experts presented papers and discussed the issues arising from them under 6 main headings:

i. Status and prospects of existing captive populations
ii. Problems of Przewalski horse reintroduction into the wild
iii. General biology of small populations
iv. Small populations of Przewalski horse
v. Review of feral horses
vi. Techniques for reintroduction

The Expert Consultation then formulated their recommendations, which are given with appropriate appendixes in the first part of this report with a brief summary of the Papers and Discussion, Welcome addresses, Agenda and List of Participants. In the second part of this report, the papers are presented in full, as it is considered that they are valuable resources for understanding the nature of the problems and the recommendations made.

Appreciation was expressed to the USSR as the host country by the Experts and on behalf of FAO and UNEP, for the excellent organization of the meeting.

## RECOMMENDATIONS

1. The Experts recognize that the objectives are to create a free-ranging, self-propagating population in the wild state, in a self-sustaining defined area of Mongolia. The population will need protection but is not intended to be managed in the conventional sense.

2. The Experts recognized from information made available to them during the course of the Consultation that several important bodies are fully committed to the task and are

willing to make available resources to achieve the objectives when they are adequately and competently formulated. These bodies include the captive breeders' groups who hold individual animals, and the governments of Mongolian People's Republic and of the USSR.

3. The Experts also recognized from papers presented and from discussion, that sufficient expertise, knowledge and experience are now available for the task, and that it is only in details specific to this project that they need to be organized and compiled into an Action Programme. The Expert Consultation committed itself to the task of designing an Action Programme.

4. The Experts noted with pleasure that the captive breeder groups are willing to give suitable animals without charge, provided that the costs of handling them from their present locations are borne by the project.

5. The Experts also learned that there is a willingness to start planning in 1985, and to initiate work in practice during 1986.

6. The Expert Consultation has prepared criteria for some decisions in the Action Programme as follows:

   a. Selection of individual animals, including genetic and health traits (Appendix A).

   b. Essential and desirable qualities of sites, both for final release of animals in the wild and for intermediate sites (Appendix B).

   c. Numbers of horses recommended as a minimum, including the guidelines on the numbers of separate groups within the overall population and capability of forming harem bands (Appendix C).

7. The Expert Consultation also provides a preliminary listing of possible sites, with their characteristics relevant to the task, which may be considered both for final release sites in the wild and for semi-wild intermediate staging (Appendix D).

   The Consultation appreciates the information presented by the Joint Soviet-Mongolian Biological Expedition on possible release sites for the release of Przewalski Horse in Mongolia. Since this knowledge has been acquired by experts when engaged upon work other than a specific investigation for suitability for a wild Przewalski Horse population, the Expert Consultation recommends that a small group of individual experts should visit the most suitable sites in order firmly to establish their quali-

ties. Such a group should include experts in the ecological and nutritional requirements of wild horses, and should visit the sites in winter especially and if necessary, also in summer.

8. The Expert Consultation has considered the matter of staging the move of animals from a variety of captive locations to the eventual release into the wild. It recognizes the desirability of minimizing the number of intermediate sites at which horses should be relocated, in order to avoid undesirable losses, reduced fertility, increased social stress and disease risk. In seeking to minimize the number of such sites the Consultation feels that the possibility of having only one intermediate, semi-wild site between the zoos and the wild is optimum. It is also desirable to have the intermediate, semi-wild site adjacent to the site of eventual release. The process of a major move is then undertaken only once, and the withdrawal of management interventions to foster acclimatization, social adjustments including harem band formation and increasing freedom is adjustable to the needs of the animals, the weather of the time, and other unseen exigencies. This method also provides the possibility of a soft release thus keeping stress to a minimum. The process as visualized thus provides several stages of management interaction with the animals, at one site, prior to release into the wild.

The Expert Consultation therefore recommends a dual approach.

A. Establish a semi-wild site in Mongolia as a part of the final wild release site, so that a soft release may be achieved without a second major relocation. All donated animals will go direct to this site from their home zoos in Europe or North America, thus having only one intermediate semi-wild stop at which human support systems may be progressively withdrawn.

B. Establish a semi-wild site at Askania Nova in the USSR adjacent to the present area there on which the horses are kept. Animals at Askania Nova selected for reintroduction to the wild state in Mongolia will enter this semi-wild site for acclimatization. When the wild site in Mongolia is established, these animals from Askania Nova will be relocated directly to it thus also having only one major relocation.

The advantages of the twin approaches (A) and (B) are seen as follows:

i. It will take time to establish the semi-wild site in Mongolia. Selection of animals from many different zoos in Europe and Noth America which will also take time can progress concurrently.

ii. Zoo facilities with all the supporting services are already established at Askania Nova. The preparation of the semi-wild site in close proximity to the existing area can be achieved quickly as the desired area of steppe and funding in the USSR are immediately available. Animals can therefore begin their acclimatization at Askania Nova relatively soon without waiting for site location in Mongolia and for external funding.

iii. No animals, whatever their origin, will have to go through a major relocation more than once.

iv. Methods (A) and (B) above offer two alternative types of semi-wild site for transfer from the zoo to the wild. One, (A), follows the practice which has been used in preparing animals of other species for reintroduction to the wild, namely the use of a semi-wild, acclimatization site adjacent to the site of release. The experts recognize, nevertheless, that there are merits in examining the alternative (B) of a semi-wild acclimatization site adjacent to the home zoo, particularly in the case of Askania Nova, with its unique resources. These include the largest group of captive Przewalski Horses, with harem bands in formation, a developed infrastructure of services, and an extensive area of steppe with some features in common with the proposed wild reserves in Mongolia. In this situation, the method of a semi-wild acclimatization site near the captive breeding location followed by direct transfer to the wild, can be adequately examined and documented, with benefits to the scientific community in gained experience. If experience at Askania Nova at the semi-wild site indicates that animals would benefit also from a period of acclimatization in the Mongolian semi-wild site, or if animals from Europe and North America would benefit from social and behavioural contact with the established bands from Askania Nova, then the option remains for the latter to spend a period in the semi-wild site in Mongolia, still having only one major relocation of site.

9. The Expert Consultation recommends that it is essential for follow-up studies to be conducted on the populations when finally released to the wild, in order to document the level of success of the reintroduction, to correct for

any imbalances, to monitor the biological parameters, such as population growth, causes of loss and of disease incidence, evidence of human interference, etc. It is also expected that the project will be seen as a possible model for similar introductions of other species later, and it is essential to document progress. It is highly recommended that radio telemetry be used for this follow-upwork, and that nationals of local origin and knowledge be involved in the monitoring work.

10. The Expert Consultation recommends that the Soviet-Mongolian Biological Expedition of Academies of Sciences of the USSR and Mongolia should survey possible release and semi-wild sites in the summer of 1985 in Mongolia and forward their recommendations to FAO and UNEP. It was confirmed that this survey will generously be carried out by the joint expedition as additional national contributions of Mongolia and the USSR to the project.

11. It is recommended that, following the confirmation of the actual semi-wild and wild sites to be used and subject to request from the Mongolian government, a detailed plan of equipment, facilities, staff and other desired resources should be drawn up in conjunction with the Mongolian government, and that installation of them should be undertaken as soon as possible.

12. It is recommended that the Askania-Nova Centre and semi-wild reserve be used for training of Mongolian and other specialists based upon international training courses developed in agreement with the relevant international bodies. Emphasis should be given to training Mongolian specialists as teachers for personnel to operate the acclimatization centres at the adaptation and release site in Mongolia. Lecturers and teachers for this training programme should include experts experienced in the ecology, nutrition, genetic, social and health needs of both Przewalski horses and wild horses.

13. It is recommended that all information concerning the selection of animals for transfer later to Mongolia should be sent to the Przewalski Horse stud book keeper immediately the animals are chosen, so that it can be used in the selection of animals from other zoos. Information from Mongolia should also be sent to him.

14. It is recommended that the USSR research and other organizations should investigate the possibility of the establishment of a separate Przewalski Horse population in a suitable wild habitat in Kazakhstan, which is a western part of the Przewalski Horse historic range.

15. A recommended time schedule has been developed for the Action Programme and is given in Appendix E.

# PART I

# THE MEETING

APPENDIX A

## CRITERIA FOR SELECTION OF INDIVIDUAL ANIMALS

I. GENETIC CRITERIA

1. Studbook registered.

2. Genetic contribution from all founders should be represented by individuals designated for breeding propagules. This includes genetic contributions from the domestic mare with 6% Domestic Mare Average in the propagule and no individual 15% Domestic Mare. Ages not specified. Average founder contribution should be represented within the female cohort.

3. Unique individual (in sense of pedigree) should not be designated and thus protect the captive population.

4. Measure of sanguinity (default to F or the coefficient of inbreeding). Average F of potential offspring in propagules should be 0.3 or 0.25.

II. HEALTH CONTROL CRITERIA

1. Top constitution and condition, excellent health status, normal behaviour, correct hoofs, descent of testes.

2. Vaccinations:

   a. Virus abortion (Herpes)
   b. Tetanus
   c. Rabies
   d. Horse influenza
   e. Additional vaccinations according to the local infection situation of domestic horses in Mongolia (Rickettsia, Malleomyces mallei, and other).
   f. Additional vaccinations against local infections in the country donating the horses.

3. Parasites control:

   a. Roundworms: Parascaris equorum e.a. (Mebendazol 10 mg/kg, 7 consecutive days or 500 ppm M. 14 days or Fenbendazol 5 mg/kg 7 days.

Deworming of the animals every 2 months 6 times before the transport, even with negative faeces control test.

b. Tapeworm, Gastophilus, (fluke?), and other local parasites (ticks): Treatment only if animals are infested according to the treatment schedule recommended for domestic horses.

Clear up Trypanosoma situation in Mongolia.

c. Ectoparasites: Mallophagae, ticks, lice, etc.: Animals must be free of ectoparasites during 6 months before transport. Animals from a breeding centre and possibly infected with scabies are generally excluded from a restoration programme.

4. Medical requirements:

Additional to the necessary veterinarian equipment:

a. Large animal Immobilon
b. Revivon (3x more than L.A. Immobilon)
c. Hyaluronidase
d. Ivermectin
e. Mebendazol/Fenbedazol
f. Injectable selenium
g. Oral vitamin/mineral mixture containing selenium

5. Technical requirements:

a. Freeze branding tools
b. Blow pipe and Airinject system (70 metre range). Do not use in any case hot gas systems. Recommend: Telinject System.

APPENDIX B

## CRITERIA FOR SELECTION OF WILD AND SEMI-WILD RESERVES

I. WILD RESERVES (FINAL RELEASE SITE) (These are taken from the paper of Miller which is included with the collection of papers.)

1. Historic occurrence - has the Przewalski horse been found here in the past?

2. Land status - who controls use of the land?

3. Topography - is the topography suitable for the horse?

4. Cover - what is the vegetative cover?

5. Range condition - what is the condition and trend for the forage plants?

6. Presence of domestic animals - what domestic animals are present and are they competitors or carrying diseases to which the horse is vulnerable. Are domestic and feral horses present and in what numbers and distribution?

7. Presence of wildlike - what wildlife species are present and are they competitors or disease sources? Are wolves or other predators of horses present?

8. Human disturbance - what level of human use does the area receive? Are the horses likely to be subject to poaching?

9. Available water - what quantity and quality of water is available on a year-round basis and at how many sites?

10. Dispersion and size of the habitat area - what is the size of the available area? How are the resources such as food, cover, and water dispersed and distributed? How much of the area will be unavailable due to topography or seasonal changes?

11. Potential for expansion - is there a potential to expand the area if the population does well?

12. Fencing - are there potential problems with existing or planned fences? Will it be possible or necessary to fence the reserve area? What will be the cost?

13. Seasonal habitat - are the seasonal needs of the animal such as wind cover, forage, water, and foaling areas available?

II. SEMI-WILD RESERVE (INTERMEDIATE ADAPTATION SITE)

1. An area of not less than 5000 hectares providing all year round ranging requirements for a group of horses including forage and water. It should provide territory necessary for formation of natural social grouping - harems or bands - which will allow the horses to acquire and demonstrate the normal behavioural patterns of wild horses. If necessary for the survival of the horses in the judgment of the management specialists, additional feeding may be provided.

2. Dry steppe climate which is close to the environmental conditions (or biotope) of the release site in Mongolia.

3. Competent research, breeding, zootechnical, veterinary, and administrative services.

4. Can support several harems or bands which reproduce on a natural selection basis.

APPENDIX C

## CRITERIA FOR NUMBERS OF PRZEWALSKI HORSES FOR A REINTRODUCTION PROGRAMME

1. Should be at least 2 populations initially.

2. Founders for each population:

   There should be 20-30 individuals because of harem structure. It is suggested that they be: 15-20 females and 10-15 males over a 1 to 3 age span if yearlings are chosen. The composition will differ for the construction of a band from older animals and would include a stallion and up to 10 mares.

3. Carrying capacity (=Ultimate size for each population)

   Suggest: 200 to 1000.

APPENDIX D

**SHORT DESCRIPTION OF 4 AREAS IN MONGOLIA FOR POSSIBLE RELEASE INTO THE WILD OF THE PRZEWALSKI HORSE**

1. AREA AT THE EXTREME EAST OF MONGOLIA; EASTERN AIMAK (REGION), MACHAD SOMON (DISTRICT)

   a. The area is suitable for reacclimatization of horses within a range of several thousand $km^2$, and for establishment of a large wild population. The area is in the steppe zone.

   b. The distance from Ulan-Bator is 750 km (dirt road), and from the city Choibalsan - 150 km.

   c. Terrain is mostly plain, 600-800 m above sea level; chestnut or dark-chesnut soils, both carbonate and carbonate-free.

   d. Precipitation is 200-300 mm per annum, mostly in summer, snow in winter. The average temperature is +20-25°C in July and -20-25°C in January; strong winds are frequent in winter.

   e. Natural water sources are rare, no rivers, occasional small salt lakes and temporary water bodies. Drilling of artesian wells is possible.

   f. Grass steppe vegetation (Stipa, Cleistogenes, Koeleria, Zeymus, Agropyron) with shrubs; Nos. 40 and 42 on the geobotanical map of Mongolia.

   g. Among herbivorous animals the most common is dzeren (Procapra gutturosa), and among predators - wolf.

   h. Domestic horses are rare, and feral ones are non-existent.

   i. Density of human population is low; the area is poorly developed: the predominant occupation is sheep husbandry with absence of arable land.

   j. The proposal for establishment of a reserve in this area has been made and at present is under consideration with competent Mongolian organizations.

2. USHUGIN-NURU MOUNTAIN MASSIF IN SOUTHERN KHANGAI; UVER-KHANGAI AIMAK

a. This area is suitable for reacclimatization of horses within a range of about 1000 $km^2$, sufficient for establishment of a large natural population. The area is situated on the border of steppe and semi-desert zones.

b. The distance from Ulan-Bator is 600 km (dirt road) and from the regional capital Arbai-Here - 150 km.

c. The mountains are not high, the maximum is 2348 m above sea level; elevation from the foot of slope is only 300-500 m. Light-chestnut carbonate soils.

d. Precipitation is 200-300 mm per annum, in some years only 100-200 mm, mostly in summer; no snowfall in some winters. The average temperature is +18-20°C in July and -15-20°C in January.

e. Natural water sources are present; these are rivers flowing down from Khangai mountains.

f. Semi-desert vegetation; grass and solonchak kind in mountains (Stipa, Ajania, Anabasis, Kochia, Caragana) - No. 58 of geobotanical map, and grass steppe in the surrounding plain (Stipa, Cleistogenes, Artemisia) - No. 48 of geobotanical map.

g. Among hoofed animals the most common are muflons; there are also wolves.

h. The human population raises domestic horses, and therefore it is desirable to set up limits for keeping such horses in this area; feral horses do not occur.

i. Economically the area is poorly developed, sheep husbandry prevails; there are also massifs of arable land to the north of the mountain ridge.

j. It is fully realistic to have hunting banned in this area; also it is desirable to obtain legislation limiting the number of domestic horses.

3. LOW MOUNTAIN MASSIF IN KHAN-BOGDO SOMON OF SOUTH-GOBY AIMAK

a. The area is suitable for reacclimatization of horses within a range of not less than 1000 $km^2$, and for establishment of a large population. The area is situated in the southern part of the semi-desert zone.

b. The distance from Ulan-Bator is 700 km (dirt road), and from the regional centre - 200 km.

c. The mountains are not high, the maximum is 1300 m above sea level; the terrain is undulating: elevation from the foot of the slope is 100-300 m. Brown steppe and semi-desert soils.

d. Precipitation is 100-200 mm per annum, mostly in summer; no snowfall in some winters. The average temperature is +25°C in July and -15°C in January.

e. Natural water sources are rare, only occasional springs. Drilling of wells is indispensable.

f. Semi-desert vegetation, feather-grass and solonchak-type in the mountains (Stipa, Ajania, Anabasis, Kochia, Caragana) - No. 58 of Geobotanical map.

g. Among hoofed animals the most common are muflons; there are also wolves.

h. Population of domestic horses is small; no sightings of feral horses.

i. Economically the area is poorly developed; the principal occupation is camel husbandry.

j. It is fully realistic to have hunting banned in this area.

4. MOUNTAIN MASSIF EDRENGEEN-NURU IN THE NORTHERN PART OF GREAT GOBY RESERVE

a. The area is suitable for reacclimatization of horses within a range of not less than 1000 $km^2$; nevertheless, it is sufficient for establishment of only a small (several dozen) population. The mountains are in the northern part of the desert zone.

b. The distance from Ulan-Bator is 1000 km (dirt road). The Reserve administration has its headquarters in Bayan-Toroy somon nearby.

c. The mountains are not high, the maximum is 2076 m above sea level; elevation from the foot of the slope is 300-600 m. Grey-brown desert soils

d. Precipitation is 0-100 mm per annum, mostly in summer; no snowfall in some winters. The average temperature is +20°C in July and -15°C in January.

e. Natural water sources are rare.

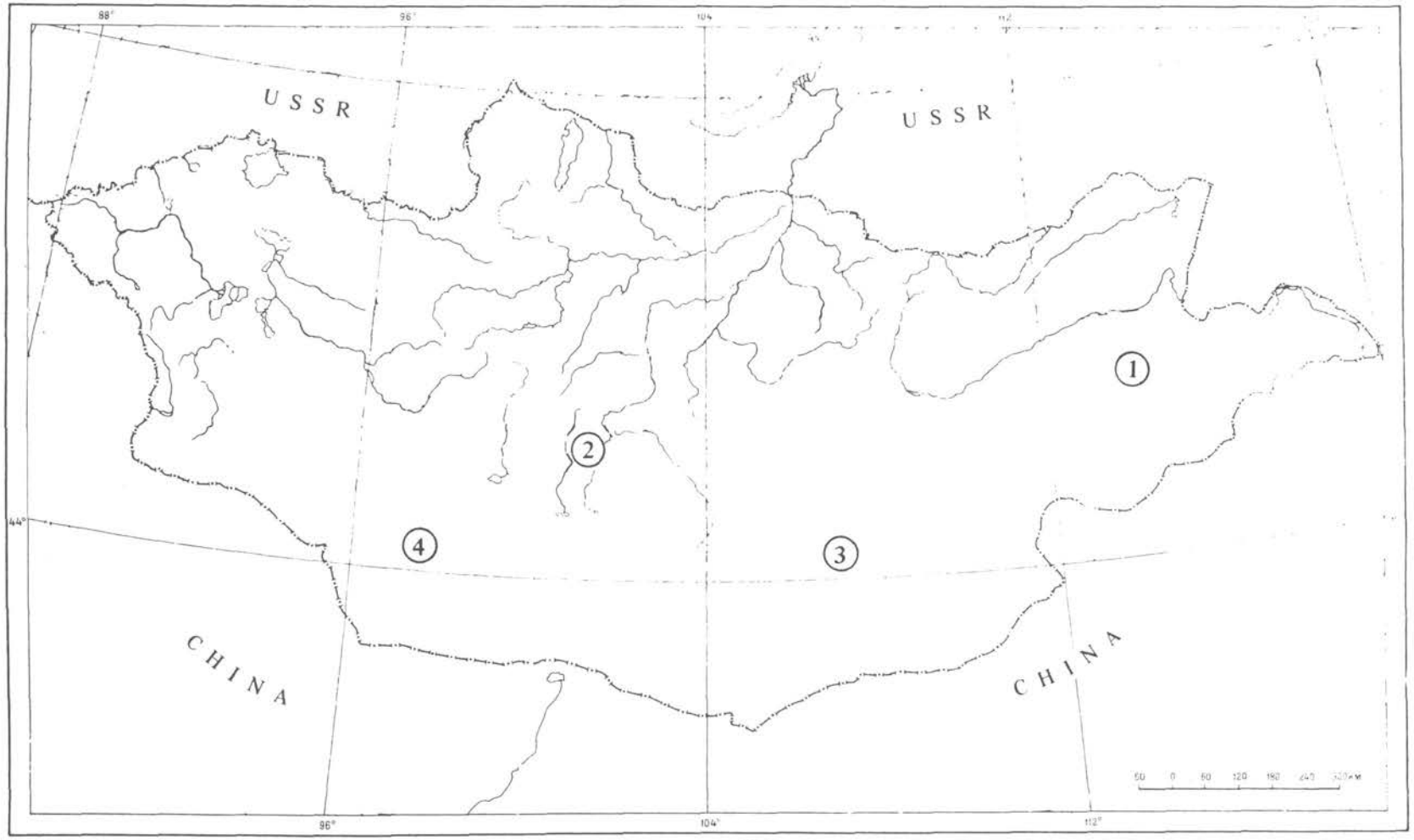
f. Desert vegetation of solonchak type (Salsola, Sympegma, Anabasis) - No. 73 of geobotanical map.

g. Occurrence of Capra sibirica, Gazella subgutturosa.

h. Domestic horses are rare; no feral horses.

i. Reservation conditions.

## MONGOLIA: PRZEWALSKI HORSE REINTRODUCTION SITES




(1) Eastern Aimak Region, Machad Somon District

(2) Ushugin-Nuru mountain massif in southern Khangai; Uver-Khangai Aimak

(3) Low mountain massif in Khan-Bogdo Somon of South-Goby Aimak

(4) Mountain massif Edrengeen-Nuru in Northern part of great Goby Reserve

APPENDIX E

## TIME FRAME FOR REINTRODUCTION OF PRZEWALSKI HORSE TO WILD IN MONGOLIA

1. 1985 (Summer) Field mission by Soviet-Mongolian Biological Expedition of Academies of Sciences of the USSR and Mongolia to survey possible sites for release and semi-wild reserves.

2. 1985 (Autumn) Report by above expedition to be sent to FAO and UNEP.

3. 1986 (early part of year - winter) Expert mission of 4/5 scientists to visit sites recommended to evaluate in winter conditions. Mission to contain 4/5 experts including:
1 Mongolian scientist )
1 USSR scientist ) from expedition
2/3 Experts in (i) ecology, range management, wild horses; (ii) equine range nutrition; (iii) social structure of wild ungulates and their habitats in cold, arid zones

   The expert mission will also assist the Mongolian Government to prepare a list of needed equipment and supplies, as well as help in preparation of a budget for construction activities at the site.

4. 1986 (Summer) Expert mission to be repeated if necessary. Could be undertaken by Soviet-Mongolian Biological Expedition which usually visits area each summer.

5. 1986 Use of remote sensing date to evaluate site and vegetation in detail (upon agreement by Mongolian government).

6. 1986 Animals at Askania Nova to be selected and moved to semi-wild site at Askania Nova.

   International Training Course Programme for 1987 to be planned by Askania Nova in association with UNEP and other international bodies involved in programme.

7. 1987 (Summer) Setting up facilities on semi-wild site in Mongolia (after formal request from Mongolian government).

| | | |
|---|---|---|
| 8. | 1987 | (Autumn) Training Course in Askania Nova for Mongolian staff. |
| 9. | 1986-87 | Selection of animals in Europe and North America. |
| 10. | 1988 | (Summer) Movement of animals from Europe and North America to semi-wild site in Mongolia. (Proposed to minimize cost by flying animals to London UK on service flights, and then by charter to Ulan-Bator with refuelling in Moscow. Road to semi-wild site.)<br><br>(Summer) Movement of animals from Askania Nova to Mongolia.<br><br>A reliable and active coordination mechanism for monitoring the adaptation and journey of the horses from different origins and their release to the wild is essential at this stage. |
| 11. | 1990-91 | Release to wild site of animals from semi-wild site. |
| 12. | 1991 | Goal: Przewalski Horse in wild in Mongolia |

APPENDIX F

**BUDGET ITEMS FOR EXTERNAL FUNDING (PROPOSED FAO/UNEP/MONGOLIAN GOVERNMENT PROJECT)**

| | | |
|---|---|---|
| 1. | 1986 | (Early months - winter) Expert Mission to Mongolia. |
| 2. | 1986 | (Summer) Possible repeat of mission (may not be needed if work can be done by USSR/ Mongolian Expedition, which visits each summer). |
| 3. | 1986 | Analysis of remote sensing data (if approved) and all other data on release sites in Monglia to be carried out by International Coordination Group, who will make a recommendation of the final site to the Mongolian Government. |
| 4. | 1987/88 | Setting up facilities in semi-wild site in Mongolia. |
| 5. | 1987 | Training Course in Askania Nova (preparation from 1986). |
| 6. | 1988/89 | Movement of animals from Askania Nova to wild site in Mongolia. |
| 7. | 1988 or 1989 | Movement of animals from Europe and North America. |
| 8. | 1988/89 | Supplementary feed and radio telemetry equipment. |
| 9. | 1988-1991 | Project staff at site in Mongolia. |
| 10. | Travel of project supervisory staff. | |
| 11. | Meeting of scientists. | |
| 12. | Reports. | |

Note: Follow-up activities are to be responsibility of Mongolian Government, with annual mission by expedition (in different seasons).

## SUMMARY


INTRODUCTION AND WELCOME

Introductory statements on behalf of the host country, the USSR, were made by Academician L.K. Ernst, Vice-President of the All-Union Academy of Agricultural Sciences who formally opened the meeting, by Academician V. Sokolov of the All-Union Academy of Sciences who was Chairman of the Expert Consultation, and by Dr. WS. Baibakov, Director of the Centre for International Projects. Welcome statements on behalf of FAO and UNEP were also made.

It was emphasized that the reintroduction of Przewalski Horse to the native habitat in Mongolia was of benefit not only for the maintenance of the species itself, but also as an international model for such reintroductions with other species, since such experience is limited. The importance of maintaining genetic diversity and purity in the Przewalski Horse was mentioned. The sandy desert system of the Mongolian Gobi and the current plans and project for maintaining the ecosystem were described briefly. This work is consistent with the World Conservation Strategy and is the location in which the Przewalski Horse was last found in the wild state. This planned project for the Przewalski Horse is closely related to the UNEP programme on wildlife and protected areas.

I. STATUS AND PROSPECTS OF EXISTING CAPTIVE POPULATIONS

The captive population now numbers 680 living animals. One hundred and three (45 males and 58 females) horses wereborn in 1984. The annual rate of increase now appears to be 10-12% per year. It appears that 30 animals per year could be made available for a reintroduction programme subject to their suitability according to selection criteria and that they not be specific animals vital to the health of the captive population.

There is a need for all programmes of captive breeding populations and wild populations including reintroduced populations to be managed in parallel and to be regarded as one population.

The willingness of the captive breeding community to donate animals for this restoration to Mongolia was apparant.

II. PROBLEMS OF PRZEWALSKI HORSE REINTRODUCTION INTO THE WILD

Vast amounts of land appear to be available, but it has been difficult to date to identify specific tracts with sufficient resources to support a free-ranging population of wild horses. There are problems with domestic and feral horses and protection from hunting since everyone carries a gun. So at present no suitable area for

release has been identified. Semi-reserve areas need to be found elsewhere and in that context Kazakhstan was mentioned.

During the discussion it became obvious that complete surveys have yet to be completed and there have been no studies on the impact of wolves on the reintrodution. The need for formulation and application of specific criteria of site selection was indicated.

It was indicated that several batches of 30-50 animals each will be needed over several years. Social groups will need to be formed for the release. Perhaps the initial group could be all males to serve as a test for unsuspected problems. The director of Askania Nova indicated that they were prepared to receive 3-5 visiting international scientists per year for periods of 4-6 months each.

A lengthy discussion took place on the need for preparation of zoo-bred animals for release into the wild. It was felt that 1 to 2 years of preparation of young animals will be required to allow formation of social groups, adaptation to climate, adaptation to food supplies, and development of good condition. The resources for a reintroduction programme at Askania Nova in the USSR were described and it was indicated that 8000 hectares additional steppe habitat were scheduled for fencing in the near future. The programme and animals at Askania Nova are suggested as being particularly suitable for preparation of animals for reintroduction to the wild since the conditions under which they are maintained closely approximate the wild condition.

Mongolian representatives indicated that they are pleased that a reintroduction programme for the Mongolian Horse is to begin and that they will cooperate fully. Adequate land resources are available under national protection and funds are available for construction of a reception and reintroduction centre. There is a need to make provisions for training people and for study of feed requirements. Also a series of biotechnical requirements needs to be met. The Great Gobi Reserve was suggested as the prefered site for the release programme because (1) it is fully protected; (2) no economic development is allowed in the reserve, and (3) personnel are available to carry out the programme.

## III. GENERAL BIOLOGY OF SMALL POPULATIONS OF PRZEWALSKI HORSE AND REVIEW OF FERAL HORSES

There was discussion of genetically effective and minimum viable population sizes. The relative importance of equalizing of breeding lines versus minimizing inbreeding coefficients led to the conclusion that equalizing of breeding lines (founder representation) should have priority.

Discussion of effective population size (Ne) and actual population size (N) indicated that Ne/N is about 0.5 under current

management of the captive population but could be increased to 1.0 fairly easily.

In a captive population management of blood lines is more important that strict adherence to management of Ne. However, in wild populations management of Ne will take precedence since blood lines will not be controlled or readily known. In the wild population, the sex ratio of breeding horses will have a dominant effect on the Ne. The benefits of subdivision of a population for preservation of genetic diversity was considered and led to the conclusion that multiple wild populations would be beneficial. Ne's for each wild population in the range of 50 to several hundred were recommended, recognizing that this might require total populations of several hundreds to a thousand.

It was noted that animals are sometimes more easily mated in computers than in reality. Also it was observed that ecological considerations are likely to be more important that genetic in the early phases of the reintroduction. Papers on the review of feral horse populations generated discussion of possible minimum area requirements for the minimum viable populations proposed. In semi-desert conditions of North America, it was stated an area of 300 000 hectares seems necessary to support 100 horses. There was extensive discussion of habitat requirements for horses.

## IV. TECHNIQUES FOR REINTRODUCTION

After papers on reintroduction techniques, there were discussions on optimal ecological and social preparation for horses to be returned to the wild. A consensus seemed to develop on the desirability of bands and the possible importance of a few older, more experienced animals to act as ecological mentors. It was also suggested that in general males should be 1 or 2 years older than females for reintroduction. There was also further discussion of turnover rates in herd stallions and their possible effect on the genetic size of populations.

Risks of repeated handling and moving of horses were discussed at length.

The necessity of monitoring the reintroduced animals was emphasized. Individual marking of animals using freeze branding and/or ear notching was proposed. Radio telemetry studies, such as used for the Arabian oryx, were strongly recommended. Traps around waterholes were suggested to facilitate the possible recapture that follow-up might require.

The Arabian oryx project was described in some detail. Two points especially noted were the recruitment of former local hunters to serve as rangers and the assumption of project costs by the host government of Oman where the reintroduction was occurring.

## V. DISCUSSION ON RECOMMENDATIONS

Much additional material was presented and illustrated on potential sites in Mongolia. Discussion indicated that there is a need for further information on food resources for horses available during the winter since little survey work has been done during this season.

Considerable discussion took place on the number and nature of intermediate sites that should be a part of the reintroduction programme. The resources of Askania Nova as an intermediate site were discussed in detail.

The approach being used for the Arabian oryx was favoured for the reintroduction of the Przewalski Horse with emphasis on the acclimatization occurring at the actual location of the release into the wild. It was noted that all previous projects have used this approach to avoid the multiple hazards of repeated handling and movement of wild animals. Horses need more time to accommodate to new surroundings than other ungulates. Western zoos strongly support a programme of direct transfer of their animals to Mongolia for a release programme.

# PRZEWALSKI HORSE RESTORATION TO MONGOLIA - IMPORTANT TASK OF INTERNATIONAL COOPERATION ON CONSERVATION OF THE WORLD'S NATURAL HERITAGE

L.K. Ernst
Academician, Vice-President
All-Union Academy of Agricultural Sciences
named after V.I. Lenin

The Expert Consultation on Przewalski Horse Restoration to Mongolia is being held in compliance with the agreement between FAO and relevant Soviet organizations with support from UNEP.

We are happy to welcome experts and specialists from seven countries of Asia, America and Europe as well as officers of such authoritative international bodies as UNEP, FAO and IUCN.

Thousands of years of animal domestication and breeding have shown that man was able to alter genotype of domestic animals' ancestors drastically, using empirical methods only.

Thousands of breeds have been developed that are characterized by a great variety of biological and economically useful properties.

Nowadays when cell and gene engineering methods are being elaborated on a larger scale, the possibility to create radically new forms of animals has increased manifold.

It should be readily apparent that in the course of prolonged breeding man has developed many properties and qualities of domestic animals that their wild ancestors lacked. And this process will go ahead at a higher rate.

Having ensured great progress, these processes however have negative aspects. Successful development of some properties needed by man has led to a loss of other qualities mainly related to viability and resistance to diseases and extreme environmental conditions. Therefore, preservation of domestic animal ancestors' gene pool is of great practical value for future prospects of breeding science. There is no need to say that the principal goal of mankind consists in conservation of nature including preservation of all unique living forms in the course of evolution.

This problem receives primary consideration in this country. A special law has been passed on animal protection. Banks are created for long-term semen conservation for local breeds and this work goes on.

Problems on preservation of genetic diversity of wildlife,

maintenance of biological productivity of species, associations and ecosystems are represented in the topic of this meeting - scientific and practical aspects of Przewalski horse reintroduction into the wild. The Przewalski horse introduction into its former habitat and restoration of its wild population can guarantee the future of the Przewalski horse, preserve conditions for natural genetic variability of this species and enrich the wildlife.

It should be emphasized that this work will serve as a model for saving other zoological species. It will involve research, planning, personnel training and management.

The Przewalski horse restoration to Mongolia has put forward an important task of elaborating a multipurpose and relatively cheap international project. This work makes it possible to use, on a wide scale, local resources of the countries involved in this sophisticated experiment in nature. Of great importance is guidance of the international organizations on integration of efforts at the international level, establishment of the system for exchange of practical information and research results as well as on subsequent distribution and application of the findings to be obtained. Experience in Przewalski horse captive management is reflected in more than 500 scientific publications, proceedings of four international workshops and the IUCN report on the Przewalski horse survival issued in 1982. The principal conclusion from all these papers is to restore the Przewalski horse in the wild.

This meeting represented by competent experts serves to synthesize the research data available, assess resources of the donating zoos, prepare recommendations on the use of the Adaptation Centre in Askania Nova and the elaboration of the international project programme.

The meeting faces an important task of drawing up draft recommendations. This task can be divided into three levels:

1st level - Analysis of the state of art of the Przewalski horse restoration in the wild.

2nd level - Definition of basic guidelines for the action programme. Framing of the integrated approach. In this respect UNEP draft proposals on activities undertaken within the framework of the international project "Wildlife and Protected Areas Management in Mongolia" can be actively supported as a basis required for development of integrated actions.

3rd level - Analysis of optimal scientific, organizational and financial aspects of the suggested programme as well as its assessment as a possible model for restoration of other vanishing species. Also important are recommendations on participation of all the private persons, national and international organizations involved.

Soviet experts under Academician V.E. Sokolov have prepared basic material for discussion. It includes: basic theory, information covering the experience in Askania Nova, findings of the Soviet-Mongolian Biological Expedition, bibliography of the most outstanding papers on the Przewalski horse by Russian, Soviet and Mongolian scientists.

The work undertaken by the Soviet experts enabled them to prepare proposals on the Przewalski horse reintroduction to Mongolia to be discussed at this meeting. These proposals are based on 4 major stages of 6 years of work to be carried out. In my opinion, these proposals are worthy of analysis and assessment by the experts present to succeed in drawing up the recommendations.

I wish every success to the consultation and consider it as another important stage in international cooperation on rational use of the planet's ecological resources.

Joint activities of scientists and specialists from various countries on nature conservation vividly exemplify peaceful cooperation for the well-being of peoples, demonstrating great advantages of cooperation between countries with different political systems to solve global problems concerning the whole of mankind.

The USSR Commission for UNEP and Centre of International Projects, GKNT, made all the arrangements enabling us to carry out this work successfully and to become familiar with cultural life in Moscow - a hero-city, the heart of Russia and the USSR.

Once again I wish you success in your undertakings, happiness and prosperity.

## INTRODUCTORY REMARKS BY FAO

John Hodges
Animal Production Officer
Animal Breeding and Genetic Resources

Mr. Chairman, Distinguished Participants

I am honoured to speak on behalf of the Food and Agriculture Organization of the United Nations (FAO) at the start of this interesting and important Expert Consultation on the restoration of the Przewalski Horse to the wild in Mongolia.

FAO is pleased to work closely here with UNEP on this project. FAO and UNEP are cooperating together under the terms of the FAO/UNEP project on the Conservation and Management of Animal Genetic Resources, which makes provision for a wide-ranging series of tasks. They include:

1. Conservation of Indigenous Breeds of Livestock.
2. Data Banks
3. Gene Banks
4. Training
5. Joint Expert Panel of Scientists
6. Newsletter (Animal Genetic Resources Information)
7. Monograph on the Animal Genetic Resources of the USSR
8. Restoration of the Przewalski Horse to Mongolia

In the case of the last subject which is to be considered here for the next three days, FAO wishes to express special thanks to the Government of the USSR, to whom we are indebted for hosting this Expert Consultation. We wish to recognize particularly the contributions to the planning and scientific programme undertaken by the USSR All-Union Committee of Science and Technology, by UNECOM, by the USSR All-Union Academies of Sciences and of Agricultural Sciences, and by the Centre for International Projects.

FAO is also pleased to be working together at this meeting with the International Union for the Conservation of Nature (IUCN), whose Survival Service Commission and Captive Breeding Specialist Group are internationally recognized for their initiatives. It is also pleasing to be able to welcome representatives of the International Union of Directors of Zoological Gardens.

We are delighted to welcome here the distinguished scientists from many different countries, especially Academicians Sokolov and Ernst and their colleagues of the USSR, who have much experience with the Przewalski Horse at Askania Nova. I extend to Academician Sokolov and to Dr. Seal our congratulationg on appointment as Chairman and Co-Chairman respectively. We are especially delighted to welcome scientists from the People's Republic of Mongolia, with whom we all look

forward to working on this most interesting topic. Mongolia is a member country of FAO and we are pleased and privileged to respond to the request for assistance on this subject. Although the work of FAO in animal genetic resources is more often directed towards the domestic species, we have always recognized the value of their wild ancestors and also of feral populations. It is a remarkable tribute to the captive breeding specialists, who are well represented at this meeting, that there are now about 600 Przewalski Horses in the world in captivity, having been built up from near extinction over the last few decades. The willingness with which the captive breeders have already indicated their wish to donate animals for the wild in Mongolia, given a competent reintroduction programme, is a tribute not only to their success in saving the species, but also to their vision for its future.

Finally, we at FAO recognize the benefits which will flow from this Expert Consultation. If as we trust you are able to design an effective Action Programme for transfering the Przewalski Horse to Mongolia, then the project will not only succeed in restoring a previously endangered species to the wild, but will also offer a model for such reintroductions for use with other species.

I wish you a most successful and enjoyable meeting.

## INTRODUCTORY REMARKS BY UNEP

Mona Bjorklund
Environmental Management Service

Mr. Chairman, Distinguished Participants,

It gives me great pleasure to have the opportunity to say a few words on behalf of the United Nations Environment Programme (UNEP) to this joint FAO/UNEP Expert Consultation on restoration of Przewalski's Horse to Mongolia being hosted by the Government of the USSR.

I should like first of all, Mr. Chairman, to join the participants in congratulating you, Academician Sokolov, on your designation as Chairman and Dr. Seal on his designation as Co-Chairman of this important meeting.

May I also take the opportunity of paying tribute to the USSR Centre of Inernational Projects and especially to its Director, Dr. Baibakov, and to Dr. Korshenko, the Liaison Officer for this expert consultation. I would also like to express UNEP's deep appreciation to the Government of the USSR for hosting this meeting and for having so generously devoted its time and facilities to its organization. UNEP is also very pleased that so many experts have been able to gather here today with financial support from UNEP.

Mr. Chairman, UNEP was established to implement the Plan of Action on the Human Environment adopted at the Stockholm Conference in 1972. Since then, UNEP's activities have been - and they will continue to be - directed towards achieving proper management of human activities affecting the environment. UNEP's major objective, within its overall involvement in conservation activities, is to ensure better conservation of living resources. UNEP's conservation activities are undertaken within the framework of the World Conservation Strategy, which was developed by UNEP, IUCN and WWF, and which the United Nations General Assembly in 1979, and later the UNEP Governing Council in 1980 have formally endorsed. The implementation of the Strategy is a high priority item in the programme of UNEP. It is hoped that with the pooling of international resources, involving Governments, the United Nations system and the non-governmental organization or NGO community, the Strategy will provide a practical and useful tool for living resource conservation for sustained development. This brings me to the subject of this workshop namely the reintroduction of the Przewalski horse to its native habitat in the Great Gobi National Park in Mongolia.

Mr. Chairman, the Mongolian Gobi is a unique area of great significance for the whole of Central Asia, since its natural desert and semi-desert ecosystems have undergone but slight changes. However, unless an effective nature conservation and management programme is carried out in the Mongolian Gobi, the near future will inevitably see

irreversible changes in this important ecosystem, a reduction and extinction of many wildlife species populations in addition to the Przewalski's horse.

Mr. Chairman, as some of the participants in the workshop know, the United Nations Environment Programme (UNEP) has been collaborating since 1978 with the Governments of the Mongolian People's Republic and the USSR in the large-scale project "Assistance to the Mongolian People's Republic in the establishment of the Great Gobi National Park in Mongolia". Within this project, broad scientific investigations have been carried out, which have yielded a large amount of information on the status of animals and plants and their habitats as well as on the impact of anthropogenic factors on desert ecosystems. The results of field investigations on the status of natural resources in the Gobi have been summarized in a Monograph and a Master Plan of the Great Gobi National Park and recommendations have been made for the protection of rare animals and plants as well as of the unique desert ecosystems, which can serve as models for nature conservation in Central-Asian deserts. These investigations were supported by a large group of Soviet specialists (botanists, zoologists, soil scientists, hydrologists and geographers) who took part in the project; their enthusiasm and high professional qualities ensured high scientific input into all the activities. The authorities of the Mongolian People's Republic provided the necessary finances, together with UNEP, and ensured the participation of Mongolian specialists. UNEP's contribution towards the project amounted to more than 1.5 million United States dollars. During the implementation of the Gobi National Park project, UNEP has been in continuous contact with the Mongolian Government and the Mongolian and USSR specialists concerning the possible reintroduction of Przewalski's horse, which had been presumed extinct, into Mongolia. Important prerequisites for a successful reintroduction programme are, of course, availability of horses and the willingness of the owners to provide them free of charge, as well as the full cooperation of the Mongolian Government in providing substantial counterpart contribution. The Mongolian Government has informed UNEP that it attaches great importance to a follow-up to the Great Gobi National Park Project designed to protect rare animal species, including Przewalski's horse, and has requested further UNEP assistance in the realization of such a project with priority being given to the implementation of activities pertaining to Przewalski's horse.

Mr. Chairman, dear Colleagues, I would like to conclude these brief remarks by expressing a sincere hope that this meeting will help strengthen our mutual cooperation in promoting the objectives of the World Conservation Strategy and that we will come up with technically sound recommendations for the successful reintroduction of Przewalski's horse into Mongolia. Such recommendations should outline concrete measures and be as specific as possible and indicate how the ecological requirements for Przewalski's horse in the wild would be met, including the provision of adequate undisturbed natural waterholes and pasture without any competition from domestic stock or any

anthropogenic disturbances, points I will come back to during our technical discussions in this workshop. Such competition was probably the main reason for the decline and presumed extinction of Przewalski's horses in Mongolia in the first place. The planned scheme to breed and then release Przewalskis horses in Mongolia may have a good chance of success if the species enjoys special protection and if its rehabilitation is closely monitored.

I wish our meeting here in Moscow a successful outcome.

Thank you.

FAO/UNEP EXPERT CONSULTATION ON RESTORATION
OF PRZEWALSKI HORSE TO MONGOLIA
(29-31 May 1985)
Moscow

**AGENDA**

29 May 1985 (Rapporteur: Mr. Knowles)

10.00 Official opening: Dr. Ernst (USSR), Dr. Hodges (FAO), Ms. Bjorklund (UNEP)

11.15 Status and Prospects of Existing Captive Populations (Dr. Ryder, Dr. Musienko, Dr. Volf, Mr. Knowles)

13.00 Lunch

14.30 Problems of Przewalski Horse Reintroduction into the Wild (Dr. Sokolov, Dr. Musienko, Dr. Tovuu)

18.00 Conclusion

19.00 Visit to the Moscow Zoo

30 May 1985 (Rapporteur: Dr. Foose)

10.00 General Biology of Small Populations (Dr. Foose)

10.30 Small Populations of Przewalski Horse (Dr. Wiesner, Dr. Klimov, Dr. Ryder, Dr. Klimov)

11.45 Review of Feral Horses (Dr. Miller, Dr. Orlov, Dr. Klimov)

13.00 Lunch

14.30 Techniques for Reintroduction (Mr. Knowles, Dr. Pohle, Dr. Miller, Dr. Wiesner, Dr. Klimov)

18.00 Conclusion

31 May 1985 (Rapporteurs: Mr. Knowles/Dr. Foose)

10.00 Presentation of Draft Recommendations

10.30 Discussion of Draft Recommendations

13.00 Lunch

14.30 Further Discussion of Draft Recommendations

16.45 Adoption of Recommendations

17.30 Concluding Statements

18.00 Expert Consultation closes

19.00 Dinner by USSR government

FAO/UNEP EXPERT CONSULTATION ON RESTORATION
OF PRZEWALSKI HORSE TO MONGOLIA
(29-31 May 1985)
Moscow

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Footnotes: 1. Academician V. Sokolov and Dr. U.S. Seal were appointed Chairman and Co-Chairman respectively.
2. Dr. John Hodges, FAO - Secretary.
3. Dr. V. Korzhenko, CIP - USSR Liaison Officer.

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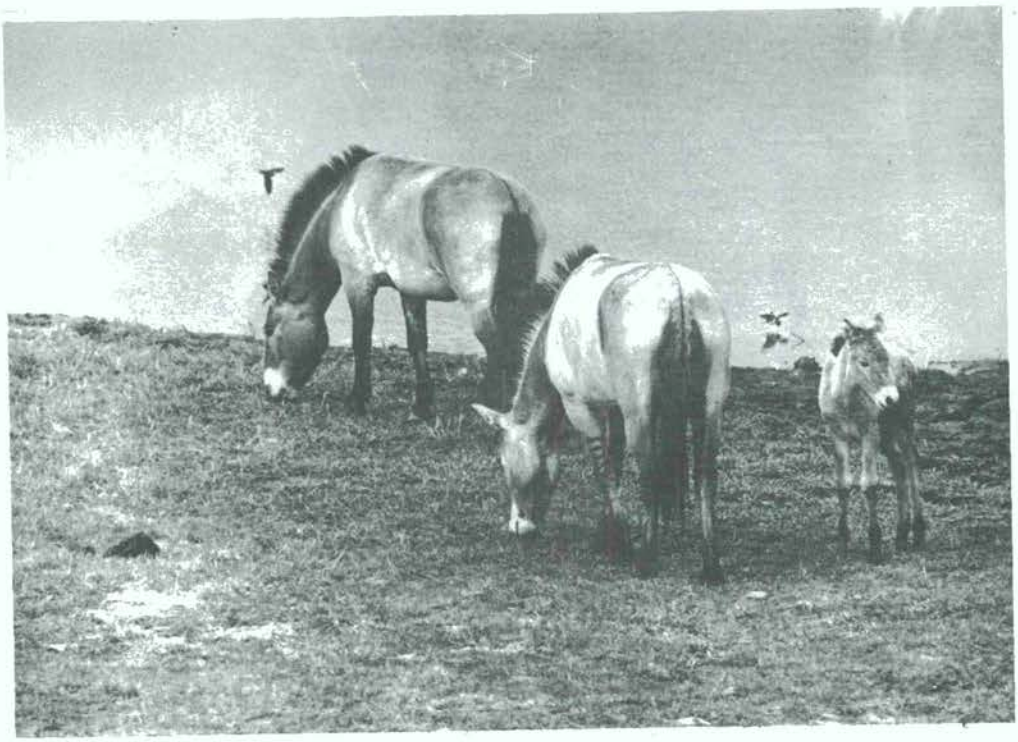
# STATUS AND PROSPECTS OF EXISTING CAPTIVE POPULATIONS



# GENETIC ANALYSIS OF PRZEWALSKI'S HORSES IN CAPTIVITY

Oliver A. Ryder

The wild horse of the Asian steppe was first described to western scientists by Poliakov in 1881. The considerable interest that this significant discovery created ultimately resulted in the capture of Przewalski's horse foals, their transfer to captive environments, subsequent acclimatization, and successful captive breeding. Many zoologists were fascinated by this unique creature but, were it not for the dedicated efforts of the early owners and breeders of Przewalski's horses they would almost surely be extinct today.

All Przewalski's horses living today in captivity trace their ancestry to twelve animals brought out of Mongolia at the turn of the century and a single mare captured in 1947. Growth of the captive population was at first slow and the population numbers declined severely during World War II. The dedicated interest of zoologist Dr. Erna Mohr resulted in the publication of the first Pedigree Book of the Przewalski's Horse. International Symposia have been held to consider the biology of this endangered species beginning in 1959. Following the publication of the first Pedigree Book by Dr. Mohr in Prague, Czechoslovakia zoo has maintained the studbook under the direction of Dr. Jiri Volf. The initial studbook and the annual update of new information have set a standard for all subsequent studbooks.

A studbook is a historical record of births, deaths and parentage of individuals. Although many extremely useful tools for genetic analysis are available now it is still the case that the single most powerful tool for genetic analysis is studbook data. Thus the numerous volumes of the Pedigree Book of **Equus przewalskii** constitute one of the most sophisticated and useful records of long-term captive breeding.

Aspects of analysis of studbook data such as the calculation of demographic parameters suggest the growth potential of captive populations. Other calculations based upon pedigree data are reflections of the degree to which the genetic contributions of individuals brought into captivity have been assimilated into subsequent generations of captive individuals. The techniques and methodologies of pedigree analysis are a continuing focus of medical scientists and zoologists. For very few species of large mammals do pedigree data exist over ten or more generations. Consequently the application of new and sophisticated genetic analysis techniques provides additional insights concerning the extent to which captive populations may differ from the free-living populations from which they were derived.

## DEMOGRAPHIC ANALYSIS

The growth of the captive population of Przewalski's horses has

been thoroughly documented by Studbookkeeper Dr. Volk and elaboration has been provided by Bouman, Foose and others. The captive population is growing at a sufficient rate that significant new collections of Przewalski's horses have been established in Asia and Australia while, at the same time, substantial increases in the sizes of collections have taken place at institutions that have long histories of propagating the species. It is growing increasingly clear that Przewalski's horse individuals surplus to the requirements for adequate conservation of the species **ex situ** are now available in limited numbers and that in a few short years substantial numbers of individuals will be available for appropriate restoration and reintroduction projects. The relatively large numbers of individuals in the younger age classes of the world population of **Equus przewalskii** suggest that sufficient numbers of animals for establishing an appropriate programme of restoration of the species to its historic range in the People's Republic of Mongolia will be available (Figure 1). The broad base of the age distribution suggests that, under continued patterns of reproduction such as have been occurring recently, the population is capable of rapid expansion.

## INBREEDING IN PRZEWALSKI'S HORSE

The early history of breeding Przewalski's horses in captivity was greatly influenced by the significance of domestic horsepower for human societies. Numerous governmental and non-governmental institutions were interested in the possibility of producing superior domestic horses and, considering this background, it is not at all surprising that numerous hybrids between **Equus przewalskii** and **E. caballus** were created. Fortunately, only one documented hybrid is depicted in the International Studbook. Similarly, selective inbreeding has long been recognized as an important tool for the agricultural breeder. It is not unexpected that the early breeding of Przewalski's horses included matings of close relatives. Furthermore, the pioneering work of modern population geneticists was unavilable to those first owners and breeders of Przewalski's horses. The propensity for normally outbreeding populations to suffer losses of vitality (i.e. fitness depression) as a result of consanguineous matings is well documented for mammalian populations. The negative effect may be only transitory and, for those populations able to have sufficient numbers of offspring surviving to produce numerous progeny themselves, the deleterious alleles may be purged. In populations founded by relatively few individuals, inbreeding is unavoidable and some genetically less-fit individuals are expected to succumb. In such small populations low to moderate levels of inbreeding may be necessary in order to avoid population extinction (e.g. Speke's gazelle at St. Louis Zoo, Missouri, USA ([Templeton and Read, in press]).

Avoidance of close inbreeding is generally observed in natural populations of feral horses and other equids. Consequently, to more closely simulate the genetical relationships presumed to have been exhibited by free-living populations of Przewalski's horses as well as

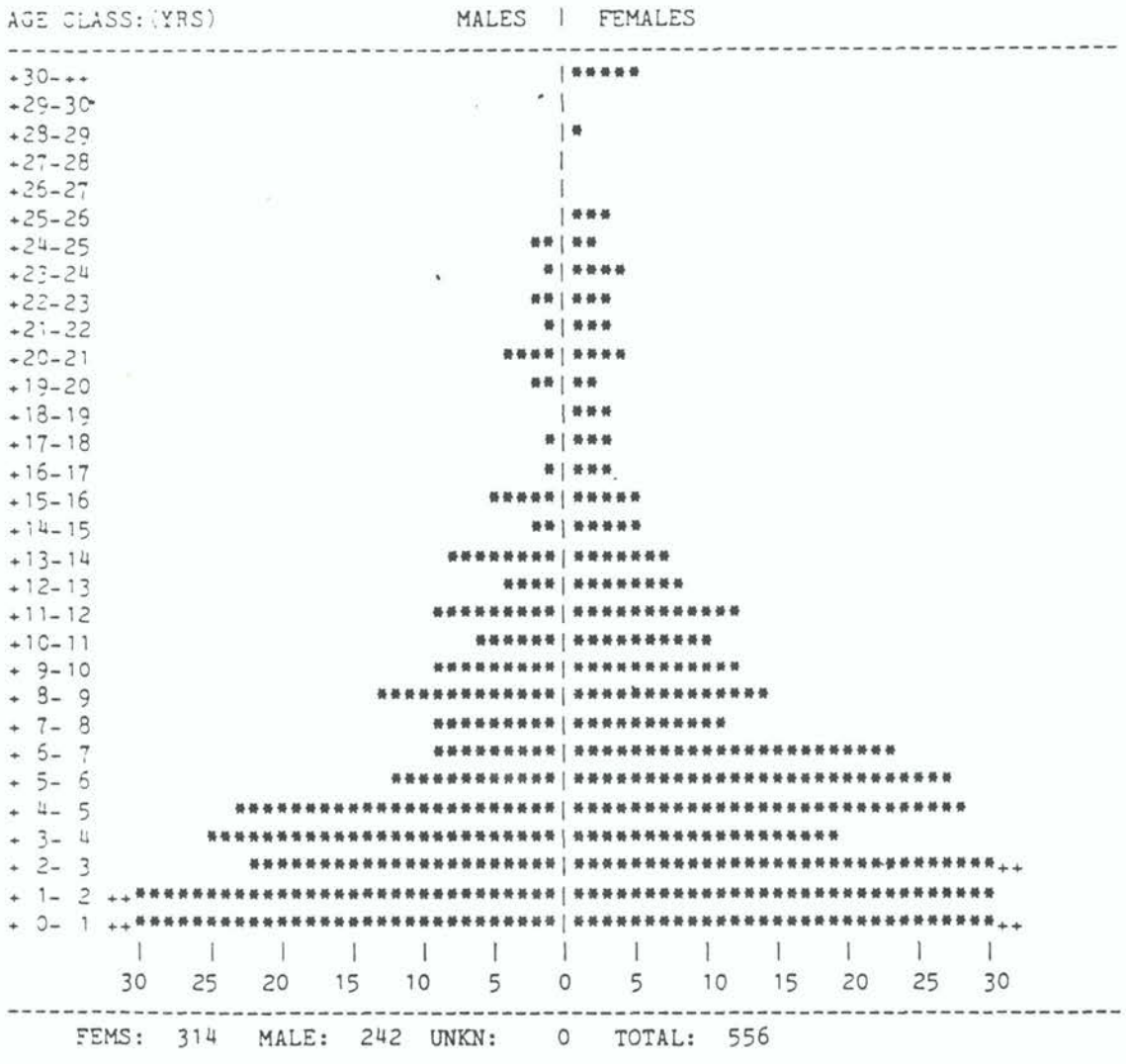



Fig. 1 All institutions - population age structure for species: Przewalski Horse

to minimize the loss of genetic variability, inbreeding levels should not dramatically increase. Analysis of the world trend in levels of inbreeding as measured by the average coefficients of inbreeding of foals born each year is presented in Figure 2. As the world population grows and with periodic animal transfers among major geographical centres of breeding, e.g. Europe, North America, British Isles, as suggested by Bouman (1979) the worldwide increase in coefficients of inbreeding has been arrested. Since the inception of the Species Survival Plan for the Asian Wild Horse under the auspices of the American Association of Zoological Parks and Aquariums a previous trend toward increasingly higher values of coefficients of inbreeding in North American collections has been reversed (Figure 2).

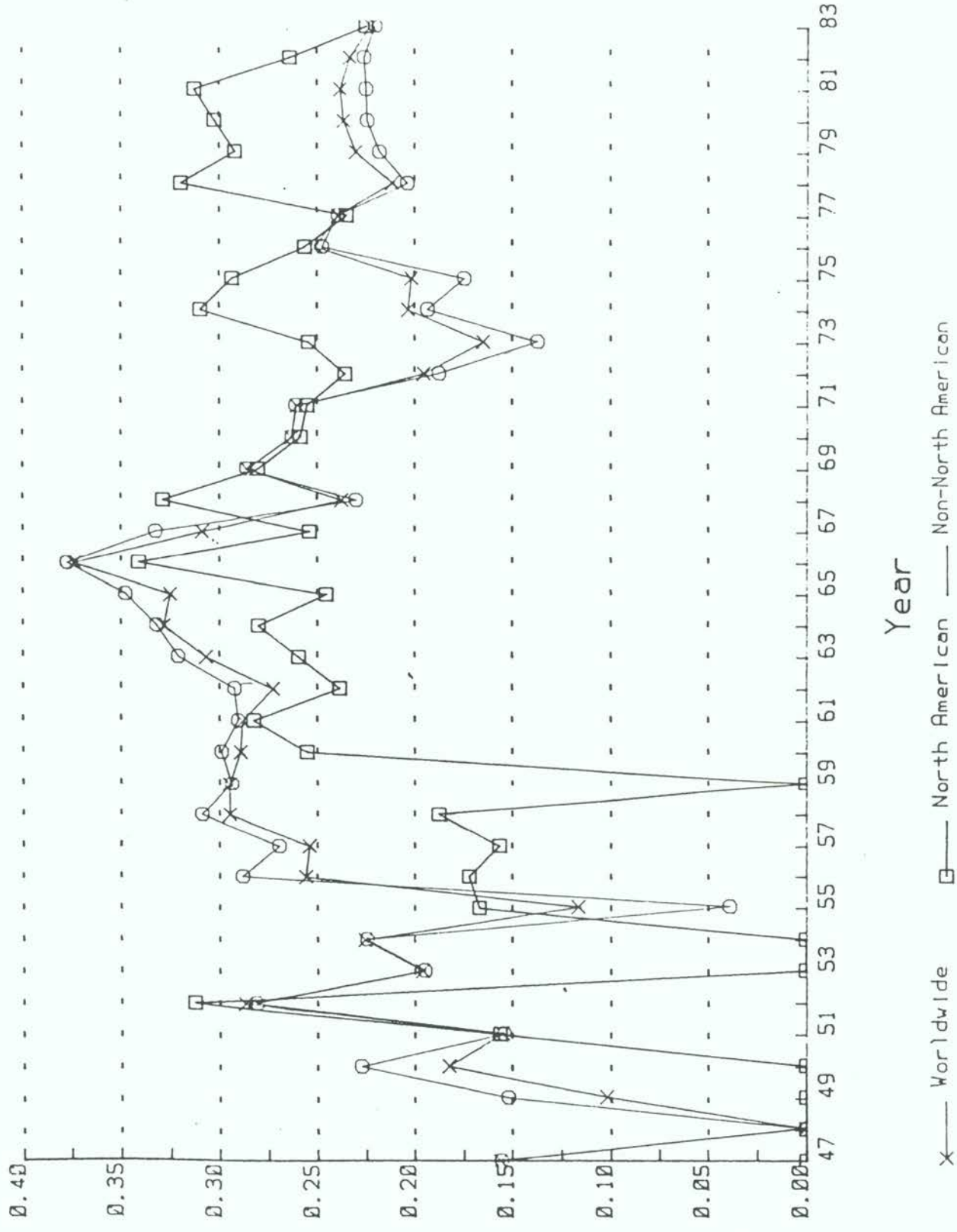



Fig. 2 Przewalski horse inbreeding coefficients: yearly trend

Coefficients of inbreeding for all Przewalski's horses listed in the International Studbook issued in Prague on 1 January 1984 are presented in Appendix 1.

## SELECTIVE BREEDING OF PRZEWALSKI'S HORSES

The milieu in which much of the captive breeding of Przewalski's horses has occurred included both conscious and unconscious selection. Unconscious selection began when the first foals began to die because they could not, in their wildness, adapt to their surrogate mothers and the journey to the west. Even currently, as inexperienced stallions run into fences and break their necks, unconscious (or unwilling) selection occurs. Conscious selection takes other forms. Some selection of stallions by phenotype has undisputedly occurred. On a worldwide basis there has been a 20-year trend of relative reduction on the genetic contribution of the **E. caballus** mare (who was the dam of #56, Halle 1) to the gene pool of captive **E. przewalskii** (Figure 3). During the same period of time there has been a dramatic increase in the relative genetic contribution of the last wild-caught mare, #231 Orlica III (Figure 3). Under common circumstances and for species whose populations are quite small (less than 100) conscious selection should be severely restricted. For other, larger, populations, and for the special case of introgression (in which genes from one species are introduced into another species) some selection against individuals with extreme attributes ("outliers") or selection for reduction in the overall genetic contribution of the introgressing individual(s) is acceptable (Frankham **et al.**, in press). This is, in fact, the currently occurring worldwide trend for captive **E. przewalskii.**

The extent to which the selection against the domestic mare has reduced the genetic variation derived from #58 Halle C, the single genetically effective offspring of two wild-caught individuals (#11, Bijsk 1 and #12, Bijsk 2), is a subject of current investigation (MacClure **et al.**, in press; Gilpin **et al.**, in preparation). It should be noted that studies of blood group and electrophoretic variation in Przewalski's horses have indicated that lower average levels of heterozygosity are present in those horses descended from #56 Halle 1 without the incorporation of genetic input from #285, Askania 3, Bars, than are observed among either the descendants of #56 Halle 1 after the introduction of genetic contribution from Bars to the captive gene pool or among the horses lacking genetic input from the domestic mare (Ryder **et al.**, Equus, in press; Ryder **et al.** 1982).

## POPULATION MANAGEMENT FOR GENE POOL PRESERVATION AND RESTORATION

There is ample documentation establishing the phenotypic diversity of the Przewalski's horses imported from Mongolia (Mohr 1959). Genetic analysis of proteins and DNA from recent generations of Przewalski's horses has readily demonstrated that substantial vari-

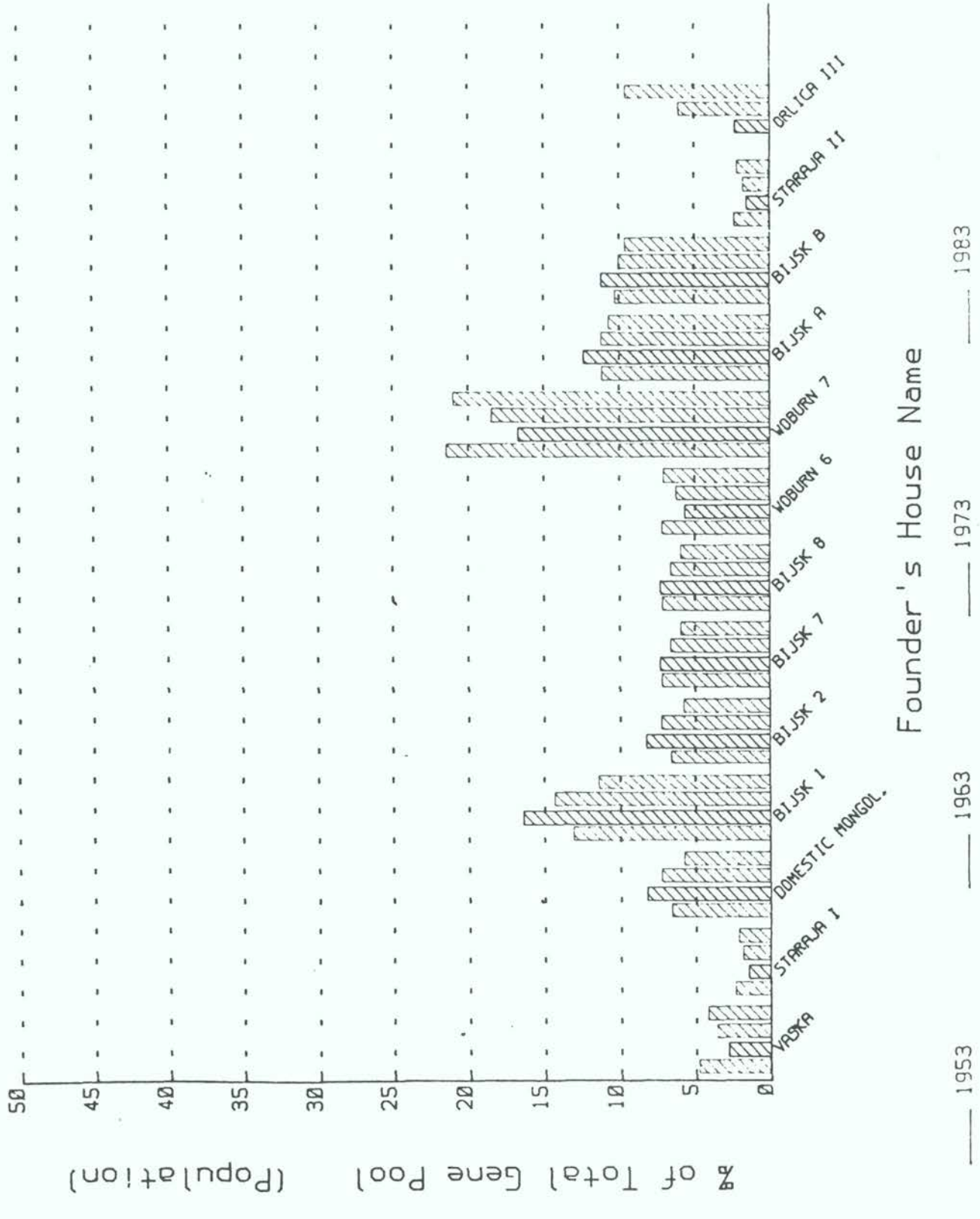



Fig. 3 Przewalski horse founder blood representation

ability remains within the captive gene pool. It is this reservoir of genetic variation that represents the potential source of adaptive variation upon which natural selective forces will act as individuals are restored to free-living conditions. Consequently, an important aspect of the total effort to preserve Przewalski's horses and restore them to appropriate habitats is the maintenance of genetic variation within the captive gene pool in order that the restoration efforts have the greatest chances for success. The dependence of an established free-living population of Przewalski's horses upon the captive population will not cease until many generations of breeding in nature have occurred. Even at that time it is highly probable that some periodic exchanges of individuals will be considered desirable. Genetic bottlenecks must be anticipated as a result of strong selective forces acting on the reintroduced population as has been demonstrated for the reintroduction of the Arabian oryx (Stanley-Price **et al.**, in press).

In order to minimize the loss of gene pool resources for captive Przewalski's horses it is desirable to incorporate a relatively greater proportion of males born in one generation as sires of the next generation. For example three living stallions had sired 133 foals as of 1 January 1982 whereas some stallions with comodious pedigrees are underrepresented or not represented at all in subsequent generations. A listing of the reproductive contributions of all stallions having sired offspring listed in the studbook from its inception until 1 January 1982 appears in Appendix II.

Rather than placing single stallions in many small zoos with inadequate exercise space for Przewalski's horses, several new male-only groupings have been created in zoos in the British Isles and the United States. One new stallion group at Woburn Abbey re-establishes the species at one of the historical sites of early captive breeding success. Such groupings probably more closely reflect the natural groupings of adolescent males occurring in free-living populations of other equids. Care must be taken in the creation of all-male groups. Factors such as the relatedness of the colts, the age differential among individuals, and animal density must be taken into consideration. Even so, fighting and occasional injury may occur.

## PRZEWALSKI'S HORSE AND THE EVOLUTION OF MONODACTYL EQUIDS

Following Poliakov's identification of the Mongolian wild horse as a species distinct from domestic horses in 1881, controversy surrounded the systematic status of the wild horse of Mongolia. The discovery that the diploid chromosome number of **E. przewalskii** differs from that of domestic horses provided new insights into the systematic differentiation of the two taxa (Benirschke and Malouf 1966). More recently, blood grouping analysis, electrophoretic studies and comparative studies of DNA have added further information concerning the genetic differentiation of Przewalski's and domestic horses (Ryder **et al.** in press; Ryder **et al.** 1979; Ryder et al. 1981; Ryder **et al.**

1982). A comparison of mitochondrial DNA restriction maps of **E. przewalskii** (representing three separate female founders) and **E. caballus** suggests the extent of divergence of their mitochondrial genomes is not indicative of a recent close genetic relationship. These data rather suggest that it was well before humans domesticated wild horses that Przewalski's horses and the wild ancestors of domestic horses had diverged from a common ancestor (George and Ryder 1983; George and Ryder, submitted for publication).

ACKNOWLEDGEMENTS

The contributions of The Canyon Colorado Equid Sanctuary, Wagon Mound, New Mexico (USA) in the form of computer-generated studbook analyses (represented by Figures 1, 2 and 3 as well as Appendix I) are gratefully acknowledged. This work was supported by NIH grant GM23073, the Zoological Society of San Diego, and the Ceasar Kleberg Foundation.

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**et seq.**

APPENDIX I

CANYON COLORADO EQUID SANCTUARY
FOR SPECIES: Przewalski Horse
MATRIX/KEY (STUDBOOK NO.) CROSS REFERENCE TABLE

| MAT# | KEY# | NAME | ICOEF |
|---|---|---|---|
| 1 | 0001 | KOBDO 1 | .000 |
| 2 | 0002 | KOBDO 2 | .000 |
| 3 | 0003 | KOBDO 3 | .000 |
| 4 | 0004 | KOBDO 4 | .000 |
| 5 | 0005 | KOBDO 5 | .000 |
| 6 | 0006 | KOBDO 6 | .000 |
| 7 | 0007 | KOBDO 7 | .000 |
| 8 | 0008 | MOSKVA 1 | .000 |
| 9 | 0009 | MOSKVA 2 | .000 |
| 10 | 1200 | DOMESTIC MONGOL. | .000 |
| 11 | 0010 | MOSKVA 3 | .000 |
| 12 | 0011 | BIJSK 1 | .000 |
| 13 | 0012 | BIJSK 2 | .000 |
| 14 | 0013 | BIJSK 3 | .000 |
| 15 | 0014 | BIJSK 4 | .000 |
| 16 | 0015 | BIJSK 5 | .000 |
| 17 | 0016 | BIJSK 6 | .000 |
| 18 | 0017 | BIJSK 7 | .000 |
| 19 | 0018 | BIJSK 8 | .000 |
| 20 | 0019 | BIJSK 9 | .000 |
| 21 | 0020 | BIJSK 10 | .000 |
| 22 | 0021 | BIJSK 11 | .000 |
| 23 | 0022 | BIJSK 12 | .000 |
| 24 | 0023 | BIJSK 13 | .000 |
| 25 | 0024 | BIJSK 14 | .000 |
| 26 | 0025 | BIJSK 15 | .000 |
| 27 | 0026 | BIJSK 16 | .000 |
| 28 | 0027 | BIJSK 17 | .000 |
| 29 | 0028 | BIJSK 18 | .000 |
| 30 | 0029 | BIJSK 19 | .000 |
| 31 | 0030 | BIJSK 20 | .000 |
| 32 | 0031 | BIJSK 21 | .000 |
| 33 | 0032 | BIJSK 22 | .000 |
| 34 | 0033 | BIJSK 23 | .000 |
| 35 | 0034 | BIJSK 24 | .000 |
| 36 | 0035 | BIJSK 25 | .000 |
| 37 | 0036 | BIJSK 26 | .000 |
| 38 | 0037 | BIJSK 27 | .000 |
| 39 | 0038 | BIJSK 28 | .000 |
| 40 | 0211 | WOBURN 6 | .000 |
| 41 | 0212 | WOBURN 7 | .000 |
| 42 | 0039 | BIJSK A | .000 |
| 43 | 0040 | BIJSK B | .000 |
| 44 | 0041 | BIJSK C | .000 |
| 45 | 0042 | BIJSK D | .000 |
| 46 | 0043 | BIJSK E | .000 |
| 47 | 0044 | BIJSK F | .000 |
| 48 | 0045 | BIJSK G | .000 |
| 49 | 0046 | BIJSK H | .000 |
| 50 | 0047 | BIJSK J | .000 |
| 51 | 0048 | BIJSK K | .000 |
| 52 | 0049 | BIJSK L | .000 |
| 53 | 0050 | KOBDO A | .000 |
| 54 | 0051 | KOBDO B | .000 |
| 55 | 0052 | KOBDO C | .000 |
| 56 | 0053 | KOBDO D | .000 |
| 57 | 0054 | KOBDO E | .000 |
| 58 | 0206 | WOBURN 1 | .000 |
| 59 | 0421 | ASKANIA K | .000 |
| 60 | 0056 | HALLE 1 | .000 |
| 61 | 0055 | HALLE A | .000 |
| 62 | 0422 | ASKANIA L | .000 |
| 63 | 0057 | HALLE B | .000 |
| 64 | 0423 | ASKANIA M | .000 |
| 65 | 0058 | HALLE C | .000 |
| 66 | 0203 | GOOILUST 1 | .000 |
| 67 | 0100 | YORK 1 | .000 |
| 68 | 0424 | ASKANIA N | .000 |
| 69 | 0124 | PARIS 1 | .000 |
| 70 | 0204 | GOOILUST 2 | .000 |
| 71 | 0425 | ASKANIA O | .000 |
| 72 | 0426 | ASKANIA P | .000 |
| 73 | 0101 | YORK 2 | .000 |
| 74 | 0113 | CINC 1 | .000 |
| 75 | 0059 | HALLE 2 | .125 |
| 76 | 0102 | YORK 3 | .250 |
| 77 | 0427 | ASKANIA R | .000 |
| 78 | 0103 | YORK 4 | .000 |
| 79 | 0205 | GOOILUST 3 | .000 |
| 80 | 0428 | ASKANIA S | .000 |
| 81 | 0060 | HALLE 3 | .125 |
| 82 | 0429 | ASKANIA T | .000 |
| 83 | 0125 | PARIS 2 | .000 |
| 84 | 0061 | HALLE 4 | .125 |
| 85 | 0430 | ASKANIA U | .000 |
| 86 | 0104 | YORK 5 | .000 |
| 87 | 0431 | ASKANIA V | .000 |
| 88 | 0105 | YORK 6 | .250 |
| 89 | 0106 | YORK 7 | .000 |
| 90 | 0126 | PARIS 3 | .000 |
| 91 | 0114 | PHIL 1 | .000 |
| 92 | 0107 | YORK 8 | .250 |
| 93 | 0062 | HALLE 5 | .125 |
| 94 | 0063 | HALLE 6 | .313 |
| 95 | 0108 | YORK 9 | .000 |
| 96 | 0115 | PHIL 2 | .000 |
| 97 | 0064 | HALLE 7 | .313 |
| 98 | 0432 | ASKANIA Z | .250 |
| 99 | 0187 | ASKANIA A | .125 |
| 100 | 0116 | PHIL 3 | .000 |

CANYON COLORADO EQUID SANCTUARY
FOR SPECIES: Przewalski Horse
MATRIX/KEY (STUDBOOK NO.) CROSS REFERENCE TABLE

| MAT# | KEY# | NAME | ICOEF |
|---|---|---|---|
| 101 | 0065 | HALLE 8 | .125 |
| 102 | 0066 | HALLE 9 | .313 |
| 103 | 0117 | PHIL 4 | .000 |
| 104 | 0067 | HALLE 10 | .125 |
| 105 | 0188 | ASKANIA B | .250 |
| 106 | 0433 | ASKANIA a | .125 |
| 107 | 0118 | PHIL 5 | .000 |
| 108 | 0434 | ASKANIA b | .250 |
| 109 | 0222 | SIDNEY 1 | .250 |
| 110 | 0435 | ASKANIA c | .250 |
| 111 | 0436 | ASKANIA d | .250 |
| 112 | 0127 | PARIS 4 | .000 |
| 113 | 0437 | ASKANIA e | .125 |
| 114 | 0109 | YORK 10 | .250 |
| 115 | 0438 | ASKANIA f | .250 |
| 116 | 0189 | ASKANIA C | .125 |
| 117 | 0119 | PHIL 6 | .000 |
| 118 | 0439 | ASKANIA g | .250 |
| 119 | 0191 | ASKANIA E | .125 |
| 120 | 0068 | PRAHA 1 | .313 |
| 121 | 0110 | YORK 11 | .250 |
| 122 | 0177 | LONDON 1 | .000 |
| 123 | 0440 | ASKANIA h | .250 |
| 124 | 0192 | ASKANIA F | .125 |
| 125 | 0223 | SIDNEY 2 | .250 |
| 126 | 0069 | PRAHA 2 | .313 |
| 127 | 0216 | WOBURN 11 | .000 |
| 128 | 0178 | LONDON 2 | .000 |
| 129 | 0224 | SIDNEY 3 | .375 |
| 130 | 0111 | YORK 12 | .250 |
| 131 | 0070 | PRAHA 3 | .313 |
| 132 | 0194 | ASKANIA H | .188 |
| 133 | 0197 | BERLIN 1 | .250 |
| 134 | 0441 | ASKANIA j | .188 |
| 135 | 0442 | ASKANIA k | .313 |
| 136 | 0120 | WASH 1 | .250 |
| 137 | 0179 | LONDON 3 | .000 |
| 138 | 0071 | PRAHA 4 | .313 |
| 139 | 0443 | ASKANIA i | .188 |
| 140 | 0444 | ASKANIA m | .188 |
| 141 | 0198 | BERLIN 2 | .250 |
| 142 | 0112 | YORK 13 | .250 |
| 143 | 0180 | LONDON 4 | .000 |
| 144 | 0225 | SIDNEY 4 | .250 |
| 145 | 0226 | SIDNEY 5 | .375 |
| 146 | 0445 | ASKANIA n | .188 |
| 147 | 0121 | WASH 2 | .250 |
| 148 | 0446 | ASKANIA o | .188 |
| 149 | 0447 | ASKANIA p | .250 |
| 150 | 0072 | PRAHA 5 | .313 |
| 151 | 0199 | BERLIN 3 | .250 |
| 152 | 0448 | ASKANIA r | .188 |
| 153 | 0449 | ASKANIA s | .188 |
| 154 | 0450 | ASKANIA t | .313 |
| 155 | 0181 | LONDON 5 | .000 |
| 156 | 0451 | ASKANIA u | .375 |
| 157 | 0193 | ASKANIA G | .125 |
| 158 | 0140 | HELL 13 | .406 |
| 159 | 0128 | HELL 1 | .000 |
| 160 | 0122 | WASH 3 | .250 |
| 161 | 0129 | HELL 2 | .000 |
| 162 | 0200 | BERLIN 4 | .250 |
| 163 | 0130 | HELL 3 | .000 |
| 164 | 0141 | HELL 14 | .000 |
| 165 | 0182 | LONDON 6 | .250 |
| 166 | 0123 | WASH 4 | .250 |
| 167 | 0131 | HELL 4 | .000 |
| 168 | 0073 | PRAHA 6 | .000 |
| 169 | 0230 | MONGOL | .000 |
| 170 | 0142 | HELL 15 | .000 |
| 171 | 0196 | WARSZAWA 1 | .313 |
| 172 | 0143 | HELL 16 | .484 |
| 173 | 0144 | HELL 17 | .000 |
| 174 | 0195 | ASKANIA J | .375 |
| 175 | 0132 | HELL 5 | .000 |
| 176 | 0201 | BERLIN 5 | .250 |
| 177 | 0452 | ASKANIA v | .375 |
| 178 | 0074 | PRAHA 7 | .000 |
| 179 | 0202 | BERLIN 6 | .250 |
| 180 | 0145 | HELL 18 | .000 |
| 181 | 0075 | PRAHA 8 | .000 |
| 182 | 0146 | HELL 19 | .000 |
| 183 | 0147 | HELL 20 | .000 |
| 184 | 0183 | LONDON 7 | .000 |
| 185 | 0148 | HELL 21 | .000 |
| 186 | 0076 | PRAHA 9 | .000 |
| 187 | 0149 | HELL 22 | .000 |
| 188 | 0150 | HELL 23 | .000 |
| 189 | 0151 | HELL 24 | .000 |
| 190 | 0152 | HELL 25 | .000 |
| 191 | 0231 | MONGOL 1 | .000 |
| 192 | 0153 | HELL 26 | .313 |
| 193 | 0154 | HELL 27 | .000 |
| 194 | 0155 | HELL 28 | .000 |
| 195 | 0134 | HELL 7 | .305 |
| 196 | 0133 | HELL 6 | .000 |
| 197 | 0156 | HELL 29 | .000 |
| 198 | 0157 | HELL 30 | .000 |
| 199 | 0135 | HELL 8 | .131 |
| 200 | 0077 | PRAHA 10 | .297 |

CANYON COLORADO EQUID SANCTUARY
FOR SPECIES: Przewalski Horse
PAGE: 3 MATRIX/KEY (STUDBOOK NO.) CROSS REFERENCE TABLE

| MAT# | KEY# | NAME | ICOEF |
|---|---|---|---|
| 201 | 0078 | PRAHA 11 | .219 |
| 202 | 0079 | PRAHA 12 | .266 |
| 203 | 0158 | HELL 31 | .156 |
| 204 | 0159 | HELL 32 | .156 |
| 205 | 0160 | HELL 33 | .305 |
| 206 | 0161 | HELL 34 | .156 |
| 207 | 0136 | HELL 9 | .000 |
| 208 | 0080 | PRAHA 13 | .297 |
| 209 | 0081 | PRAHA 14 | .266 |
| 210 | 0082 | PRAHA 15 | .219 |
| 211 | 0162 | HELL 35 | .313 |
| 212 | 0163 | HELL 36 | .313 |
| 213 | 0164 | HELL 37 | .313 |
| 214 | 0137 | HELL 10 | .000 |
| 215 | 0083 | PRAHA 16 | .219 |
| 216 | 0084 | PRAHA 17 | .297 |
| 217 | 0085 | PRAHA 18 | .266 |
| 218 | 0086 | PRAHA 19 | .297 |
| 219 | 0087 | PRAHA 20 | .266 |
| 220 | 0165 | HELL 38 | .188 |
| 221 | 0166 | HELL 39 | .156 |
| 222 | 0088 | PRAHA 21 | .219 |
| 223 | 0167 | HELL 40 | .156 |
| 224 | 0138 | HELL 11 | .000 |
| 225 | 0168 | HELL 41 | .188 |
| 226 | 0139 | HELL 12 | .078 |
| 227 | 0169 | HELL 42 | .156 |
| 228 | 0089 | PRAHA 22 | .297 |
| 229 | 0090 | PRAHA 23 | .266 |
| 230 | 0091 | PRAHA 24 | .219 |
| 231 | 0184 | LONDON 8 | .328 |
| 232 | 0170 | HELL 43 | .188 |
| 233 | 0171 | HELL 44 | .156 |
| 234 | 0219 | BLIJDORP 1 | .332 |
| 235 | 0092 | PRAHA 25 | .266 |
| 236 | 0185 | LONDON 9 | .328 |
| 237 | 0172 | HELL 45 | .250 |
| 238 | 0093 | PRAHA 26 | .309 |
| 239 | 0094 | PRAHA 27 | .309 |
| 240 | 0173 | HELL 46 | .156 |
| 241 | 0227 | CATSKILL 1 | .156 |
| 242 | 0220 | BLIJDORP 2 | .332 |
| 243 | 0228 | CATSKILL 2 | .188 |
| 244 | 0221 | ANVERS 1 | .398 |
| 245 | 0095 | PRAHA 28 | .266 |
| 246 | 0174 | HELL 47 | .250 |
| 247 | 0096 | PRAHA 29 | .297 |
| 248 | 0097 | PRAHA 30 | .309 |
| 249 | 0098 | PRAHA 31 | .309 |
| 250 | 0232 | BLIJDORP 3 | .332 |
| 251 | 0233 | PRAHA 32 | .297 |
| 252 | 0234 | PRAHA 33 | .309 |
| 253 | 0235 | PRAHA 34 | .266 |
| 254 | 0236 | PRAHA 35 | .309 |
| 255 | 0237 | HELL 48 | .250 |
| 256 | 0238 | BLIJDORP 4 | .482 |
| 257 | 0239 | BLIJDORP 5 | .332 |
| 258 | 0240 | ANVERS 2 | .328 |
| 259 | 0241 | HELL 49 | .328 |
| 260 | 0242 | CATSKILL 3 | .309 |
| 261 | 0243 | PRAHA 36 | .297 |
| 262 | 0244 | ASKANIA 1 | .000 |
| 263 | 0245 | PRAHA 37 | .309 |
| 264 | 0246 | LONDON 10 | .328 |
| 265 | 0247 | PRAHA 38 | .266 |
| 266 | 0248 | CATSKILL 4 | .305 |
| 267 | 0249 | CATSKILL 5 | .156 |
| 268 | 0250 | PRAHA 39 | .398 |
| 269 | 0251 | PRAHA 40 | .309 |
| 270 | 0252 | KOBEN 1 | .207 |
| 271 | 0253 | HELL 50 | .250 |
| 272 | 0254 | CATSKILL 6 | .328 |
| 273 | 0255 | PRAHA 41 | .309 |
| 274 | 0256 | ANVERS 3 | .328 |
| 275 | 0257 | BLIJDORP 6 | .482 |
| 276 | 0258 | PRAHA 42 | .309 |
| 277 | 0259 | ASKANIA 2 | .000 |
| 278 | 0260 | PRAHA 43 | .297 |
| 279 | 0261 | PRAHA 44 | .398 |
| 280 | 0262 | CATSKILL 7 | .250 |
| 281 | 0263 | CATSKILL 8 | .309 |
| 282 | 0264 | AMSTER 1 | .332 |
| 283 | 0265 | CATSKILL 9 | .156 |
| 284 | 0266 | CATSKILL 10 | .250 |
| 285 | 0267 | HELL 51 | .250 |
| 286 | 0268 | CATSKILL 11 | .305 |
| 287 | 0269 | PRAHA 45 | .266 |
| 288 | 0270 | PRAHA 46 | .297 |
| 289 | 0271 | PRAHA 47 | .309 |
| 290 | 0272 | BLIJDORP 7 | .482 |
| 291 | 0273 | PRAHA 48 | .398 |
| 292 | 0274 | KOBEN 2 | .207 |
| 293 | 0275 | CATSKILL 12 | .207 |
| 294 | 0276 | CATSKILL 13 | .250 |
| 295 | 0277 | CATSKILL 14 | .156 |
| 296 | 0278 | HELL 52 | .250 |
| 297 | 0279 | CATSKILL 15 | .328 |
| 298 | 0280 | ANVERS 4 | .328 |
| 299 | 0281 | PARIS 5 | .047 |
| 300 | 0282 | PRAHA 49 | .309 |

CANYON COLORADO EQUID SANCTUARY
FOR SPECIES: Przewalski Horse
MATRIX/KEY (STUDBOOK NO.) CROSS REFERENCE TABLE

| MAT# | KEY# | NAME | ICOEF |
|---|---|---|---|
| 301 | 0283 | PRAHA 50 | .398 |
| 302 | 0284 | BLIJDORP 8 | .482 |
| 303 | 0285 | ASKANIA 3 | .000 |
| 304 | 0286 | PRAHA 51 | .266 |
| 305 | 0287 | PRAHA 52 | .459 |
| 306 | 0288 | PRAHA 53 | .459 |
| 307 | 0289 | ASKANIA 4 | .250 |
| 308 | 0290 | PRAHA 54 | .297 |
| 309 | 0291 | PRAHA 55 | .309 |
| 310 | 0292 | CATSKILL 16 | .309 |
| 311 | 0293 | CATSKILL 17 | .305 |
| 312 | 0294 | HELL 53 | .250 |
| 313 | 0295 | HELL 54 | .242 |
| 314 | 0296 | PRAHA 56 | .383 |
| 315 | 0297 | KOBEN 3 | .207 |
| 316 | 0298 | CATSKILL 18 | .207 |
| 317 | 0299 | CATSKILL 19 | .328 |
| 318 | 0300 | CATSKILL 20 | .402 |
| 319 | 0301 | CATSKILL 21 | .250 |
| 320 | 0302 | CATSKILL 22 | .156 |
| 321 | 0303 | PRAHA 57 | .398 |
| 322 | 0304 | BERLIN-O. 1 | .332 |
| 323 | 0305 | ANVERS 5 | .328 |
| 324 | 0306 | PRAHA 58 | .309 |
| 325 | 0307 | BLIJDORP 9 | .558 |
| 326 | 0308 | BLIJDORP 10 | .482 |
| 327 | 0309 | PRAHA 59 | .309 |
| 328 | 0310 | PRAHA 60 | .398 |
| 329 | 0311 | PRAHA 61 | .309 |
| 330 | 0312 | PRAHA 62 | .297 |
| 331 | 0313 | ASKANIA 5 | .250 |
| 332 | 0314 | PRAHA 63 | .309 |
| 333 | 0315 | PRAHA 64 | .266 |
| 334 | 0316 | CATSKILL 23 | .305 |
| 335 | 0317 | CATSKILL 24 | .207 |
| 336 | 0318 | PRAHA 65 | .459 |
| 337 | 0319 | CATSKILL 25 | .309 |
| 338 | 0320 | CATSKILL 26 | .250 |
| 339 | 0321 | ASKANIA 6 | .000 |
| 340 | 0322 | HELL 55 | .328 |
| 341 | 0323 | PRAHA 66 | .398 |
| 342 | 0324 | PRAHA 67 | .383 |
| 343 | 0325 | PRAHA 68 | .406 |
| 344 | 0326 | ANVERS 6 | .328 |
| 345 | 0327 | LEIPZIG 1 | .469 |
| 346 | 0328 | PRAHA 69 | .309 |
| 347 | 0329 | CATSKILL 27 | .328 |
| 348 | 0330 | BERLIN O 2 | .332 |
| 349 | 0331 | PRAHA 70 | .398 |
| 350 | 0332 | PRAHA 71 | .297 |
| 351 | 0333 | ASKANIA 7 | .250 |
| 352 | 0334 | CATSKILL 28 | .195 |
| 353 | 0335 | PRAHA 72 | .309 |
| 354 | 0336 | BLIJDROP 11 | .482 |
| 355 | 0337 | PRAHA 73 | .309 |
| 356 | 0338 | HELL 56 | .250 |
| 357 | 0339 | CATSKILL 29 | .207 |
| 358 | 0340 | HELL 57 | .242 |
| 359 | 0341 | CATSKILL 30 | .250 |
| 360 | 0342 | PRAHA 74 | .383 |
| 361 | 0343 | AMSTER 2 | .486 |
| 362 | 0344 | PRAHA 75 | .459 |
| 363 | 0345 | ANVERS 7 | .328 |
| 364 | 0346 | BLIJDORP 12 | .558 |
| 365 | 0347 | LEIPZIG 2 | .469 |
| 366 | 0348 | WASS 1 | .566 |
| 367 | 0349 | LONDON 11 | .355 |
| 368 | 0350 | LONDON 12 | .355 |
| 369 | 0351 | LONDON 13 | .342 |
| 370 | 0352 | ASKANIA 8 | .047 |
| 371 | 0353 | PRAHA 76 | .504 |
| 372 | 0354 | PRAHA 77 | .398 |
| 373 | 0355 | PRAHA 78 | .309 |
| 374 | 0356 | BLIJDORP 13 | .482 |
| 375 | 0357 | CATSKILL 31 | .311 |
| 376 | 0358 | HELL 58 | .250 |
| 377 | 0359 | PRAHA 79 | .309 |
| 378 | 0360 | AMSTER 3 | .490 |
| 379 | 0361 | CATSKILL 32 | .309 |
| 380 | 0362 | CATSKILL 33 | .402 |
| 381 | 0365 | HELL 59 | .328 |
| 382 | 0363 | PRAHA 80 | .398 |
| 383 | 0364 | KOBEN 4 | .207 |
| 384 | 0366 | CATSKILL 34 | .328 |
| 385 | 0367 | PRAHA 81 | .398 |
| 386 | 0646 | LONDON 32 | .355 |
| 387 | 0368 | CATSKILL 35 | .207 |
| 388 | 0369 | WASH-TANK 1 | .195 |
| 389 | 0370 | LEIPZIG 3 | .469 |
| 390 | 0371 | AMSTER 4 | .486 |
| 391 | 0372 | PRAHA 82 | .309 |
| 392 | 0373 | CATSKILL 36 | .195 |
| 393 | 0374 | PRAHA 83 | .332 |
| 394 | 0375 | BERLIN-O 3 | .047 |
| 395 | 0376 | PRAHA 84 | .504 |
| 396 | 0377 | PRAHA 85 | .035 |
| 397 | 0378 | HELL 60 | .242 |
| 398 | 0379 | BLIJDORP 14 | .558 |
| 399 | 0380 | CATSKILL 37 | .195 |
| 400 | 0381 | CATSKILL 38 | .250 |

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MATRIX/KEY (STUDBOOK NO.) CROSS REFERENCE TABLE

| MAT# | KEY# | NAME | ICOEF |
|---|---|---|---|
| 401 | 0382 | WASS 2 | .566 |
| 402 | 0383 | HELL 61 | .250 |
| 403 | 0384 | CATSKILL 39 | .402 |
| 404 | 0385 | HABANA 1 | .403 |
| 405 | 0386 | PRAHA 86 | .023 |
| 406 | 0387 | PRAHA 87 | .047 |
| 407 | 0388 | PRAHA 88 | .047 |
| 408 | 0389 | LONDON 14 | .342 |
| 409 | 0390 | LONDON 15 | .355 |
| 410 | 0391 | ASKANIA 9 | .023 |
| 411 | 0392 | CATSKILL 40 | .328 |
| 412 | 0393 | PRAHA 89 | .023 |
| 413 | 0394 | HELL 62 | .242 |
| 414 | 0395 | PRAHA 90 | .035 |
| 415 | 0396 | PRAHA 91 | .332 |
| 416 | 0397 | HELL 63 | .250 |
| 417 | 0398 | KOLN 1 | .464 |
| 418 | 0399 | PRAHA 92 | .398 |
| 419 | 0400 | PRAHA 93 | .047 |
| 420 | 0401 | LONDON 16 | .355 |
| 421 | 0402 | BLIJDORP 15 | .482 |
| 422 | 0403 | PRAHA 94 | .023 |
| 423 | 0404 | LEIPZIG 4 | .469 |
| 424 | 0405 | BLIJDORP 16 | .558 |
| 425 | 0406 | SAN DIEGO 1 | .334 |
| 426 | 0407 | CATSKILL 41 | .250 |
| 427 | 0408 | CATSKILL 42 | .195 |
| 428 | 0409 | LONDON 17 | .342 |
| 429 | 0417 | CATSKILL 56 | .309 |
| 430 | 0410 | CATSKILL 43 | .328 |
| 431 | 0411 | HELL. 64 | .242 |
| 432 | 0412 | PRAHA 95 | .023 |
| 433 | 0413 | LONDON 18 | .355 |
| 434 | 0414 | PRAHA 96 | .035 |
| 435 | 0415 | KOLN 2 | .464 |
| 436 | 0416 | WARSZAWA 2 | .330 |
| 437 | 0457 | PARIS 6 | .330 |
| 438 | 0458 | SAN DIEGO 2 | .235 |
| 439 | 0459 | WASS 3 | .566 |
| 440 | 0460 | LEIPZIG 5 | .469 |
| 441 | 0461 | ANVERS 8 | .354 |
| 442 | 0462 | PRAHA 97 | .047 |
| 443 | 0463 | PRAHA 98 | .023 |
| 444 | 0464 | PARIS 7 | .192 |
| 445 | 0465 | LEIPZIG 6 | .029 |
| 446 | 0466 | PARIS 8 | .200 |
| 447 | 0467 | NURNBERG 1 | .342 |
| 448 | 0468 | PRAHA 99 | .398 |
| 449 | 0469 | CATSKILL 44 | .207 |
| 450 | 0485 | KOBEN 5 | .207 |
| 451 | 0470 | CATSKILL 45 | .195 |
| 452 | 0471 | PRAHA 100 | .023 |
| 453 | 0472 | PRAHA 101 | .406 |
| 454 | 0473 | SAN DIEGO 3 | .334 |
| 455 | 0474 | ANVERS 9 | .342 |
| 456 | 0475 | LONDON 19 | .355 |
| 457 | 0476 | CATSKILL 46 | .328 |
| 458 | 0477 | LONDON 20 | .342 |
| 459 | 0478 | HELL. 65 | .242 |
| 460 | 0479 | BERLIN-O. 4 | .047 |
| 461 | 0480 | CATSKILL 47 | .195 |
| 462 | 0481 | PRAHA 102 | .035 |
| 463 | 0482 | WARSZAWA 3 | .330 |
| 464 | 0483 | PRAHA 103 | .330 |
| 465 | 0484 | KOLN 3 | .464 |
| 466 | 0509 | BLIJDROP 17 | .558 |
| 467 | 0486 | PRAHA 104 | .047 |
| 468 | 0487 | SAN DIEGO 4 | .235 |
| 469 | 0488 | PRAHA 105 | .023 |
| 470 | 0489 | ASKANIA 10 | .035 |
| 471 | 0490 | ASKANIA 11 | .375 |
| 472 | 0491 | MARWELL 1 | .354 |
| 473 | 0492 | PRAHA 106 | .023 |
| 474 | 0493 | PRAHA 107 | .023 |
| 475 | 0494 | CATSKILL 48 | .289 |
| 476 | 0495 | LONDON 21 | .355 |
| 477 | 0496 | BROOK. 1 | .209 |
| 478 | 0497 | HOWLETTS 1 | .398 |
| 479 | 0498 | CATSKILL 49 | .250 |
| 480 | 0499 | HOWLETTS 2 | .354 |
| 481 | 0500 | LONDON 22 | .342 |
| 482 | 0501 | CATSKILL 50 | .172 |
| 483 | 0502 | LONDON 23 | .355 |
| 484 | 0503 | HELL 66 | .250 |
| 485 | 0504 | SAN DIEGO 5 | .334 |
| 486 | 0505 | CATSKILL 51 | .289 |
| 487 | 0506 | HOWLETTS 3 | .262 |
| 488 | 0507 | RIGA 1 | .332 |
| 489 | 0508 | MARWELL 2 | .330 |
| 490 | 0510 | PARIS 9 | .192 |
| 491 | 0511 | PRAHA 108 | .047 |
| 492 | 0512 | WARSZAWA 4 | .330 |
| 493 | 0513 | ANVERS 10 | .354 |
| 494 | 0514 | ANVERS 11 | .342 |
| 495 | 0515 | BERLIN-OST 5 | .047 |
| 496 | 0516 | HOWLETTS 4 | .354 |
| 497 | 0517 | MARWELL 3 | .039 |
| 498 | 0518 | KOLN 4 | .464 |
| 499 | 0519 | PRAHA 109 | .023 |
| 500 | 0520 | PARIS 10 | .330 |

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| MAT# | KEY# | NAME | ICOEF |
|---|---|---|---|
| 501 | 0521 | PARIS 11 | .200 |
| 502 | 0522 | MARWELL 4 | .000 |
| 503 | 0523 | PRAHA 110 | .023 |
| 504 | 0524 | ASKANIA 12 | .375 |
| 505 | 0525 | ASKANAIA 13 | .035 |
| 506 | 0526 | BROOK 2 | .209 |
| 507 | 0527 | MARWELL 5 | .000 |
| 508 | 0528 | ASKANIA 14 | .070 |
| 509 | 0529 | MARWELL 6 | .039 |
| 510 | 0530 | LONDON 24 | .342 |
| 511 | 0531 | SALZBURG 1 | .012 |
| 512 | 0532 | CATSKILL 52 | .207 |
| 513 | 0533 | CATSKILL 53 | .289 |
| 514 | 0534 | CATSKILL 54 | .195 |
| 515 | 0535 | CATSKILL 55 | .328 |
| 516 | 0536 | WASS 4 | .566 |
| 517 | 0537 | NURNBERG 2 | .029 |
| 518 | 0538 | LONDON 25 | .355 |
| 519 | 0539 | MARWELL 7 | .000 |
| 520 | 0540 | PRAHA 111 | .023 |
| 521 | 0541 | CATSKILL 57 | .193 |
| 522 | 0542 | HOWLETTS 5 | .221 |
| 523 | 0543 | NURNBERG 3 | .039 |
| 524 | 0570 | WARSZAWA 5 | .330 |
| 525 | 0544 | HOWLETTS 6 | .354 |
| 526 | 0545 | CATSKILL 58 | .250 |
| 527 | 0546 | MARWELL 8 | .039 |
| 528 | 0547 | LEIPZIG 7 | .414 |
| 529 | 0548 | ASKANIA 15 | .250 |
| 530 | 0549 | BROOK. 3 | .209 |
| 531 | 0550 | ASKANIA 16 | .023 |
| 532 | 0551 | PRAHA 112 | .023 |
| 533 | 0552 | ASKANIA 17 | .047 |
| 534 | 0553 | BERLIN-O. 6 | .047 |
| 535 | 0554 | MARWELL 9 | .000 |
| 536 | 0555 | MARWELL 10 | .000 |
| 537 | 0556 | SALZBURG 2 | .012 |
| 538 | 0557 | HELL. 67 | .250 |
| 539 | 0558 | PRAHA 113 | .262 |
| 540 | 0559 | MARWELL 11 | .039 |
| 541 | 0560 | ANVERS 12 | .354 |
| 542 | 0561 | PARIS 12 | .192 |
| 543 | 0562 | NURNBERG 4 | .077 |
| 544 | 0563 | LEIPZIG 8 | .029 |
| 545 | 0564 | MARWELL 12 | .000 |
| 546 | 0565 | HELL.68 | .242 |
| 547 | 0569 | SAN DIEGO 6 | .334 |
| 548 | 0566 | CATSKILL 59 | .252 |
| 549 | 0567 | CATSKILL 60 | .311 |
| 550 | 0568 | CATSKILL 61 | .226 |
| 551 | 0571 | MARWELL 13 | .000 |
| 552 | 0572 | KOLN 5 | .597 |
| 553 | 0573 | HOWLETTS 7 | .221 |
| 554 | 0574 | NURNBERG 5 | .029 |
| 555 | 0575 | HOWLETTS 8 | .354 |
| 556 | 0576 | ARNHEM 1 | .349 |
| 557 | 0577 | PRAHA 114 | .023 |
| 558 | 0578 | MARWELL 14 | .000 |
| 559 | 0579 | NURNBERG 6 | .039 |
| 560 | 0580 | HELL 69 | .309 |
| 561 | 0581 | LONDON 26 | .355 |
| 562 | 0582 | LONDON 27 | .330 |
| 563 | 0583 | PRAHA 115 | .262 |
| 564 | 0584 | MARWELL 15 | .039 |
| 565 | 0585 | HOWLETTS 9 | .354 |
| 566 | 0586 | LONDON 28 | .405 |
| 567 | 0587 | HOWLETTS 10 | .221 |
| 568 | 0588 | PRAHA 116 | .023 |
| 569 | 0589 | PRAHA 117 | .262 |
| 570 | 0590 | PRAHA 118 | .023 |
| 571 | 0591 | MARWELL 16 | .039 |
| 572 | 0592 | LEIPZIG 9 | .414 |
| 573 | 0593 | PARIS 13 | .200 |
| 574 | 0594 | MARWELL 17 | .000 |
| 575 | 0595 | PRAHA 119 | .268 |
| 576 | 0596 | LEIPZIG 10 | .029 |
| 577 | 0597 | NURNBERG 7 | .077 |
| 578 | 0598 | LONDON 29 | .469 |
| 579 | 0599 | HOWLETTS 11 | .121 |
| 580 | 0600 | ASKANIA 18 | .023 |
| 581 | 0601 | ASKANIA 19 | .250 |
| 582 | 0602 | ASKANIA 20 | .137 |
| 583 | 0603 | SAN DIEGO 7 | .285 |
| 584 | 0647 | SALZBURG 5 | .012 |
| 585 | 0604 | SAN DIEGO 8 | .365 |
| 586 | 0605 | ASKANIA 21 | .047 |
| 587 | 0606 | ASKANIA 22 | .250 |
| 588 | 0607 | HELL 70 | .410 |
| 589 | 0608 | CATSKILL 62 | .311 |
| 590 | 0609 | BLIJDORP 18 | .143 |
| 591 | 0610 | MARWELL 18 | .000 |
| 592 | 0611 | BERLIN-OST 7 | .047 |
| 593 | 0612 | NURNBERG 8 | .029 |
| 594 | 0613 | MARWELL 19 | .000 |
| 595 | 0614 | SAN DIEGO 9 | .218 |
| 596 | 0615 | LONDON 30 | .405 |
| 597 | 0616 | CATSKILL 63 | .311 |
| 598 | 0617 | PRAHA 120 | .262 |
| 599 | 0618 | CATSKILL 64 | .252 |
| 600 | 0619 | MARWELL 20 | .000 |

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| MAT# | KEY# | NAME | ICOEF |
|---|---|---|---|
| 601 | 0795 | AALBORG 1 | .012 |
| 602 | 0620 | ASKANIA 23 | .137 |
| 603 | 0621 | PARIS 14 | .200 |
| 604 | 0622 | HELL 71 | .246 |
| 605 | 0623 | PARIS 15 | .192 |
| 606 | 0624 | ASKANIA 24 | .361 |
| 607 | 0625 | MARWELL 21 | .039 |
| 608 | 0626 | YORK 14 | .252 |
| 609 | 0627 | MARWELL 22 | .039 |
| 610 | 0628 | LEIPZIG 11 | .029 |
| 611 | 0629 | HOWLETTS 12 | .221 |
| 612 | 0630 | HOWLETTS 13 | .221 |
| 613 | 0631 | PRAHA 121 | .035 |
| 614 | 0632 | NURNBERG 9 | .077 |
| 615 | 0633 | KOLN 6 | .597 |
| 616 | 0645 | SALZBURG 3 | .012 |
| 617 | 0634 | PRAHA 122 | .262 |
| 618 | 0635 | YORK 15 | .252 |
| 619 | 0636 | ASKANIA 25 | .252 |
| 620 | 0637 | ASKANIA 26 | .183 |
| 621 | 0638 | SAN DIEGO 10 | .285 |
| 622 | 0639 | SAN DIEGO 11 | .365 |
| 623 | 0640 | HELL 72 | .309 |
| 624 | 0641 | OBERWIL 1 | .023 |
| 625 | 0642 | PRAHA 123 | .273 |
| 626 | 0643 | LONDON 31 | .510 |
| 627 | 0644 | KOLN 7 | .464 |
| 628 | 0648 | CATSKILL 65 | .334 |
| 629 | 0649 | NURNBERG 10 | .039 |
| 630 | 0672 | WARSZAWA 6 | .487 |
| 631 | 0650 | HOWLETTS 14 | .354 |
| 632 | 0651 | NURNBERG 11 | .029 |
| 633 | 0652 | ASKANIA 27 | .361 |
| 634 | 0653 | ASKANIA 28 | .137 |
| 635 | 0654 | HABANA 2 | .547 |
| 636 | 0655 | BERLIN-OST 8 | .313 |
| 637 | 0656 | ASKANIA 29 | .140 |
| 638 | 0657 | LENINGRAD 1 | .326 |
| 639 | 0658 | LEIPZIG 12 | .520 |
| 640 | 0659 | LEIPZIG 13 | .414 |
| 641 | 0660 | NURNBERG 12 | .327 |
| 642 | 0661 | OBERWIL 2 | .057 |
| 643 | 0662 | LEIPZIG 14 | .327 |
| 644 | 0663 | MARWELL 23 | .346 |
| 645 | 0664 | PRAHA 124 | .262 |
| 646 | 0665 | ARNHEM 2 | .242 |
| 647 | 0666 | ASKANIA 30 | .163 |
| 648 | 0667 | LONDON 33 | .094 |
| 649 | 0668 | LONDON 34 | .110 |
| 650 | 0669 | SAN DIEGO 12 | .334 |
| 651 | 0670 | OBERWIL 3 | .023 |
| 652 | 0671 | LEIPZIG 15 | .029 |
| 653 | 0673 | ASKANIA 31 | .252 |
| 654 | 0674 | LONDON 35 | .105 |
| 655 | 0675 | ASKANIA 32 | .183 |
| 656 | 0676 | MARWELL 24 | .000 |
| 657 | 0677 | NURNBERG 13 | .077 |
| 658 | 0678 | SAN DIEGO 13 | .285 |
| 659 | 0679 | KOLN 8 | .597 |
| 660 | 0680 | HOWLETTS 15 | .221 |
| 661 | 0681 | ANVERS 13 | .504 |
| 662 | 0682 | HELL 73 | .309 |
| 663 | 0683 | YORK 16 | .252 |
| 664 | 0684 | PRAHA 125 | .262 |
| 665 | 0685 | SAN DIEGO 14 | .365 |
| 666 | 0686 | SAN DIEGO 15 | .218 |
| 667 | 0687 | SALZBURG 4 | .012 |
| 668 | 0688 | YORK 17 | .252 |
| 669 | 0689 | LONDON 36 | .105 |
| 670 | 0690 | PARIS 16 | .308 |
| 671 | 0691 | CATSKILL 66 | .311 |
| 672 | 0738 | SAN DIEGO 21 | .365 |
| 673 | 0692 | KOLN 9 | .464 |
| 674 | 0693 | HOWELETTS 16 | .120 |
| 675 | 0694 | MARWELL 25 | .000 |
| 676 | 0695 | LONDON 37 | .355 |
| 677 | 0696 | ARNHEM 3 | .219 |
| 678 | 0697 | MARWELL 26 | .039 |
| 679 | 0699 | OBERWIL 4 | .023 |
| 680 | 0700 | MARWELL 27 | .346 |
| 681 | 0701 | MEMPHIS 1 | .316 |
| 682 | 0698 | HOWLETTS 17 | .199 |
| 683 | 0702 | ASKANIA 33 | .137 |
| 684 | 0703 | HELL 74 | .391 |
| 685 | 0704 | BERLIN-O 9 | .313 |
| 686 | 0705 | LONDON 38 | .105 |
| 687 | 0706 | ASKANIA 34 | .140 |
| 688 | 0707 | WARSZAWA 7 | .487 |
| 689 | 0708 | ARNHEM 4 | .242 |
| 690 | 0709 | ASKANIA 35 | .163 |
| 691 | 0796 | AALBORG 2 | .012 |
| 692 | 0710 | ASKANIA 36 | .361 |
| 693 | 0711 | ASKANIA 37 | .140 |
| 694 | 0712 | SAN DIEGO 16 | .285 |
| 695 | 0713 | SAN DIEGO 17 | .365 |
| 696 | 0714 | ASKANIA 38 | .183 |
| 697 | 0715 | LEIPZIG 16 | .327 |
| 698 | 0716 | OBERWIL 5 | .057 |
| 699 | 0717 | LEIPZIG 17 | .029 |
| 700 | 0718 | MARWELL 28 | .039 |

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| MAT# | KEY# | NAME | ICOEF |
|---|---|---|---|
| 701 | 0719 | LEIPZIG 18 | .520 |
| 702 | 0720 | HOWLETTS 18 | .376 |
| 703 | 0721 | HOWLETTS 19 | .210 |
| 704 | 0722 | YORK 18 | .418 |
| 705 | 0723 | YORK 19 | .418 |
| 706 | 0724 | YORK 20 | .252 |
| 707 | 0725 | LONDON 39 | .110 |
| 708 | 0726 | NURNBERG 14 | .327 |
| 709 | 0727 | PRAHA 126 | .273 |
| 710 | 0728 | PRAHA 127 | .262 |
| 711 | 0729 | HABANA 3 | .547 |
| 712 | 0730 | SAN DIEGO 18 | .235 |
| 713 | 0731 | YORK 21 | .252 |
| 714 | 0732 | SAN DIEGO 19 | .334 |
| 715 | 0733 | LONDON 40 | .105 |
| 716 | 0734 | LENINGRAD 2 | .246 |
| 717 | 0735 | BLIJDROP 19 | .143 |
| 718 | 0736 | CATSKILL 67 | .311 |
| 719 | 0737 | SAN DIEGO 20 | .218 |
| 720 | 0739 | NURNBERG 15 | .029 |
| 721 | 0740 | NURNBERG 16 | .039 |
| 722 | 0741 | NURNBERG 17 | .077 |
| 723 | 0742 | BERN 1 | .263 |
| 724 | 0743 | ARNHEM 5 | .219 |
| 725 | 0744 | BERLIN-OST 10 | .047 |
| 726 | 0745 | LONDON 41 | .097 |
| 727 | 0746 | MARWELL 29 | .346 |
| 728 | 0747 | MARWELL 30 | .000 |
| 729 | 0797 | AALBORG 3 | .012 |
| 730 | 0748 | LONDON 42 | .102 |
| 731 | 0749 | MARWELL 31 | .039 |
| 732 | 0750 | BERLIN-OST 11 | .313 |
| 733 | 0751 | OBERWIL 6 | .023 |
| 734 | 0752 | WARSZAWA 8 | .487 |
| 735 | 0753 | TOPEKA 1 | .306 |
| 736 | 0754 | HELL 75 | .391 |
| 737 | 0755 | HOWLETTS 20 | .120 |
| 738 | 0756 | BERLIN-OST 12 | .313 |
| 739 | 0757 | HOWLETTS 21 | .199 |
| 740 | 0758 | ARNHEM 6 | .242 |
| 741 | 0759 | LONDON 43 | .094 |
| 742 | 0760 | SAN DIEGO 22 | .285 |
| 743 | 0761 | FROSON 1 | .224 |
| 744 | 0762 | MOSKVA 4 | .196 |
| 745 | 0763 | NURNBERG 18 | .309 |
| 746 | 0764 | ASKANIA 39 | .318 |
| 747 | 0765 | ASKANIA 40 | .375 |
| 748 | 0766 | ASKANIA 41 | .375 |
| 749 | 0767 | ASKANIA 42 | .262 |
| 750 | 0768 | HELL 76 | .309 |
| 751 | 0769 | MARWELL 32 | .000 |
| 752 | 0770 | MARWELL 33 | .039 |
| 753 | 0771 | ASKANIA 43 | .148 |
| 754 | 0772 | STUTTGART 1 | .262 |
| 755 | 0773 | ASKANIA 44 | .250 |
| 756 | 0774 | MARWELL 34 | .000 |
| 757 | 0775 | HOWLETTS 22 | .210 |
| 758 | 0776 | HOWLETTS 23 | .376 |
| 759 | 0777 | HELL 77 | .391 |
| 760 | 0778 | LONDON 44 | .097 |
| 761 | 0779 | CHESTER 1 | .165 |
| 762 | 0780 | BLIJDORP 20 | .194 |
| 763 | 0781 | SAN DIEGO 23 | .365 |
| 764 | 0782 | LONDON 45 | .105 |
| 765 | 0783 | LONDON 46 | .110 |
| 766 | 0784 | OBERWILL 7 | .057 |
| 767 | 0785 | LONDON 47 | .105 |
| 768 | 0786 | NURNBERG 19 | .327 |
| 769 | 0787 | HELL 78 | .410 |
| 770 | 0788 | LEIPZIG 19 | .414 |
| 771 | 0789 | LEIPZIG 20 | .029 |
| 772 | 0790 | KIEV 1 | .166 |
| 773 | 0791 | LONDON 48 | .355 |
| 774 | 0792 | PARIS 17 | .308 |
| 775 | 0793 | WIEN 1 | .235 |
| 776 | 0794 | NURNBERG 20 | .029 |
| 777 | 0800 | BERN 2 | .146 |
| 778 | 0801 | BERN 3 | .263 |
| 779 | 0802 | TALLINN 1 | .188 |
| 780 | 0803 | SABABURG 1 | .039 |
| 781 | 0804 | BERLIN-WEST 1 | .235 |
| 782 | 0805 | MARWELL 35 | .346 |
| 783 | 0806 | LEIPZIG 21 | .327 |
| 784 | 0807 | ARNHEM 7 | .219 |
| 785 | 0808 | MARWELL 36 | .225 |
| 786 | 0809 | WARSZAWA 9 | .487 |
| 787 | 0810 | LENINGRAD 3 | .246 |
| 788 | 0811 | LONDON 49 | .102 |
| 789 | 0812 | SAN DIEGO 24 | .365 |
| 790 | 0813 | AALBORG 4 | .012 |
| 791 | 0814 | LONDON 50 | .094 |
| 792 | 0815 | LEIPZIG 22 | .520 |
| 793 | 0816 | MARWELL 37 | .239 |
| 794 | 0817 | BERLIN-OST 13 | .313 |
| 795 | 0818 | CATSKILL 68 | .203 |
| 796 | 0819 | LONDON 51 | .097 |
| 797 | 0820 | NURNBERG 21 | .077 |
| 798 | 0821 | ASKANIA 45 | .256 |
| 799 | 0822 | SAN DIEGO 25 | .285 |
| 800 | 0823 | ASKANIA 46 | .137 |

CANYON COLORADO EQUID SANCTUARY
FOR SPECIES: Przewalski Horse
MATRIX/KEY (STUDBOOK NO.) CROSS REFERENCE TABLE

| MAT# | KEY# | NAME | ICOEF |
|---|---|---|---|
| 801 | 0824 | CHESTER 2 | .165 |
| 802 | 0825 | HOWLETTS 24 | .376 |
| 803 | 0826 | ASKANIA 47 | .375 |
| 804 | 0827 | DUISBURG 1 | .262 |
| 805 | 0828 | MARWELL 38 | .039 |
| 806 | 0829 | MARWELL 39 | .000 |
| 807 | 0830 | WIEN 2 | .185 |
| 808 | 0831 | ASKANIA 48 | .250 |
| 809 | 0832 | ASKANIA 49 | .375 |
| 810 | 0833 | HELL 79 | .309 |
| 811 | 0834 | MARWELL 40 | .000 |
| 812 | 0835 | ASKANIA 50 | .318 |
| 813 | 0836 | HOWLETTS 25 | .199 |
| 814 | 0837 | MOSKVA 5 | .196 |
| 815 | 0838 | HOWLETTS 26 | .210 |
| 816 | 0839 | ASKANIA 51 | .201 |
| 817 | 0840 | SAN DIEGO 26 | .341 |
| 818 | 0841 | SAN DIEGO 27 | .365 |
| 819 | 0842 | ASKANIA 52 | .047 |
| 820 | 0843 | ASKANIA 53 | .250 |
| 821 | 0844 | HOWLETTS 27 | .120 |
| 822 | 0845 | MARWELL 41 | .039 |
| 823 | 0846 | NEW YORK 22 | .280 |
| 824 | 0847 | LONDON 52 | .105 |
| 825 | 0848 | HELL 80 | .391 |
| 826 | 0849 | LONDON 53 | .097 |
| 827 | 0850 | OBERWIL 8 | .057 |
| 828 | 0851 | LONDON 54 | .105 |
| 829 | 0852 | ARNHEM 8 | .242 |
| 830 | 0853 | HELL 81 | .410 |
| 831 | 0854 | LONDON 55 | .110 |
| 832 | 0855 | MARWELL 42 | .000 |
| 833 | 0856 | SPRINGE 1 | .327 |
| 834 | 0857 | LEIPZIG 23 | .414 |
| 835 | 0858 | YORK 23 | .252 |
| 836 | 0859 | STUTTGART 2 | .262 |
| 837 | 0860 | PRAHA 128 | .262 |
| 838 | 0861 | NURNBERG 22 | .351 |
| 839 | 0862 | PRAHA 129 | .273 |
| 840 | 0863 | SABABURG 2 | .173 |
| 841 | 0864 | PARIS 18 | .308 |
| 842 | 0865 | MARWELL 43 | .238 |
| 843 | 0866 | LONDON 56 | .355 |
| 844 | 0867 | NEW YORK 24 | .418 |
| 845 | 0868 | WIEN 3 | .235 |
| 846 | 0869 | SAN DIEGO 28 | .448 |
| 847 | 0870 | OBERWIL 9 | .023 |
| 848 | 0871 | BERLIN-WEST 2 | .235 |
| 849 | 0872 | BERN 4 | .263 |
| 850 | 0873 | WARSZAWA 10 | .576 |
| 851 | 0874 | BLIJDORP 21 | .194 |
| 852 | 0875 | SABABURG 3 | .196 |
| 853 | 0876 | OBERWILL 10 | .023 |
| 854 | 0877 | LONDON 57 | .102 |
| 855 | 0878 | BLIJDROP 22 | .143 |
| 856 | 0879 | SAN DIEGO 29 | .265 |
| 857 | 0880 | OBERWIL 11 | .051 |
| 858 | 0881 | BERN 5 | .146 |
| 859 | 0882 | LEIPZIG 24 | .327 |
| 860 | 0883 | LEIPZIG 25 | .327 |
| 861 | 0884 | MARWELL 44 | .346 |
| 862 | 0885 | HELSINKI 1 | .287 |
| 863 | 0886 | MINNESOTA 1 | .296 |
| 864 | 0887 | TOPEKA 2 | .306 |
| 865 | 0888 | WARSZAWA 11 | .177 |
| 866 | 0889 | LEIPZIG 26 | .520 |
| 867 | 0890 | MARWELL 45 | .225 |
| 868 | 0891 | ROSTOV 1 | .303 |
| 869 | 0892 | SAN DIEGO 30 | .285 |
| 870 | 0893 | ASKANIA 54 | .375 |
| 871 | 0894 | HOWLETTS 28 | .199 |
| 872 | 0895 | WARSZAWA 12 | .487 |
| 873 | 0896 | ASKANIA 55 | .256 |
| 874 | 0897 | HELL 82 | .309 |
| 875 | 0898 | ASKANIA 56 | .256 |
| 876 | 0899 | LONDON 58 | .097 |
| 877 | 0900 | ASKANIA 57 | .137 |
| 878 | 0901 | ASKANIA 58 | .375 |
| 879 | 0902 | DUISBURG 2 | .262 |
| 880 | 0903 | HELL 83 | .391 |
| 881 | 0904 | NURNBERG 23 | .077 |
| 882 | 0905 | ASKANIA 59 | .250 |
| 883 | 0906 | YORK 25 | .438 |
| 884 | 0907 | SAN DIEGO 31 | .341 |
| 885 | 0908 | BERLIN-OST 14 | .313 |
| 886 | 0909 | MINNESOTA 2 | .046 |
| 887 | 0910 | HOWLETTS 29 | .376 |
| 888 | 0911 | CHESTER 3 | .165 |
| 889 | 0912 | MARWELL 46 | .039 |
| 890 | 0913 | LONDON 59 | .105 |
| 891 | 0914 | HOWLETTS 30 | .210 |
| 892 | 0915 | KOLN 10 | .054 |
| 893 | 0916 | MARWELL 47 | .000 |
| 894 | 0917 | CATSKILL 69 | .241 |
| 895 | 0918 | MARWELL 48 | .000 |
| 896 | 0919 | OBERWIL 12 | .057 |
| 897 | 0920 | MARWELL 49 | .039 |
| 898 | 0921 | CATSKILL 70 | .352 |
| 899 | 0922 | OBERWIL 13 | .225 |
| 900 | 0923 | HOWLETTS 31 | .120 |

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MATRIX/KEY (STUDBOOK NO.) CROSS REFERENCE TABLE

| MAT# | KEY# | NAME | ICOEF |
|---|---|---|---|
| 901 | 0924 | ARNHEM 9 | .242 |
| 902 | 0925 | WIEN 4 | .185 |
| 903 | 0926 | LEIPZIG 27 | .414 |
| 904 | 0927 | MARWELL 50 | .000 |
| 905 | 0928 | LONDON 60 | .105 |
| 906 | 0930 | LENINGRAD 4 | .246 |
| 907 | 0931 | NURNBERG 24 | .029 |
| 908 | 0932 | HELL 84 | .410 |
| 909 | 0933 | YORK 26 | .280 |
| 910 | 0934 | NURNBERG 25 | .309 |
| 911 | 0935 | HOWLETTS 32 | .357 |
| 912 | 0936 | HELL 85 | .391 |
| 913 | 0937 | PRAHA 130 | .262 |
| 914 | 0938 | SABABURG 4 | .173 |
| 915 | 0939 | KIEV 2 | .166 |
| 916 | 0940 | BERLIN-OST 15 | .313 |
| 917 | 0941 | PARIS 19 | .308 |
| 918 | 0942 | YORK 27 | .280 |
| 919 | 0943 | PRAHA 131 | .273 |
| 920 | 0944 | YORK 28 | .438 |
| 921 | 0945 | DENVER 1 | .403 |
| 922 | 0946 | S. DIEGO 32 | .365 |
| 923 | 0947 | WARSZAWA 13 | .177 |
| 924 | 0948 | MINNESOTA 3 | .159 |
| 925 | 0949 | HILVAREN 1 | .194 |
| 926 | 0950 | ARNHEM 10 | .219 |
| 927 | 0951 | MIDWAY 1 | .194 |
| 928 | 0952 | MINNESOTA 4 | .140 |
| 929 | 0953 | TALLINN 2 | .188 |
| 930 | 0954 | LONDON 61 | .110 |
| 931 | 0955 | BERN 6 | .263 |
| 932 | 0956 | SABABURG 5 | .196 |
| 933 | 0957 | LEIPZIG 28 | .327 |
| 934 | 0958 | LONDON 62 | .105 |
| 935 | 0959 | ASKANIA 60 | .023 |
| 936 | 0960 | WARSZAWA 14 | .576 |
| 937 | 0961 | S. DIEGO 33 | .285 |
| 938 | 0962 | NURNBERG 26 | .351 |
| 939 | 0963 | ASKANIA 61 | .250 |
| 940 | 0964 | DENVER 2 | .452 |
| 941 | 0965 | MARWELL 51 | .346 |
| 942 | 0966 | ASKANIA 62 | .375 |
| 943 | 0967 | LEIPZIG 29 | .520 |
| 944 | 0968 | OBERWIL 14 | .314 |
| 945 | 0969 | LONDON 63 | .102 |
| 946 | 0970 | ASKANIA 63 | .250 |
| 947 | 0971 | LONDON 64 | .097 |
| 948 | 0972 | LONDON 65 | .097 |
| 949 | 0973 | MIDWAY 2 | .195 |
| 950 | 0974 | MIDWAY 3 | .199 |
| 951 | 0975 | TOPEKA 3 | .306 |
| 952 | 0976 | OBERWIL 15 | .051 |
| 953 | 0977 | ROSTOV 2 | .303 |
| 954 | 0978 | PFORZHEIM 1 | .225 |
| 955 | 0979 | NURNBERG 27 | .077 |
| 956 | 0980 | ASKANIA 64 | .262 |
| 957 | 0981 | ASKANIA 65 | .438 |
| 958 | 0982 | MARWELL 52 | .039 |
| 959 | 0983 | ASKANIA 66 | .148 |
| 960 | 0984 | ASKANIA 67 | .256 |
| 961 | 0985 | HOWLETTS 33 | .210 |
| 962 | 0986 | LEIPZIG 30 | .029 |
| 963 | 0987 | ASKANIA 68 | .438 |
| 964 | 0988 | YORK 29 | .265 |
| 965 | 0989 | MARWELL 53 | .225 |
| 966 | 0990 | MARWELL 54 | .000 |
| 967 | 0991 | HOWLETTS 34 | .376 |
| 968 | 0992 | CHESTER 4 | .165 |
| 969 | 0993 | HELL 86 | .309 |
| 970 | 0994 | MIDWAY 4 | .225 |
| 971 | 0995 | OBERWILL 16 | .225 |
| 972 | 0996 | LEIPZIG 31 | .327 |
| 973 | 0997 | MARWELL 55 | .000 |
| 974 | 0998 | MARWELL 56 | .000 |
| 975 | 0999 | HELL 87 | .391 |
| 976 | 1000 | WARSZAWA 15 | .487 |
| 977 | 1001 | BERN 7 | .146 |
| 978 | 1002 | LEIPZIG 32 | .414 |
| 979 | 1003 | HOWLETTS 35 | .120 |
| 980 | 1004 | DUISBURG 3 | .262 |
| 981 | 1005 | MARWELL 57 | .239 |
| 982 | 1006 | ARNHEM 11 | .229 |
| 983 | 1007 | KOLN 11 | .054 |
| 984 | 1008 | KURGAN 1 | .367 |
| 985 | 1009 | LONDON 66 | .105 |
| 986 | 1010 | HOWLETTS 36 | .199 |
| 987 | 1011 | PRAHA 132 | .262 |
| 988 | 1012 | HOWLETTS 37 | .357 |
| 989 | 1013 | MARWELL 58 | .039 |
| 990 | 1014 | BERLIN-W 3 | .235 |
| 991 | 1015 | KIEV 3 | .166 |
| 992 | 1016 | SABABURG 6 | .173 |
| 993 | 1017 | YORK 30 | .330 |
| 994 | 1018 | LONDON 67 | .094 |
| 995 | 1019 | ARMHEM 12 | .220 |
| 996 | 1020 | PARIS 20 | .308 |
| 997 | 1021 | S. DIEGO 34 | .365 |
| 998 | 1022 | HILVAREN 2 | .143 |
| 999 | 1023 | OBERWIL 17 | .023 |
| 1000 | 1024 | WARSZ.16 | .177 |

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FOR SPECIES: Przewalski Horse
MATRIX/KEY (STUDBOOK NO.) CROSS REFERENCE TABLE

| MAT# | KEY# | NAME | ICOEF |
|---|---|---|---|
| 1001 | 1025 | ARNHEM 13 | .242 |
| 1002 | 1026 | WARSZ. 17 | .177 |
| 1003 | 1027 | WIEN 5 | .235 |
| 1004 | 1028 | MINNESOTA 5 | .140 |
| 1005 | 1029 | MOSKVA 6 | .315 |
| 1006 | 1030 | LENINGRAD 5 | .246 |
| 1007 | 1031 | BERN 8 | .197 |
| 1008 | 1032 | LEIPZIG 33 | .162 |
| 1009 | 1033 | OBERWIL 18 | .057 |
| 1010 | 1034 | BERLIN-O. 16 | .313 |
| 1011 | 1035 | MINNESOTA 6 | .159 |
| 1012 | 1036 | SPRINGE 2 | .122 |
| 1013 | 1037 | HELL. 88 | .506 |
| 1014 | 1038 | HELL. 89 | .391 |
| 1015 | 1039 | NURNBERG 28 | .029 |
| 1016 | 1040 | ASKANIA 69 | .137 |
| 1017 | 1041 | ASKANIA 70 | .438 |
| 1018 | 1042 | BERN 9 | .157 |
| 1019 | 1043 | ASKANIA 71 | .375 |
| 1020 | 1044 | ASKANIA 72 | .148 |
| 1021 | 1045 | MARWELL 59 | .346 |
| 1022 | 1046 | MOSKVA 7 | .121 |
| 1023 | 1047 | NURNBERG 29 | .351 |
| 1024 | 1048 | ASKANIA 73 | .250 |
| 1025 | 1049 | LONDON 68 | .102 |
| 1026 | 1050 | LONDON 69 | .097 |
| 1027 | 1051 | PFORZHEIM 2 | .225 |
| 1028 | 1052 | LONDON 70 | .355 |
| 1029 | 1096 | HOWLETTS 38 | .210 |
| 1030 | 1053 | MIDWAY 5 | .194 |
| 1031 | 1054 | MIDWAY 6 | .195 |
| 1032 | 1097 | HOWLETTS 39 | .376 |
| 1033 | 1055 | LEIPZIG 34 | .327 |
| 1034 | 1056 | MIDWAY 7 | .199 |
| 1035 | 1057 | SPRINGE 3 | .128 |
| 1036 | 1058 | LEIPZIG 35 | .520 |
| 1037 | 1059 | LENINGRAD 6 | .165 |
| 1038 | 1060 | PARIS 21 | .454 |
| 1039 | 1061 | LONDON 71 | .105 |
| 1040 | 1062 | SABABURG 7 | .262 |
| 1041 | 1098 | HOWLETTS 40 | .199 |
| 1042 | 1063 | YORK 31 | .280 |
| 1043 | 1064 | TOPEKA 4 | .290 |
| 1044 | 1065 | TOPEKA 5 | .287 |
| 1045 | 1066 | NURNBERG 30 | .309 |
| 1046 | 1067 | MARWELL 60 | .000 |
| 1047 | 1068 | MARWELL 61 | .039 |
| 1048 | 1069 | MARWELL 62 | .000 |
| 1049 | 1099 | HOWLETTS 41 | .120 |
| 1050 | 1070 | LEIPZIG 36 | .327 |
| 1051 | 1071 | S. DIEGO 35 | .365 |
| 1052 | 1072 | LEIPZIG 37 | .414 |
| 1053 | 1073 | BERN 10 | .146 |
| 1054 | 1074 | ASKANIA 74 | .262 |
| 1055 | 1075 | HELL. 90 | .309 |
| 1056 | 1076 | ASKANIA 75 | .375 |
| 1057 | 1077 | ASKANIA 76 | .256 |
| 1058 | 1078 | LONDON 72 | .105 |
| 1059 | 1100 | HOWLETTS 42 | .194 |
| 1060 | 1079 | MINNESOTA 7 | .046 |
| 1061 | 1080 | BERLIN-O. 17 | .111 |
| 1062 | 1081 | BERLIN-O. 18 | .113 |
| 1063 | 1082 | MINNESOTA 8 | .296 |
| 1064 | 1101 | HOWLETTS 43 | .176 |
| 1065 | 1102 | DUISBURG 4 | .262 |
| 1066 | 1083 | TOPEKA 6 | .347 |
| 1067 | 1084 | YORK 32 | .244 |
| 1068 | 1085 | TOPEKA 7 | .352 |
| 1069 | 1086 | PRAHA 133 | .262 |
| 1070 | 1087 | BERLIN W. 4 | .235 |
| 1071 | 1088 | STUTTGART 3 | .447 |
| 1072 | 1089 | MARWELL 63 | .039 |
| 1073 | 1090 | SABABURG 8 | .173 |
| 1074 | 1091 | MARWELL 64 | .225 |
| 1075 | 1092 | MARWELL 65 | .239 |
| 1076 | 1093 | WIEN 6 | .185 |
| 1077 | 1094 | YORK 33 | .355 |
| 1078 | 1095 | PARIS 22 | .308 |
| 1079 | 1103 | S. DIEGO 36 | .252 |
| 1080 | 1104 | DENVER 3 | .290 |
| 1081 | 1105 | SPRINGE 4 | .116 |
| 1082 | 1106 | WARSZ. 018 | .177 |
| 1083 | 1107 | S. DIEGO 37 | .406 |
| 1084 | 1108 | WARSZ. 019 | .487 |
| 1085 | 1109 | MINNESOTA 9 | .140 |
| 1086 | 1110 | SABABURG 9 | .262 |
| 1087 | 1150 | HELL. 93 | .309 |
| 1088 | 1111 | MINNES. 10 | .124 |
| 1089 | 1112 | NIKOLAEV 1 | .257 |
| 1090 | 1113 | BERLIN-O. 19 | .113 |
| 1091 | 1114 | ASKANIA 77 | .250 |
| 1092 | 1115 | HELL. 91 | .506 |
| 1093 | 1116 | OBERWIL 19 | .051 |
| 1094 | 1117 | ASKANIA 78 | .148 |
| 1095 | 1118 | ASKANIA 79 | .318 |
| 1096 | 1119 | ASKANIA 80 | .256 |
| 1097 | 1120 | HALLE 11 | .239 |
| 1098 | 1121 | NURNBERG 31 | .414 |
| 1099 | 1122 | HOWLETTS 44 | .194 |
| 1100 | 1123 | WARSZ. 20 | .177 |

CANYON COLORADO EQUID SANCTUARY
FOR SPECIES: Przewalski Horse
MATRIX/KEY (STUDBOOK NO.) CROSS REFERENCE TABLE

| MAT# | KEY# | NAME | ICOEF |
|---|---|---|---|
| 1101 | 1124 | HELL. 92 | .506 |
| 1102 | 1125 | MINNES. 11 | .214 |
| 1103 | 1126 | BERLIN-O. 20 | .111 |
| 1104 | 1127 | PRAHA 134 | .084 |
| 1105 | 1128 | ASKANIA 81 | .288 |
| 1106 | 1129 | MARWELL 66 | .346 |
| 1107 | 1130 | TOPEKA 8 | .306 |
| 1108 | 1131 | LONDON 74 | .105 |
| 1109 | 1132 | MOSKVA 8 | .071 |
| 1110 | 1133 | ARNHEM 14 | .229 |
| 1111 | 1134 | HOWLETTS 45 | .357 |
| 1112 | 1135 | PRAHA 135 | .084 |
| 1113 | 1136 | SABAB. 10 | .344 |
| 1114 | 1137 | MOSKVA 9 | .108 |
| 1115 | 1138 | LONDON 73 | .097 |
| 1116 | 1139 | WARSZ. 21 | .338 |
| 1117 | 1140 | LONDON 75 | .102 |
| 1118 | 1141 | SPRINGE 5 | .128 |
| 1119 | 1142 | OBERWIL 20 | .057 |
| 1120 | 1143 | LEIPZIG 38 | .520 |
| 1121 | 1144 | MARWELL 67 | .000 |
| 1122 | 1145 | ASKANIA 82 | .256 |
| 1123 | 1146 | KIEV 4 | .226 |
| 1124 | 1147 | KOLN 12 | .054 |
| 1125 | 1148 | LEIPZIG 39 | .162 |
| 1126 | 1149 | ASKANIA 83 | .262 |
| 1127 | 1151 | SPRINGE 6 | .122 |
| 1128 | 1152 | MOSKVA 10 | .367 |
| 1129 | 1153 | KOLN 13 | .037 |
| 1130 | 1154 | HOWLETTS 46 | .194 |
| 1131 | 1155 | MINNES. 12 | .206 |
| 1132 | 1156 | HOWLETTS 47 | .210 |
| 1133 | 1157 | HILVAREN. 3 | .194 |
| 1134 | 1158 | WIEN 7 | .235 |
| 1135 | 1159 | ASKANIA 84 | .250 |
| 1136 | 1160 | BERN 11 | .146 |
| 1137 | 1161 | MIDWAY 8 | .199 |
| 1138 | 1162 | BERN 12 | .197 |
| 1139 | 1163 | BERLIN-W. 5 | .235 |
| 1140 | 1164 | MINNES. 13 | .181 |
| 1141 | 1165 | DENVER 4 | .293 |
| 1142 | 1166 | MARWELL 68 | .039 |
| 1143 | 1167 | MINNES. 14 | .165 |
| 1144 | 1168 | BERN 13 | .157 |
| 1145 | 1169 | HELL. 94 | .465 |
| 1146 | 1170 | HOWLETTS 48 | .194 |
| 1147 | 1171 | MARWELL 69 | .140 |
| 1148 | 1172 | ASKANIA 85 | .438 |
| 1149 | 1173 | MARWELL 70 | .128 |
| 1150 | 1174 | LONDON 76 | .105 |
| 1151 | 1175 | MARWELL 71 | .126 |
| 1152 | 1176 | SABAB. 11 | .173 |
| 1153 | 1177 | LEIPZIG 40 | .294 |
| 1154 | 1178 | ASKANIA 86 | .375 |
| 1155 | 1179 | DENVER 5 | .293 |
| 1156 | 1180 | YORK 34 | .119 |
| 1157 | 1181 | ASKANIA 87 | .181 |
| 1158 | 1182 | WIEN 8 | .185 |
| 1159 | 1183 | HOWLETTS 49 | .199 |
| 1160 | 1184 | ROSTOV 3 | .303 |
| 1161 | 1185 | MINNES. 15 | .173 |
| 1162 | 1186 | NURNBERG 32 | .351 |
| 1163 | 1187 | HELL. 95 | .391 |
| 1164 | 1188 | LENINGRAD 7 | .114 |
| 1165 | 1189 | HOWLETTS 50 | .120 |

APPENDIX II

GENETICALLY EFFECTIVE PRZEWALSKI'S HORSE STALLIONS:
NUMBER OF OFFSPRING PER STALLION

| STUDBOOK # SIRE | NUMBER OF OFFSPRING |
|---|---|
| 293 | 51 |
| 285 | 44 |
| 259 | 38 |
| 76 | 35 |
| 78 | 35 |
| 517 | 32 |
| 154 | 31 |
| 397 | 28 |
| 383 | 26 |
| 499 | 22 |
| 171 | 21 |
| 469 | 20 |
| 182 | 19 |
| 411 | 19 |
| 85 | 18 |
| 187 | 17 |
| 391 | 16 |
| 265 | 13 |
| 314 | 13 |
| 246 | 12 |
| 1 | 11 |
| 433 | 10 |
| 185 | 81 |
| 39 | 9 |
| 56 | 9 |
| 166 | 9 |
| 287 | 9 |
| 341 | 9 |
| 523 | 9 |
| 146 | 8 |
| 281 | 8 |
| 320 | 8 |
| 430 | 8 |
| 482 | 8 |
| 245 | 7 |
| 306 | 7 |
| 388 | 7 |
| 513 | 7 |
| 87 | 6 |
| 113 | 6 |
| 157 | 6 |
| 251 | 6 |

| STUDBOOK # OF SIRE | NUMBER OF OFFSPRING |
|---|---|
| 559 | 6 |
| 638 | 6 |
| 62 | 5 |
| 103 | 5 |
| 211 | 5 |
| 367 | 5 |
| 11 | 4 |
| 35 | 4 |
| 106 | 4 |
| 118 | 4 |
| 120 | 4 |
| 257 | 4 |
| 260 | 4 |
| 574 | 5 |
| 466 | 5 |
| 421 | 5 |
| 440 | 4 |
| 543 | 4 |
| 613 | 4 |
| 747 | 4 |
| 15 | 3 |
| 81 | 3 |
| 83 | 3 |
| 220 | 3 |
| 269 | 3 |
| 368 | 3 |
| 533 | 3 |
| 552 | 3 |
| 568 | 3 |
| 571 | 3 |
| 597 | 3 |
| 613 | 3 |
| 661 | 3 |
| 90 | 2 |
| 180 | 2 |
| 235 | 2 |
| 271 | 2 |
| 313 | 2 |
| 385 | 2 |
| 399 | 2 |
| 473 | 2 |
| 555 | 2 |
| 558 | 2 |
| 605 | 2 |
| 606 | 2 |
| 607 | 2 |
| 615 | 2 |
| 652 | 2 |
| 685 | 2 |
| 688 | 2 |
| 689 | 2 |
| 17 | 1 |

THESE STALLIONS ALL SIRED ONE OFFSPRING:

17
132
191
235
262
303
324
342
392
437
470
494
505
584
590

A total of 109 effective stallions...

# EXPERIENCE IN PRZEWALSKI HORSE MANAGEMENT IN ASKANIA-NOVA

Yu. Musienko, N. Krylov, N. Lobanov and V. Klimov

In 1987 the Askania-Nova zoo, one of the oldest in the USSR, will mark its 100th anniversary. It was established in 1885-1887 in the steppes of Tavria on the Black Sea northern shores. In historic times these steppes gave refuge to numerous herds of wild horses - tarpans eliminated by man last century.

When N. Przewalski discovered a new species of wild horses that were seen by few people and doubted by many others, it was decided in Russia to catch and transit them to Europe. By doing so, the existence of true wild horses could be proved.

At the end of the 19th century an expedition was sent to Mongolia and in 1900 the Askania-Nova zoo was the first in Europe to accommodate wild horses. Mares Staraya-I and Staraya-II and a stallion Vaska initiated captive reproduction of these horses and first foals were born. During 40 years 37 foals were produced in the zoo to form an old Askania line. The horses propagated normally till the Second World War. They formed a basis of Munich (Hellabrunn) line, thus preserving blood of the Askania line in current Przewalski horses. The Second World War that brought about vast devastations to Europe and the USSR put an end to existence of the line, the horses in Askania-Nova were destroyed.

In 1948 a stallion Orlik-Robert was delivered from Germany and in 1957 the zoo admitted a mare Orlitsa-III caught in the wild in Mongolia. These animals became founders of a new Askania line.

## LINE STRUCTURE, DEMOGRAPHY

The horses of this line began to reproduce since 1960 and 100 animals have been produced over 25 years. Some of them (50 percent) form a nucleus of the line, the others have been distributed among the USSR and other countries' zoos. As related to the foals produced per year, the Askania-Nova zoo is acknowledged to be a leader among the world's zoos. The average surplus accounts for 12-15 percent per annum exceeding other zoos' indices by 5-7 percent. Practically all the sexually mature mares are productive. In some years fertility reached 100 percent, averaging 60 percent on the whole. Among fifty horses available in Askania-Nova only ten are efficient. The zoo does its utmost to improve these indices.

Demographic figures are given in Table 1. As one can see, the population's reproductive potential is increasing.

Analysing the line structure, mention should be made of two

Table 1 DEMOGRAPHIC FIGURES OF THE PRZEWALSKI HORSE

| Age classes | Male | Female | Total | % |
|---|---|---|---|---|
| 0 - 1 | 5 | 6 | 11 | 23.5 |
| 1 - 3 | 8 | 7 | 16 | 27.7 |
| 3 - 5 | 6 | 2 | 8 | 14.8 |
| 5 - 10 | 2 | 7 | 9 | 16.7 |
| 10 - 15 | 1 | 8 | 9 | 16.7 |
| Over 20 | 1 | 1 | 2 | 0.6 |

Prague-line mares involved in reproduction (Gasana and Vada) as well as two females and a male imported from the USA in 1982. The latter represent American branches of the Munich line. The line geneology clearly indicates three families - offspring of Orlitsa-III, Vada and Gasana. As for the stallions, the horses relate to Orlik-Robert and his offpsring and Gordyi of the Prague line. One more line is likely to be formed, involving a stallion Sigor from the USA into reproduction. Therefore, the new Askania line includes blood of all the wild founders of the Przewalski horse captive population. This fact favours genetic variability of the line and reproductive processes.

MANAGEMENT, BREEDING

Now the Przewalski horses in Askania-Nova occupy a portion of reserve feather grass steppe divided into large enclosures. Depending on the time of the year they are kept in either isolated or common enclosures varing from 45 to 1550 ha. All-year round ranging promotes better development and reproduction of horses. In relation to morphology, exterior, coloration, hair coat and behaviour, the Askania-line horses are closer to a standard of wild horses that has been repeatedly indicated by other specialists. They are more successful in reproduction as compared with horses from other zoos. The inbreeding level is very high in captive population on the whole, while being much less in Askania-Nova. Inbreeding coefficient of the line makes 0.25 on the average though it surpasses 0.30 in some animals. It happens due to long-term consanguineous mating because a stallion Pegas has been a major sire for a long period of time. To remedy the situation, in 1982 the Askania-Nova zoo exchanged horses with the US Bronx and San Diego zoos. Askania-Nova received two mares Lisa and Bollette and a stallion Sigor that made it possible to propagate horses in several directions. Since 1983 the animals have been mated and managed in four groups according to the prepared programme on interbreeding:

1. stallion Pegas and American mares
2. stallion Sigor and three Askania-line mares
3. stallion Parad and eight Askania-line mares with young stock of 1-2 years of age

4. group of bachelors - genetic reserve of the population.

Group 2 produced three foals in 1984 and two foals were born to the American mares. The international exchange of horses has favoured the animals' reproduction and the line genetic structure that will make a high level of genetic variability possible. Now the Askania-Nova zoo owns representatives of two pure lines and can breed horses in several directions and provide the total population with animals having new gene combinations. In the future efforts will be taken to enhance the quality and numbers of the line by: stimulation of reproductive processes, increasing the level of the line genetic variability, isolation of the Prague-line horses and their separate management, pure breeding, line breeding, formation of new lines and breeding groups with qualitatively new gene variants.

# POSITIVE AND NEGATIVE FEATURES OF BREEDING OF PRZEWALSKI HORSES AND WHAT DO WE EXPECT FROM THEIR RESERVES

Jirí Volf

The breeding of the Przewalski horse (**Equus przewalskii** Poliakov, 1881) in captivity was started in 1899-1904. At that time six transports from Middle Asia brought a total of 54 individuals to Europe. A low reproduction rate and extensive scattering of the breed prevented additions and could not prevent a natural decrease at the beginning. In the twenties the number of wild horses kept in captivity varied within the range of 20-30 animals. In the thirties this number gradually increased exceeding several times 40 individuals. During World War II the number again temporarily decreased; another ten years passed before it was possible to substitute the losses. Despite this, the future of the species was not secure due mainly to the fact that during this period the number of freely living wild horses decreased catastrophically.

In September 1959, the 1st International Symposium on the Protection of the Przewalski Horse took place and the Prague Zoo, at the time the most important breeder, was assigned the task of compiling an all-world card-index on this animal.

An accurate central card-index makes it possible to publish annually the international Pedigree Book of the Przewalski horse. This book increases the direct interest of breeders aimed at the reproduction of animals, surveys the results of all-world breeding, facilitates the exchange of animals and supplementation of breeding herds and due to its wide distribution propagates the protection of this endangered species. When I started to publish the Pedigree Book in 1960, 59 Przewalski horses lived at 17 breeding stations; by 1 January 1985, as many as 620 individuals were living at 100 zoological gardens, scientific institutes and private breeders. This means that during twenty-five years the number of Przewalski horses kept in captivity increased more than ten times.

Irrespective of this indisputable success some undesirable aspects accompanying the worldwide breeding of wild horses should be taken into consideration.

First of all is the domestication effect. This is manifested by morphological changes, of the extremities and the cranium in particular. We found that these changes could be proved as soon as the first generation of horses was born in captivity. This change affects above all the lower jawbone, where the **Corpus mandibulae** narrows and the jaw assumes the fine form of tweezers. The cause of this weakening of the lower jawbone is the relatively soft food ingested by the animals in captivity which does not adequately put to use the biting apparatus of the horses.

However, negative selection, used by some breeders mainly with stallions, also cannot be overlooked. As a consequence, the dark-nosed form has presently almost disappeared from breeding herds (this form was formerly described by Pallas as **Equus equiferus typicus**). Some of the hyppologists considered the so-called meal-nose as a specific art of wild horses. Up to now it has depended on every single breeder whether he prefers the lighter form of wild horses with striped extremities, which can be for instance found in the Prague breed, or the darker form with black extremities kept at the Munich collection.

One has also to be aware of the breeding of relatives, which has already been observed in Przewalski horses for a long time. All wild horses living in captivity at present descended from only ten imported individuals: one pair which came to Falz-Fein in 1899 and a mare in 1902, two pairs of the Hagenbeck transport in 1901 and a pair in 1902, and the last the mare "Orlica III". It lived in the Scientific Research Institute in Askania Nova (Ukraine) until the end of 1974. It is a pity that for a long time she was crossed with domestic stallions and did not influence to a great extent the breeding of wild horses all over the world. Only three purebred descendents of her remain.

In my opinion, it is possible to suppress partly the above mentioned aspects. The most effective approach would be the release of a greater number of individuals to a reserve. As the number of Przewalski horses in captivity is continually rising this step can be fully justified.

The reserve should ensure good living conditions for the animals so that the many years of effort of the breeders are not be wasted.

In the reserve the horses must be completely safe from their natural enemies - beasts of prey - as well as from hunters. We can use wild asses - Kulans (**Equus hemionus kulan**) as an example here. They found a new home on the island Barsa-Kelmes in the Aral sea some time ago.

Further important factors, which must be observed when releasing wild horses to a reserve, include soil and climatic conditions. The animals have to rub their hoofs regularly, because otherwise these would grow to such dimensions that these individuals could become completely lame. Thus, a hard sandy ground is essential.

The continential climate with a greater variation of temperature and little rainfall is a natural area for wild horses. We know that moisture is in fact much more unfavourable for wild horses than the greatest possible frost. Therefore, the reserve should have an arid climate.

This also influences feeding conditions favourably. Thus,

prairie grass favourably influences the development of the chewing muscles and the whole mandible.

In addition, from the point of view of genetics, the reservation has to be isolated from domestic horses. The danger of cross-breeding holds not only for domestic stallions, but also for domestic mares that cannot withstand the aggression of wild stallions, and also for domestic mares that are introduced to the herd by wild stallions.

If a suitable reserve is found all breeders should be informed. If some of them are willing to give a part of their herd for the new reserve, they should be given the opportunity to get personally acquainted with the reserve and give their possible comments and recommendations before shipping the horses - I think that about 5% of the world's wild horses should be introduced at first, that means about 25-35 animals.

I believe sincerely that the foundation of a special reserve of Przewalski horses will reflect the successful international cooperation in the preservation of this endangered species and, in addition, will secure its fruitful future.

I wish your session in Moscow full success.

**EQUUS PRZEWALSKI** - 1 January 1985
Location of animals, with numbers of males and females

| | | | | | |
|---|---|---|---|---|---|
| Adelaide | 1, 2 | Hilvarenbeek | 2, 3 | Oberwil | 2, 5 |
| Anvers | 2, 3 | Hohenstadt | 1, 0 | de Ooij | 4, 0 |
| Arnhem | 3, 4 | Jersey | 3, 0 | Paignton | 1, 0 |
| Askania Nova | 22, 31 | Karaganda | 1, 1 | Paris | 2, 3 |
| Barcelona | 2, 0 | Karl-Marx-Stadt | 1, 0 | Peking | 2, 2 |
| Bekesbourne | 14, 24 | Karlsruhe | 1, 1 | Pforzheim | 1, 2 |
| Berlin-Ost | 5, 10 | Keokuk | 1, 0 | Praha | 3, 7 |
| Berlin-West | 2, 4 | Kiev | 3, 2 | Riga | 2, 1 |
| Bern | 3, 4 | Kingussie | 6, 0 | Roma | 1, 0 |
| Bernburg | 1, 1 | Kisinev | 1, 1 | Rostov/D. | 1, 1 |
| Bratislava | 1, 0 | Köln/R. | 3, 6 | Rotterdam | 1, 2 |
| Budapest | 1, 0 | Krakow | 2, 2 | Sababurg | 1, 7 |
| Cardigan | 1, 0 | Kurgan | 0, 1 | Salzburg | 2, 2 |
| Catskill | 6, 10 | Leipzig | 2, 8 | San Diego | 1, 2 |
| Cavriglia | 1, 0 | Lelystad | 2, 4 | San Diego WAP | 5, 14 |
| Cévennes | 1, 0 | Leningrad | 2, 4 | Schwerin | 1, 0 |
| Chester | 1, 3 | Lodz | 1 0 | Seul | 1, 1 |
| Chiba | 2, 2 | London | 2, 0 | Soest | 1, 1 |
| Colombo | 1, 0 | Los Angeles | 1, 1 | Springe | 4, 6 |
| Colwyn Bay | 1, 1 | Lymington | 2, 0 | Stendal | 1, 0 |
| Denver | 2, 3 | Marwell | 8, 14 | Stuttgart | 1, 2 |
| Dubbo | 6, 11 | Memphis | 1, 2 | Tallinn | 1, 1 |
| Duisburg | 2, 1 | Midway Manor | 2, 7 | Taskent | 3, 0 |
| Edmonton | 3, 2 | Minnesota | 13, 8 | Termez | 1, 0 |
| Front Royal | 2, 7 | Montpellier | 1, 4 | Thot a Thomac | 1, 0 |
| Frösön | 0, 1 | Moskva | 6, 7 | Tokyo | 2, 2 |
| Gdansk-Oliva | 1, 1 | München | 8, 15 | Topeka | 5, 3 |
| Genk | 4, 2 | Münster | 2, 2 | Toronto | 1, 3 |
| Gramat | 1, 1 | Neumünster | 1, 0 | Warszawa | 3, 7 |
| Gronau | 5, 0 | Neuwied | 1, 0 | Whipsnade | 3, 11 |
| Habana | 2, 3 | New York | 4, 11 | Wien | 3, 4 |
| Halle/S. | 1, 2 | Nikolaev | 4, 3 | Woburn | 5, 0 |
| Helsinki | 2, 2 | Norderheide | 0, 4 | | |
| Herberstein | 1, 2 | Nürnberg | 3, 11 | | 260,348 |

## STATUS OF EXISTING CAPTIVE POPULATIONS

M. Knowles

SUMMARY

The present picture of numbers of animals in different locations is given in the paper by the Studbook keeper Dr. J. Volf and the paper by Dr. O. Ryder on this subject. The only comment additionally needed is to indicate that there are sufficient animals in captivity for a release to be made without prejudice to the captive population. There is also a strong commitment from the captive breeding population to make animals available.

# PROBLEMS OF PRZEWALSKI HORSE REINTRODUCTION

# INTO THE WILD

## INTRODUCTION OF PRZEWALSKI HORSES INTO THE WILD

V.E. Sokolov and V.N. Orlov

The Asian wild horse, known as **Equus przewalskii** and named after N.M. Przewalski, explorer of Central Asia, earlier populated a vast territory of Asian steppes, stretching from the Kazakh area to the piedmonts of Tien Shan and the Mongolian Altai.

Yet in the 18th century the wild horse was usual in the steppes of the Kazakh area, Mongolia and Dauria. Already in 1637 a wild mare was caught in the territory of the modern Choybalsan Aimak, in the interfluvial area of the Onon and Kerulen rivers; it was later given as a gift to the Manchurian Emperor. In accordance with the information provided by last century travellers the wild horses ranged in the vast area of Dzungaria, from the piedmont areas of the Mongol Altai in the north to the Tien Shan in the south, from longitude 86°E in the west to longitude 95°E in the east. The reports said that the wild horse populated the areas even more to the east, the southern piedmont areas of the Mongol Altai (longitude 105°E) and the Shargyn Gobi to the north from the Mongol Altai.

In the 1940s big herds of the wild horse were still observed in the Dzungar Gobi, in the territory of Mongolia. Nevertheless, in the late 1940s the wild horses almost fully disappeared in Mongolia. Thus, only one expedition out of the four working in that region in the 1950s was lucky to see a lone stallion and one band was seen by the arats (local residents) in the winter of 1956. In the 1960s, only two expeditions out of the eight visiting that area saw the wild horses; 5 horses in June 1967, the same number was seen in May 1968; both times in the vicinity of solontchak Takhiin-Us. Three reported sightings of the wild horses by the local residents are registered in the 1960s as well (in the winter of 1969, 1964 and in the summer of 1969). Since that time neither members of the expeditions, nor the local people, have seen any bands of the wild horses. We thoroughly studied the Dzungar Gobi in the territory of Mongolia in the summer of 1976 and 1977, in the summer and winter of 1979, and no traces of the wild horse were found. Having enquired with the local residents we came to a conclusion that the Przewalski horse no longer exists in the territory of Mongolia. It is unlikely that the wild horse is still preserved in China. The piedmont areas of the Tien Shan and of the Baitag Bogdo range are more developed and more populated than the Mongol part of Dzungaria. A well-known geographer E.M. Mourzayev did not see the wild horse and could not obtain any information from the local residents during his travels in Sinkiang in 1956-1959, though he travelled in the places where the sightings of the wild horse were frequent in the last century. The expedition of the Peking zoo that worked in Sinkiang in 1955/57 did not meet the Przewalski horse either.

The firearms that became available to the local residents and the shooting of the animals in the 1940s, severe winters and the intensive economic use of grazing lands and watering places are considered to be the principal factors responsible for the rapid extinction of the Przewalski horse. All that is true. Nevertheles, Kulan, another perissodactyl species, managed to secure its high numbers under the same conditions. Przewalski horse extinction, as we see it, can be explained in the first place by the fact that they were ousted by man to the desert from the optimal habitat, that is the Stipa-Artemisia and other types of arid steppes. Contrary to Kulan, the wild horse can live in steppes and semi-deserts but not in deserts. Ousted by man to the desert, the wild horse was doomed to death. Due to that reason, the wild horses disappeared in the Kazakh area one hundred years earlier than Kulans. Within the boundaries of the restored habitat of the Przewalski horse in Dzungaria, the Stipa-Artemisia arid steppes occupy a relatively small territory, namely the northern piedmont areas of the Tien Shan and the narrow strips along the southern piedmonts of the Mongol Altai, piedmonts and low mountains of the Baitag-Bogdo and Takhin-Shara-Nuru chains, stretched longitudinally. These three strips of arid steppes are alternated by the vast areas of Halozylon and Salsola deserts. Consequently, the wild horses were distributed sporadically within that restored vast habitat, and their total number was not great.

Yet in the 19th century, the wild horses were ousted from the piedmonts of the Tien Shan to the desert areas. Typical samples of the Przewalski horse and the horse obtained by the Grum-Grzimailo brothers were shot in the sand area and the crushed stone desert to the north from the Tien Shan piedmonts. It is significant that the last sightings of the wild horse in Mongolia were registered in the Haloxylon desert, in the vicinity of Takhiin-Us solontchak.

At present, the representatives of this species can be seen only in the zoos and reserves of the world. The total captive population of the wild horse derives from 12 wild horses, imported from Dzungaria into Europe at different times and one domestic mare. Totally, 53 wild foals were imported. Since the horses were small in number they were distributed among the zoos of Europe and North America by pairs or by one, that later resulted in the formation of isolated inbred groups. It is not accidental that only three zoos (New York, Woburn, Askania Nova) managed to ensure stable reproduction. In total, a little over one hundred foals were born before the Second World War. After its boom, the reproduction of the wild horse in captivity started to decline and by the late 1930s almost all the captive population had become extinct. The horses that were later used for breeding remained only in the Prague and Hellabrunn Zoos. That was an unsuccessful end to the first stage of Przewalski horse captive reproduction.

Among the reasons that led to the extinction of the wild horses in the zoos one can mention the unacceptability of the urban zoo environment for the wild horse, contradiction between the commercial

objectives and those of preservation of a diverse gene pool, as well as the Second World War during which many zoos were destroyed. After the end of the war the second stage of the wild horse reproduction began and it was more successful. The horses that currently populate more than 80 zoos of the world established a great number of new genetic lines and branches. The world population of the wild horse began to grow steadily only after 1950 and by 1 January 1984 it had reached 552 head that are distributed among many zoos; as mentioned above, the majority of zoos keep one or a pair of horses. Foals are born every year in only 20-30 centres out of a total of 80, and 15-17 zoos have an increase of only one new foal annually. Taking into account mortality (6-8%) the total annual growth accounts for 8-10%. Within the total population the purebreds that have no blood of the domestic horse account for only 30%. The mares account for 60-70% of that group, and only about 20% of them participate in reproduction and produce the offspring. Total number of newborn foals per one year is 70-80 and 17-26% of them die. Among the two-year-olds 42% die and only 3% of them reach the age of 30 (Volf 1984). The changes in gene frequencies of the protein polymorphic systems, in enzymes and the blood groups are observed within the isolated populations of the Przewalski horse.

Descendants lose certain alleles which results in the decrease of the protein and blood enzyme polymorphic characteristics of each first or second generation by 10%, and accounts for 50-70% in the modern population of the wild horse. The inbreeding coefficient increases by 0.03-0.06% with each subsequent generation. When this coefficient amounts to 0.5%, infertility and non-viability are observed. The efficient number of horses even in large zoos does not exceed 4 head. And the total horse number in those zoos reaches 15-20!

All this points to the fact that only one stallion is used for breeding in these zoos. Not a single zoo in the world uses its capabilities to the full extent. As a result, homozygosity is increasing and the gene pool is being depleted in the isolated groups of horses, and it affects their reproduction abilities and viability.

The Przewalski horses in captivity are subject to behavioural morphological changes. The stallions that are not involved in competition do not obtain the typical agonistic behaviour patterns that can change their social ranking and would eventually allow them to take over mares. They are not able to take possession over mares and to fix their reproductive success. Due to the absence of physical loads and the decreased consumption of feeds the horses that are in captivity for a long period have less teeth and the face bones are poorly developed; the skeletal bones, not having sufficient loads, become somewhat shorter and more massive. The horses gain additional weight and their overall exterior is shifting from gait-type to that typical for walking. Already they are not capable of covering long distances as their ancestors in nature did.

Overall, it can be said that this species has lost a number of features that allowed the wild horse in the past to withstand the severe environmental conditions of Central Asia. This refers both to the phenotype and genotype features, taking into account the growing homozygosity and the loss of gene pool variability. Since the factors that cause such phenomena are still existing these processes continue to develop and the captive evolution of the species continues. That is why there is a possibility to have another species under the name of **Equus przewalskii** Pol. tomorrow! As we see it, the perspectives for the future survival of this species in captivity, under conditions totally different from the natural environment, are not very bright. In the future we will face further domestication and the loss of variability of the gene pool that is in full contradiction with the objectives of preserving that species. The world scientists display permanent concern over the fate of **Equus przewalskii** as a species. The resolutions of all international symposia on the survival of **Equus przewalskii** stress that captive reproduction does not guarantee the preservation of the diverse gene pool. The most radical measure of saving that species will be the wild horse introduction into the natural biotopes and creation of a big population in nature. The return of the horses to the natural steppe biotopes will not only ensure the preservation of their gene pool, genetic type, and the follow-up natural evolution, but will enrich the natural communities and will become a model for the preservation of other types that will give a powerful impetus to world environmental activities.

It is necessary to find out what number of horses will be sufficient for the preservation of the species gene pool. We believe that the natural population of the wild horse should be no less than 300-500. It is this number that provides a guarantee for the preservation of genetic variability for quite a long period. The total wild population should be 1-2000. It is essential to reach this level during the first decade, by the beginning of reproduction of 3-4 generations of horses. Under favourable conditions such a level can be reached if 30-50 horses from the zoos are reintroduced into nature during the first years and the same number is introduced for the next 3-5 years.

The horses to be introduced will be provided free of charge by the zoos of some European countries, of North America and the USSR. By 1 January 1985 the population of **Equus przewalskii** in the zoos of the Soviet Union was 100 (47 females, 53 males). About 10% of that population can be allocated for introduction in Mongolia.

In recent years the USSR Academy of Sciences and the State Committee for Science and Technology of Mongolia have undertaken a number of steps aimed at preparation for the introduction of **Equus przewalskii** into nature. Thus, the USSR-Mongolian biological expedition studied various regions of Mongolia and a number of areas for the future reintroduction was selected. On the suggestion of the expedition the Council of Ministers of the Mongolian People's Republic passed a decision on reacclimatization in that country of the Takhi wild horse.

The selection of areas in the MPR suitable for the wild horse reintroduction, conducting their zoological and geographical survey, and designing a Horse Reintroduction Centre in the Bogdo-Ula natural reserve in the vicinity of Ulan Bator can be assessed as the practical results of that activity.

It is very positive that such authoritative international organizations as UNEP, FAO, IUCN and others, as well as the national institutions in the countries where the Przewalski horse is managed, are ready to participate in such a programme.

On the threshold of another stage of the Przewalski horse survival programme the Soviet scientists are presenting their views on the processes of **Equus przewalskii** introduction into nature.

It is necessary to organize a step-by-step shipping of the wild horses from the zoos into nature. During the first stage the horses will go through an initial adaptation in semi-reserves of the USSR. During stage two after adaptation in the USSR, the horses will be moved to the semi-reserves in Mongolia. They will adapt there to the even more severe natural conditions of Central Asia, and then they will be transported to the places of release which will be the third step of introduction.

At the first stage of this process that will be taking place in the steppe area of the European part of the Soviet Union and in the Kazakh republic, the following objectives are outlined:

1. Initial acclimatization of zoo horses in semi-reserves in the more severe environment of Eastern Europe and the Kazakh republic which stipulates both climatic and social adaptation. In the conditions of competition adequate behavioural patterns will be formed that will assist in their survival in the conditions of the natural bioptopes and to their on-going reproduction.

2. Production of offspring and horse breeding.

3. Preparations for introduction, including the formation of groups, selection of the best groups for introduction.

4. Monitoring and study of adaptation processes, formation of the desirable behaviour patterns.

In order to realize the above mentioned objectives, a semi-reserve should meet the following requirements:

1. Availability of large fenced steppe plots with a size of at least 5-7000 hectares.

2. Availability of administrative and management staff to provide services.

3. The presence of research personnel, veterinarians, etc. is essential.

4. Locality in the steppe area, in the vicinity of highways and railroads.

The best place to set up such a semi-reserve will be "Askania Nova" steppe reserve, as we see it. It is situated within the boundaries of the historic range of the East European Tarpan that became extinct in the last century. The vast plots of virgin feather grass with sheep, a fescue steppe that has been conserved since the last century, have remained intact. The reserve boasts good traditions in preservation and breeding of the Przewalski horse and other rare species of mammals and birds. It has a proper geographical location in the steppe zone of the European part of the USSR. The climate is mild but severe enough for the animals from the zoos of West Europe and North America. The average winter air temperature is -3°C, sometimes as low as -20°C. The average summer temperature is +20°C, up to +40°C.

The second semi-reserve for the first stage of the programme may be one of the zoos in the Kasakh republic, e.g. Karaganda zoo in the Eastern part of the Kazakh republic, or Chimkent zoo in the South of the republic. Both are situated within the boundaries of the historic range of **Equus przewalskii**, in the steppe zone. Both zoos have a vast enough territory to set up such a semi-reserve. The climate in those areas is even more severe than in Askania. The winter air temperature reaches -25-30°C.

Besides assisting in the realization of introduction, such semi-reserves will be important for the preservation of the zoo horse populations.

Thus, the horses that go through the initial adaptation in semi-reserves can be shipped back to the zoos that provided them. The breeding activities may be more efficiently carried out in semi-reserves, as well as horse exchanges, holding, and formation of groups.

In order to fulfil the objectives of the second stage it is essential to set up semi-reserves for management and adaptation in the Mongolian People's Republic. The objectives of this stage are as follows:

1. Holding and adaptation of horses provided by semi-reserves of Askania Nova and the Kazakh Republic in the climatic conditions of the region.

2. Formation of stable social groups and creation of adequate behavioural patterns that assist horse survival. These include the skill of getting food from under the snow cover with the help of hooves in the winter, self protection from midges, wind, etc.

3. Reproduction, production of offspring, their adaptation, "education", etc.

4. Monitoring of the introduction and adaptation processes.

5. Providing aid to the horses that failed to withstand the severe environmental conditions; providing them with veterinary aid, additional feeding.

6. Preparation of horse groups to release into nature: formation of groups.

The requirements of the places for such semi-reserves are the same as in the first stage. The additional requirement is to locate them in the zone of the Mongolian steppes of the mountain steppes of the semi-arid zone. The possible places for setting up such semi-reserves are the Eastern Khangai, Mongolian Altai near the northern border of the Gobi reserve, the Kerulen river valley and the surroundings of Ulan Bator.

It should be stressed that contrary to the steppes of Western Europe and the Kazakh area with steppe associations of plants, the Mongol steppes are poorer. Therefore, the wild horses have to be additionally fed on almost a year-round basis both in semi-reserves and in the places of release. That is why the semi-reserves should be supplied with a large stock of rough fodder.

The final choice of the place for a semi-reserve can be made in agreement with the Mongolian side. Nevertheless, we shall give a brief description of some above mentioned regions.

One of the oldest Mongolian reserves of Bogdo Ula is situated in the vicinity of Ulan Bator. The total territory of the reserve is 54 200 hectares and it is located at an altitude of 2256 m above sea level. The highest parts of the Bogdo Ula mountains are covered with Cedrus forests and partially by alpine meadows. The border-line parts of the mountains and slopes are covered with steppes: Sedge, Poa and motley grass steppe on the northern macro-slope; wheat grass, motley grass, and soddy and grassy areas on the southern macro-slope. Petrophyte and Festuca motley grass are observed on the eastern and western macro-slopes. The total area of steppes in the reserve is 33 600 hectares. In the winter the air temperature may reach -20-35°C, averaging -10°C. The temperature in the summer reaches +22°C, the average figure being +5.6°. The snow cover is 3-5 cm on average, up to 14 cm and annual precipitation is 250-280 mm.

The area of Eastern Khangai that is suitable for the location of a semi-reserve is situated 295 km to the southwest from Ulan Bator. As compared with Ulan Bator the winter here is milder and with little snow. The summer air temperature is somewhat higher. The area is a plain with occasional mountains and cone-shaped hills up to 1300-1500 m high. In ravines groves of thickset elm trees, various brushes and

well-developed steppe vegetation are observed. The sandy loam soils prevail in these areas. The steppes are mostly covered with wheat grass, sagebrush, and Caragana, their production being 300-400 kg of dry matter per hectare. Some water resources in the southern slopes dry up in the summer; nevertheless there are several rivers that supply the surrounding biotas with water on a year-round basis.

In some of these regions, especially those situated in the steppe zone in the south, the horses may be released into nature upon their sufficient adaptation.

During the third stage of the programme the horses are held in the fenced plot near the release spot, later they are released by groups into nature. Preliminary holding is necessary to give the horses from semi-reserves an opportunity to get acquainted with a particular territory.

The objectives advanced for this stage are as follows:

1. To hold the groups of horses for a season or a year, to ensure their adaptation in the release places.

2 To release the horses by groups into the wild. Some animals, preferably related to those released, should remain in the fenced plot, attracting other horses in order to prevent their immediate dispersion over the vast territory. Since the horses lose their orientation in a strange place, they should disperse gradually.

3. To ensure monitoring of the introduction and adaptation processes in natural biotopes.

4. To give assistance to the horses that failed to tolerate the severe conditions (additional feeding, etc).

The release places should meet the following requirements:

1. Location in the regions of zonal Mongolian steppes or the mountain steppes in the semi-arid zone.

2. Available reserved territory of 250-500 square km.

3. Available optimal grazing lands, man-made or natural water reservoirs.

4. Ban on hunting (game refuge) or setting up of a reservation in the given area.

5. Introduction of certain limitations on maintenance of domestic horses, to shoot off the feral horses, if necessary.

A number of mountain steppe areas in the semi-arid zone of

Mongolia, on the border of the breeding zones of domestic horses and camels may be suggested as possible places for the future introduction since they meet the above mentioned requirements. They are the northern part of the Gobi Reserve (Dzakhoi), the mountain region of Ushougin-Nuru and a number of similar areas.

Mountain steppes in the small isolated mountain ranges, 30-50 km long are suitable for release places. The vast steppe areas stretch between low mountain ranges, in the valleys. As a rule, they are the modern or historic range of the mountain sheep. By their natural conditions they are similar to the habitat of the wild horse. The presence of the mountain sheep may serve as an indicator of suitability of a given region for the introduction of the wild horse.

If the introduction process is considered in more detail, including the timetable for the realization of separate stages, it would be as follows:

During the organizational stage of Przewalski horse reintroduction the following steps are taken:

1. To choose the places for semi-reserves in the USSR and the MPR, to agree upon the conditions of their financing.

2. To settle administrative and juridical problems as regards the establishment of such semi-reserves.

3. To design and to build semi-reserve centres.

4. To provide logistics.

5. To train the research and technical staff.

6. To set up a base of genetic, ecological and veterinary control.

All these activities may be completed in 1986-1987. It should be kept in mind that realization of this programme is possible only under the conditions of thorough scientific and veterinary control. Therefore, it is binding to ensure the creation of ecological, genetic and veterinary control services when drafting such a programme.

The semi-reserves in the USSR and in the MPR should be financed and function during all the project period (1986-1991).

In order to fulfil the goals of the first stage of the project, upon setting up of semi-reserves in the USSR, the following steps should be taken:

1. To make a demographic assessment of the horses provided by the European and American zoos.

2. To introduce a quarantine period.

3. To select and to form the groups.

4. To ensure the initial adaptation.

5. To organize reproduction and production of the offspring.

6. To make preparations for reintroduction: to form social units, to select the best ones (from the point of better adaptability).

7. To carry out monitoring of the adaptation processes.

The programme of the first stage of the project may be realized in 1987-1989.

When fulfilling the goals of the second stage of the project as regards the adaptation of **Equus przewalskii** in the Adaptation Centre in Mongolia the following activities must be ensured:

1. Transportation of the adapted horses and of their offspring to the semi-reserves in the MPR.

2. Formation of groups; ensuring adequate ecological response of the horses to the environment.

3. Organization of reproduction and production of the young stock.

4. Preparation of horses for the next stage.

5. Monitoring of the adaptation processes.

The realization of this stage may be started when the horses go through adaptation for the period of 1987-1990.

At the third stage of reintroduction the following activities should be carried out:

1. Transportation of horses from semi-reserves.

2. Holding for a certain period.

3. Release into nature of a part of horses (harems and bachelor groups).

4. Monitoring of the introduction processes.

5. Providing assistance to the horses failing to withstand the environmental pressure.

That stage may be realized upon acclimatization of the horses in a semi-reserve centre in the MPR in 1989-1991.

During the initial adaptation in the reserves of the first stage the horses may be shipped by groups into the conditions of the second stage; and they will be replaced by other horses, provided by the zoos. Following the same order, the horses, adapted in the Adaptation Centres of the Kazakh republic and Mongolia may be transported from the places of their release into the wild. At the same time the deserted enclosures may be occupied by the horses that went through the previous stage. Thus the continuity of the adaptation process and introduction will be ensured.

Upon the release of the first groups of horses into nature it is necessary to go on with this process, to feed the developing population with new genetic resources. This would assist in stabilizing the ecological adaptation of the population in the biocoenosis and stimulating the social and reproduction processes.

In order to establish a stable and genetically balanced population of wild horses in a particular steppe biotype it is necessary to reach the efficient number of 500-700 animals. Hence the real number of a wild horse population in nature should be about 2000 head. It may be necessary to establish several populations of the wild horse. This will allow the extension of the response norm of the adaptive characteristics of this species leading to a greater diversity of its gene pool. Later, a gene pool exchange between these populations can be arranged.

When the wild horse population reaches its optimal size and reproduction is stabilized, the surplus animals can be withdrawn from the natural biotypes and shipped back to the zoos, that previously provided horses for introduction. Such a condition will undoubtedly serve in involving to a greater extent the donor zoos in the process of introducing the wild horses into the wild.

In order to ensure monitoring of the developing horse population or several populations it is necessary to set up a research station in the places of horse release.

All those participating in the project and the experts in this field from the various countries concerned will undoubtedly have the possibility to work at this station, to carry out studies.

A number of important issues, both specific and general, should be discussed within the framework of this problem. The problem of adaptation that we are facing when reintroducing the horses is one of the most important. It is necessary to find out in what way the formation of morphological and behavioural characters is proceeding, e.g. what is the process of social alliance formation, of gaining skills, of development of the territory and of reproduction. What is the role of natural selection and in what way is it manifested?

Another important problem arises as regards the functioning of a horse band in a particular steppe biotype. Preliminary studies

should be carried out to assess the needs of a wild horse population for energy and feeds, the productivity of certain steppe biotypes and their response to the pressure, namely the wild horses. This makes it possible to determine the optimal density and the size of the horse groups in reserves, adaptation centres, and natural ecosystems.

It is also necessary to study the problem of conservation of the gene pool of captive horse populations. Line breeding, rotation of the genetic material (horses), and its division into separate breeding groups will be efficient.

Ways of cryoconservation of germ plasm, of artificial insemination and other forms of conservation and enlargement of the horse gene pool should be sought.

Nevertheless, we should not forget that the gene pool of the feral horse populations is no less valuable. Such horses exist in the USA, Europe, and in the Soviet Union. Being out of man's control and having adapted to the natural biotypes these horses have partially returned to the wild mode of existence of which they were deprived in the past by man. At present, taking into account the degeneration of the pure lines of horses that are bred in captivity, the use of the feral horse gene pool may have a positive effect on heterozygosity, reproduction and productive properties of the domestic horses. That is why the feral horse populations should be preserved, raised and utilized.

## CONCLUSIONS

Having analysed the present state of **Equus przewalskii** as a species, preserved only in captivity, it must be admitted that such a situation is dangerous and to ensure its survival the most radical measure will be to release the horses into the wild. To achieve this, an International Project should be set up under the auspices of UNEP. It is assumed that with the use of the existing information and the capabilities of the USSR within the framework of such a Project the introduction of the Przewalski horse into nature will be a success. At the same time it is necessary to organize the concurrent activities in preserving the gene pool of the Przewalski horse in captivity as well as of that of the feral horse.

## THE ESTABLISHMENT OF AN ADAPTATION CENTRE

Yu. Musienko, N. Krylov, N. Lobanov and V. Klimov

Since it is impossible to preserve a species as such in captivity for a long period of time, its representatives should be returned to natural biotopes.

This idea, expressed in the decisions of numerous international workshops and meetings on the Przewalski horse preservation problems, received an enthusiastic support in the Askania-Nova reserve. In this respect, Mongolian specialists visited Askania-Nova to adopt methods of horse management and preservation, some animals were selected for introduction to Mongolia, reintroduction schemes and places for release (Gobi and Hangai piedmonts) were discussed, the programme for reception and maintenance of the horses in Bogdo-Una Reserve was prepared. At this stage the Askania-Nova reserve is eager to take part in every activity on horse reintroduction.

Since the horses accommodated in the city zoos are incapable of fighting the severe climatic conditions of Central Asia due to their poor adaptability, it is essential to set up a centre for the Przewalski horse accumulation and adaptation in the steppe zone of Europe. Such a centre could be established in Askania-Nova. The following factors may be considered as favourable:

- Climate in this region is more severe than that in West Europe and the United States. Temperature in winter reaches -25-27°C. In the past this area was populated by East European tarpans.

- Optimal territorial base - over 8000 ha of virgin reserve steppe to be finalized only.

- Rich traditions in the management and preservation of wild horses, the Przewalski horse in particular, up-to-date experience, availability of technical experts and researchers.

- The new Askania-line horses have been living for a quarter of a century and possess high adaptability to external conditions and behavioural patterns practically similar to those of wild horses, i.e. stallions form their harems, lead and protect them and successfully reproduce while mares are able to protect foals and make their own decisions.

- The horses donated by European and American zoos will be able to adjust themselves to the steppe climate and acquire behavioural patterns in social environment on large areas that are essential for their normal reproduction and adequate response to changing external conditions.

To set up such a centre it is necessary to fence 8000 ha of reserve steppe, build open-air cages, connecting passages, quarantine facilities, provide water sites and reinforce the administrative and research centres.

After the zoos select horses for introduction, they will be delivered to Askania-Nova. Here they are placed in quarantine and released into enclosures according to the lines they represent. In doing so, records will be made of compatibility of the lines, increased genetic diversity and gene pool, etc.

In large enclosures groups will be formed that will serve as reproductive cells of the general population. It is suggested to mate the Askania-line stallions with the zoo mares. This is based on the fact that they possess socially adequate behaviour expressed in organization of the reproductive processes: formation of the band, its protection, management and reproduction itself. The stallions to be received can form bachelors' groups, i.e. genetic reserves of the population. In due course, it will be possible to combine several groups and bachelors on larger areas. This will enable the strongest stallions to lead harems. As a result, the population will inherit geno- and phenotypical features of the best stallions, enhancing the poulation's viability.

The groups function in isolated or common enclosures, get adjusted to natural conditions of the region and produce foals in a year.

Ideally wild horses should propagate under semi-reserve conditions by a population consisting of several functional harems as well as group and solitary bachelors. The horses, involved in natural reproductive processes within the population, acquire behavioural patterns inherent in free-living species representatives.

Due to the competition between stallions the strongest win a greater number of mares and superiority in reproduction. This factor will positively influence the size of their gene pool but lead to decreased effective number of the population. Therefore, natural reproduction should be controlled by man. Excessive harems are divided into several groups so that each group includes 5-7 females with the greatest possible number of harems. This will involve as many males and females in reproduction as possible and increase the effective number of the population, on the whole.

Stable reproduction in this centre will be secured only with effective number reaching 100 individuals.

After 1-2 year acclimatization some horses and offspring can be returned to the donating zoos to improve reproduction of their horses. In the Przewalski horse line breeding this centre will stimulate reproduction of horses of different lines and enrich the total population's gene pool, on the whole.

Primary adaptation will select horses best-adjusted to new environment basing on physiological condition, density of winter hair coat, timely shedding, adequate social behaviour in intragroup, intergroup and interspecies relations, involvement in hierarchical and reproductive competition, actions taken in extreme situations. These animals will be prepared for the second stage - introduction into the wild. They will form separate groups or the best will be selected from existing reproductive groups. The evidence accumulated through behavioural studies of the Przewalski horses in Askania-Nova shows that the reproductive cells, formed without man's intervention and including all the age groups are most adaptable to the environment. In this case the group acts as a functional system implementing vital functions of feeding, protection, self-government and coordination response to external stimuli. These functions are not fully expressed or lost in the groups incomplete in number or composed of young stock. As a result, such groups are not able to withstand environmental pressure and preserve their gene pool. Therefore, in our opinion, the introduction should involve the groups that have been formed on their personal attractions and affections. These groups will be able to protect themselves in any serious situation, preserve and hand down the genetic material to succeeding generations. This proves it necessary to transport the entire reproductive groups to their introduction sites. It will facilitate their travel and adaptation upon arrival.

The centre will be carrying out ecological and genetic monitoring and various biological studies in the course of the zoo horses' adaptation.

The horse management techniques will be mastered in relation to immobilization, cryoconservation of sperm and artificial insemination, monitoring of social dynamics (adaptation) and daily activities. Such work will require immobilization drugs (ethorphine and antidote), appropriate equipment and chemicals.

The centre can train Mongolian and other countries' specialists in the wild horse management methods.

The Przewalski horse adaptation in Askania-Nova and reintroduction to Mongolia will entail:

Stage I - 1986-87: Establishment of Przewalski Horse Adaptation Centre in Askania-Nova

1. Allocation of funds, definition of legal and financial status.

2. Fencing of 8000 ha of reserve steppe with mesh.

3. Building of quarantine facilities, open-air cages, sheds, administrative offices, laboratories, cottages for experts, drilling of artesian wells, arrangement of watering and salting sites.

4. Preparation of materials for veterinary control and research: immobilization drugs, medicine and equipment.

5. Establishment of zooveterinary and monitoring services.

Stage II - 1987-89: Definition of Number and Sex Ratio of Horses to be Donated by Zoos

1. Delivery of horses from the zoos.

2. Identification, marking, quarantine.

3. Formation of breeding groups and their adaptation.

4. Organization of reproductive processes, production of offspring.

5. Formation and preparation of groups for their transit to Mongolia.

6. Research, genetic and ecological monitoring.

Stage III - 1988-89:

1. Transit of the horse groups to Mongolia, introduction.

2. Measures aimed at the improved line breeding: international exchanges, rearrangement and rotation of genetic material.

As one can see, successful introduction of the Przewalski horses into the wild is feasible. Upon adaptation in Askania-Nova, there are no causes for concern over their life in natural biotopes since their survival will depend on properties they have acquired under semi-reserve conditions of the centre.

The Przewalski horse reintroduction will succeed only thanks to the comprehensive and coodinated efforts of all the people and institutions interested in preservation of the last wild horse on the earth!

# GENERAL BIOLOGY OF SMALL POPULATIONS

# GENETICS AND DEMOGRAPHY OF SMALL POPULATIONS

Thomas J. Foose

Small populations, whether in captivity or the wild, are subject to a number of genetic and demographic phenomena and problems that affect their survival over both the short and the long term.

The major genetic problem is loss of heritable variation or diversity. Genetic diversity seems critical at the population level to permit adaptation to changing or changed environments and at the individual level to sustain vigour in terms of survivorship and fertility (Frankel and Soule 1981). The primary causes for erosion of genetic diversity in small populations are random genetic drift and founder effect (Crow and Kimura 1970).

Genetic drift is caused by the random segregation of genes into gametes and hence from parents to progeny. Founder effect is caused when a new population is establishd with a few individuals from some other source. Both genetic drift and founder effect represent sampling processes in which only some fraction of the entire gene pool of the parent generation or source population is propagated.

Loss of genetic diversity due to random drift is a function of the size but also the structure and dynamics of a population (Crow and Kimura 1970). Very generally, the smaller the population is, the faster genetic diversity is lost (Figure 1). This phenomenon is true in captive or wild populations.

However, the population size of relevance is not merely a total census of all the animals alive. Instead, the genetically effective size ($N_e$) of a population is a measure of the way in which animals are actually contributing to the next generation of progeny. Disparities in the sex ratio and inequalities in the lifetime production of offspring (i.e. family size) will reduce the effective size $N_e$ of any total population N (Figures 2 and 3). An animal that does not reproduce during its lifetime does not contribute to $N_e$ at all. A male that dominates breeding for a long time may contribute excessively and therefore also reduce $N_e$. The $N_e$ of a population of ten horses composed of 1 male and 9 females is 3.6, even though the total population N is 10.

Thus, $N_e$ is a function of the social structure and dynamics of a population. Depending on what these characteristics are, the $N_e$ can vary from a tenth to twice the actual number of animals. In natural populations, the social organization is usually such that the genetically effective size is less than the total number. $N_e/N$ ratios of .5 or less seem likely to be common. Management can alter the genetically effective size of a population.

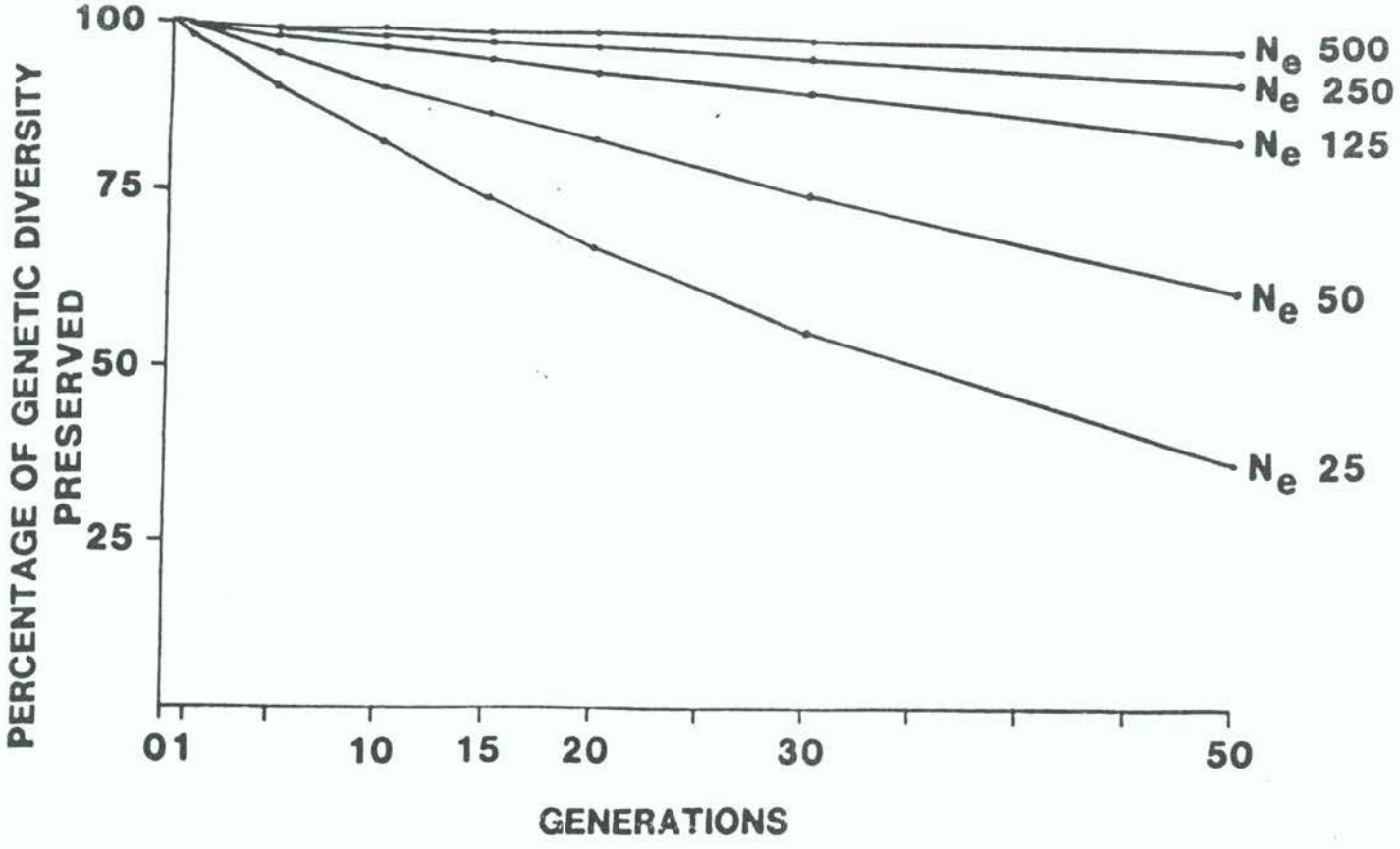



Fig. 1 Decline of genetic diversity for various effective population sizes ($N_e$) possible for a total population (N) of 250

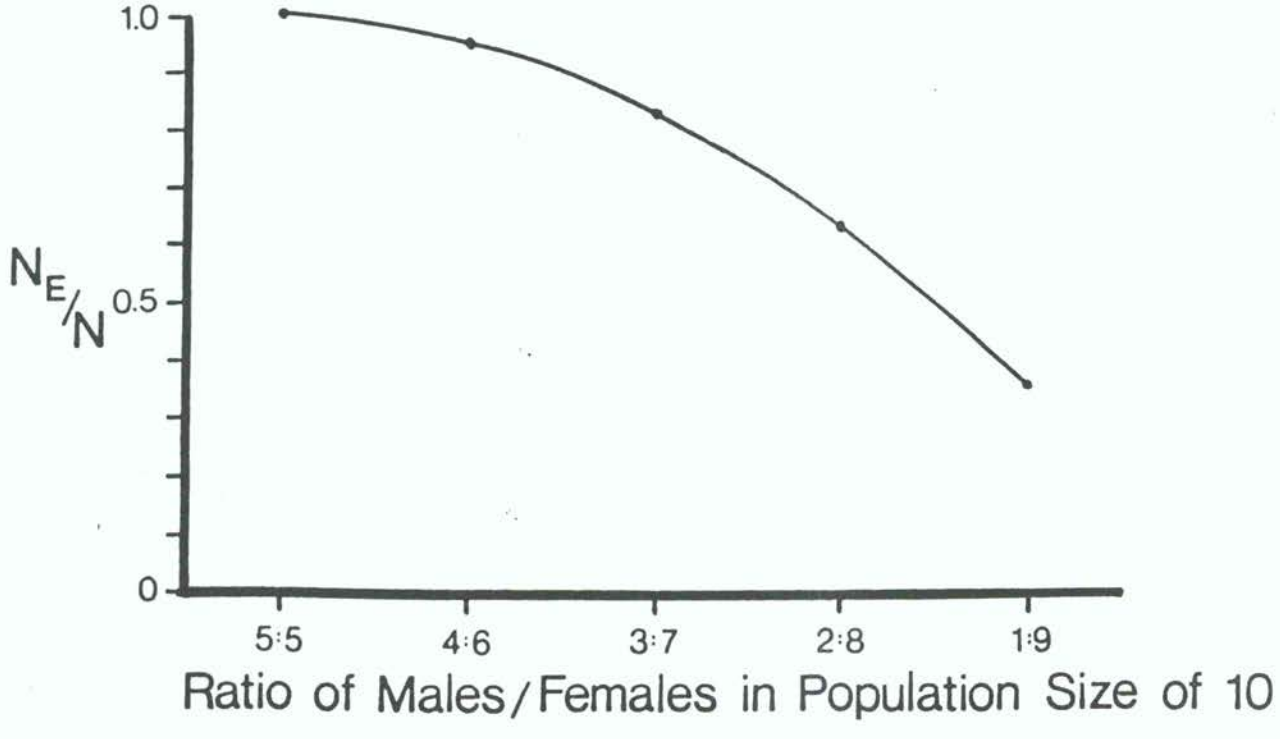



Fig. 2 Effect of sex ratio on effective population number

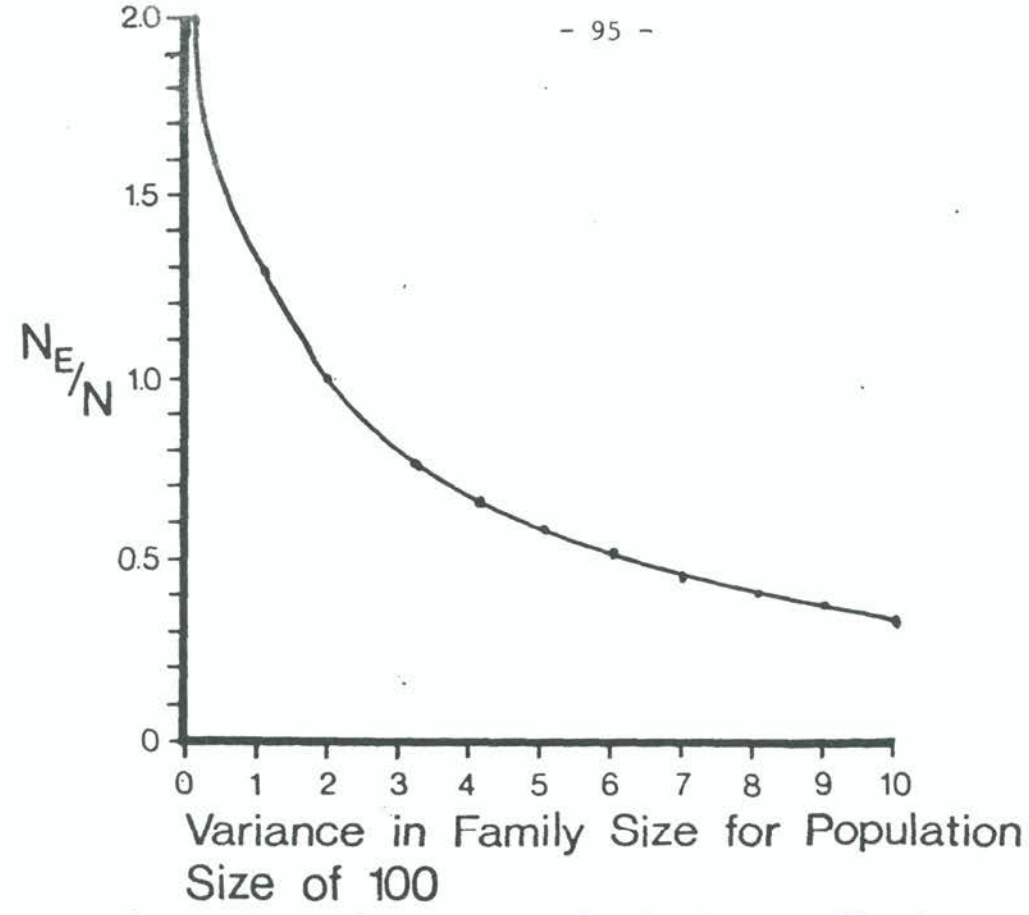



Fig. 3 Effect of variance in family size on effective population number

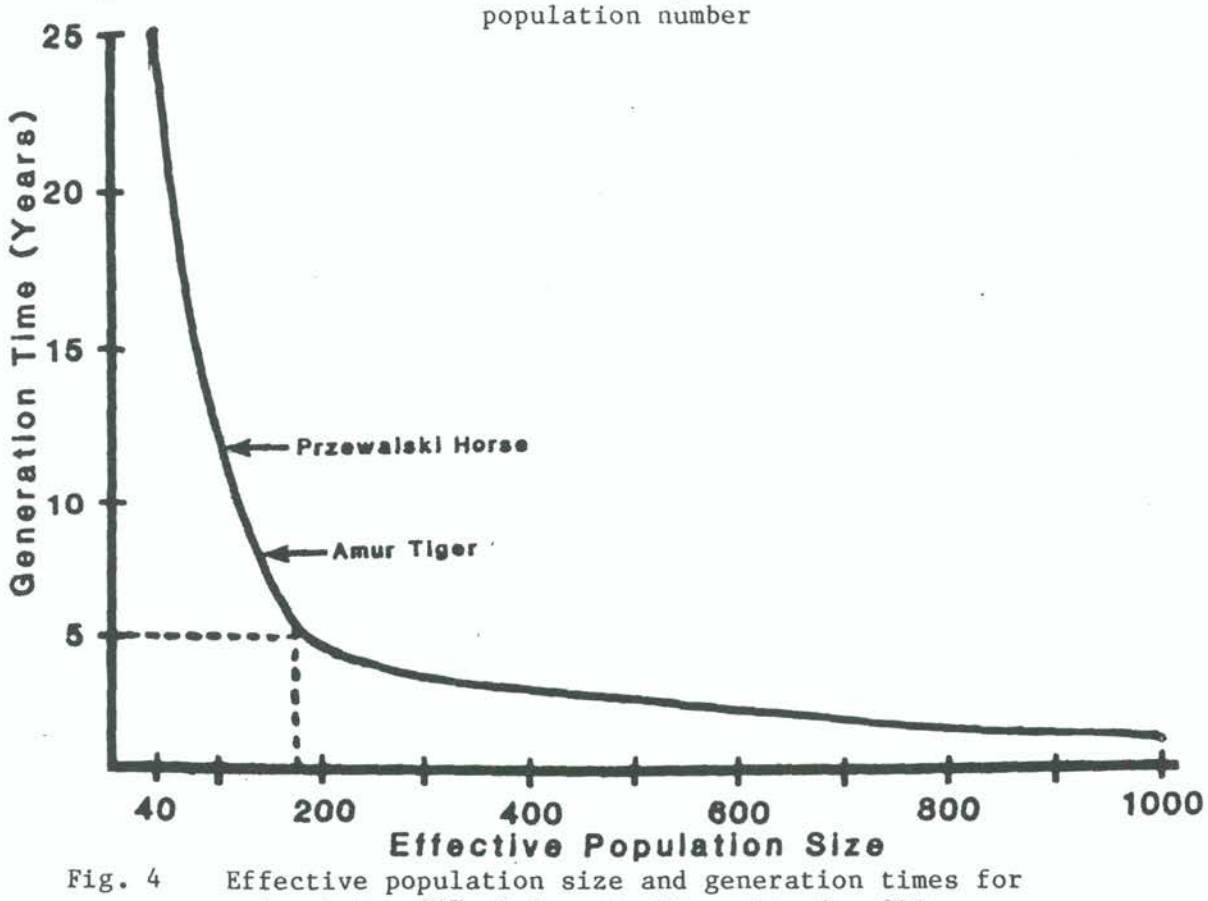



Fig. 4 Effective population size and generation times for maintaining 90% of Genetic Diversity for 200 years

Conservation of the gene pools of species requires that minimum viable populations (MVPs) be maintained. MVPs depend on a number of factors (Figure 4) (Soule **et al.** 1986; Lande and Barrowclough 1986):

1. The $N_e/N$ ratio that can be expected from the natural behaviour of the population or that can be produced by some management.

2. The amount of the gene pool it is acceptable to preserve, for example 90%, 95%, 100%.

3. The time scale over which the conservation management is to occur, for example 200 years or indefinitely.

4. The generation time of the species.

Loss of diversity occurs generation by generation. So any absolute period of time, for example 200 years, is a different number of generations for various species. For example 200 years is about 17 generations for Przewalski horses whose generation time is about 12 years, but 25 generations for Amur tigers whose generation time is about 8 years. Thus, if their $N_e$s are equal, Amur tigers would lose more genetic diversity over 200 years than Przewalski horses would.

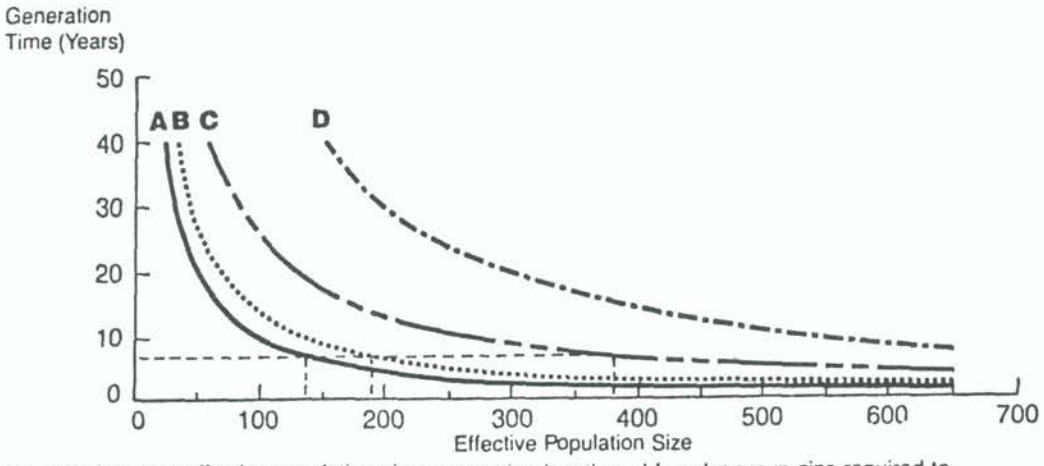
5. The size of the initial or "founder" population (Figure 5).

It is impossible to preserve more genetic diversity (over time periods on the order of several centuries) than a newly founded population originally possesses. The animals that found a population may or may not contain all or most of the genetic diversity in the source population. A founder is defined as an animal from a source population that actually reproduces in the new population. The recommended numbers for MVPs assume that founders are unrelated and non-inbred. If these conditions do not pertain, larger numbers of founders may be recommended. More founders are usually better, but there is a point of diminishing returns. A sample of 20-30 founders will normally contain well over 90% of the average genetic diversity in the source population (Soule **et al.** 1986).

Thus, the number and background (genetic characteristics) of founders should also be considered, and in relation to number of potential reserves. It will probably be desirable for multiple or repeated infusion of founders to occur (Figure 6).

6. The reproductive potential or growth rate of the population.

More important than number of founders will be rate of growth of population from its initial to a carrying-capacity or MVP size. If the founder number is much lower than the carrying capacity, considerable genetic diversity can be lost during the growth phase unless expansion of the population is very rapid.




Relationship between effective population size, generation length and founder group size required to maintain 90% of original genetic diversity for 200 years.
**A**—No founder effect **B**—*20 founders* **C**—*8 founders* **D**—*6 founders*
Assuming immediate expansion of founder groups with no loss of diversity (modified after graphics prepared by M. Soulé and J. Ballou).

(From Conway 1986)

Fig. 5 Population size, founder size, generation time and preservation of diversity

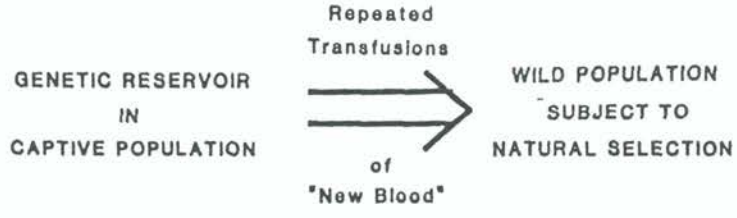



Fig. 6

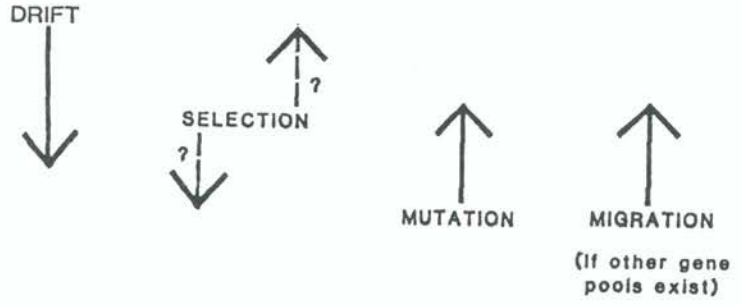



Fig. 7 Forces affecting amount of genetic variation in small populations

7. The nature and intensity of selection, artificial or natural.

Selection can operate either to maintain or diminish genetic variation in small populations. Past effects of selection (conscious or unconscious) in the captive population of Przewalski horse are not well known (Ryder and Wedemeyer 1982; Dolan 1982). But, choice of founders for reintroduction, at least initially, should encompass the widest possible range of the genotypic and phenotypic variation still present in the captive population to provide natural selection in the reserves with the greatest possible base on which to operate. Thereafter, selection in the reserves could either be restricted to what naturally occurs or could be applied artificially for more intensive genetic and demographic management.

Based on these considerations, minimum viable population (MVP) sizes can be recommended to sustain desired levels of genetic diversity for prescribed periods of time within the constraints of the biological characteristics of a particular species. Reserves should be constituted to achieve carrying capacities equal to or preferably greater than MVPs.

Genetic drift can be counteracted by mutation, selection (natural or artificial) or migration (gene flow from a different population) and therefore may modify recommendations from MVPs (Figure 7). Subdivision of a population, which in the context of reintroduction of the horse is equivalent to establishment of multiple reserves, may enhance maintenance of diversity.

Reserves should be established so that their size, shape, and number will accommodate minimum viable populations. In the case of the Przewalski horse, it seems advisable that there initially be at least two reserves each with a potential carrying capacity of several hundreds of animals.

Matters of growth rate and carrying capacity indicate importance of demographic problems and management for small populations. Small populations are also very vulnerable to problems of demographic fluctuations and stochasticity which can cause extinction (Goodman 1986). Obvious examples of stochastic perturbations are disease epidemics, and natural disasters. More subtle problems include distortions of sex ratio in the few births that might occur in a small population or low densities that inhibit potential mates from locating each other.

Deterministic (nonstochastic) demographic problems can be of equal or greater importance. Demographically, a population can be analysed and managed by three basic parameters: the age specific survival rates; the age specific fertility rates; the number and ages of the population at any time (Goodman 1980). In captivity, Przewalski horse populations manifest growth rates of 10% or more per year (Figure 8). Feral populations of domestic horse in North America manifest annual growth rates of 10-20% per year. Such growth rates are

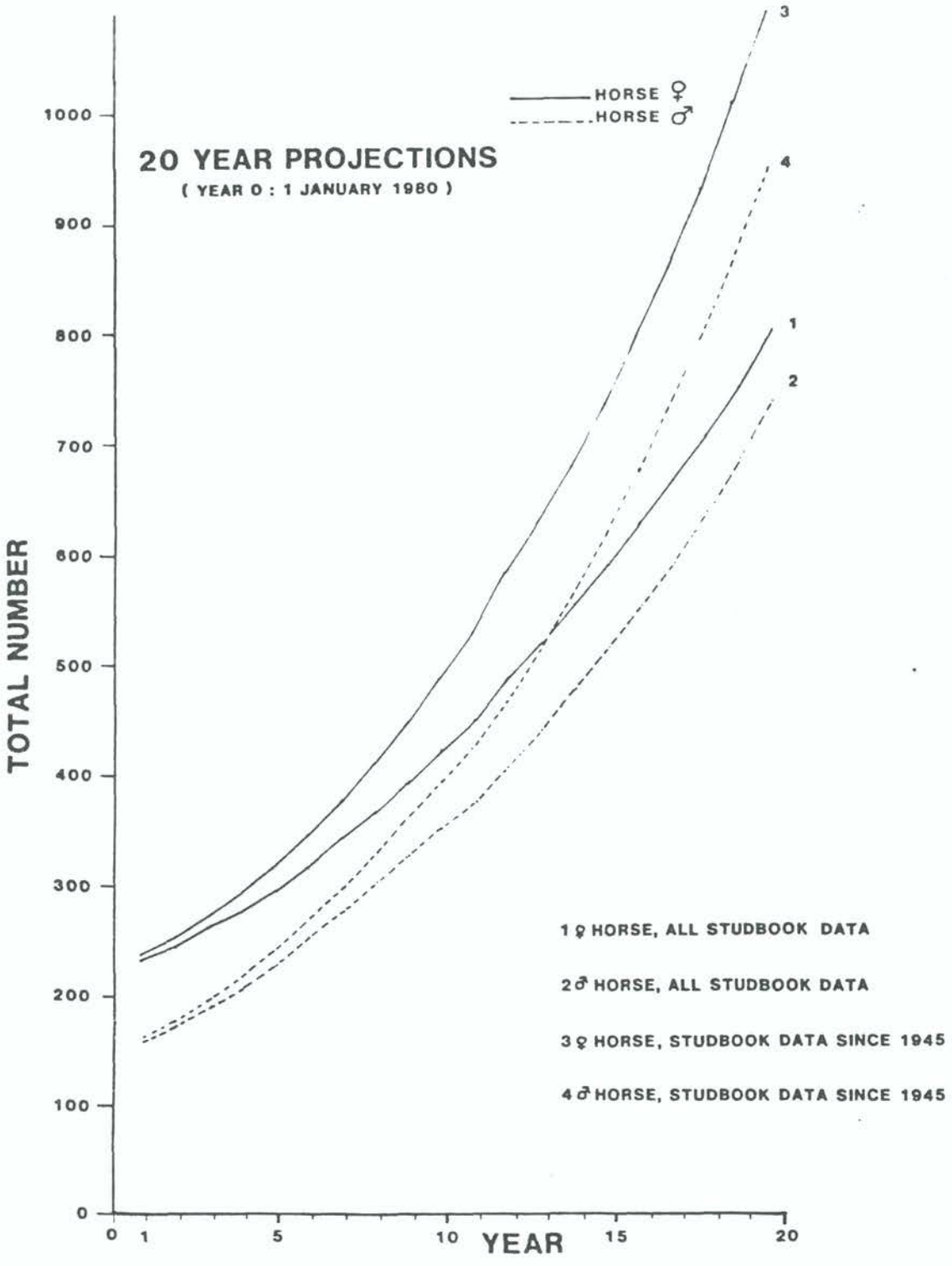
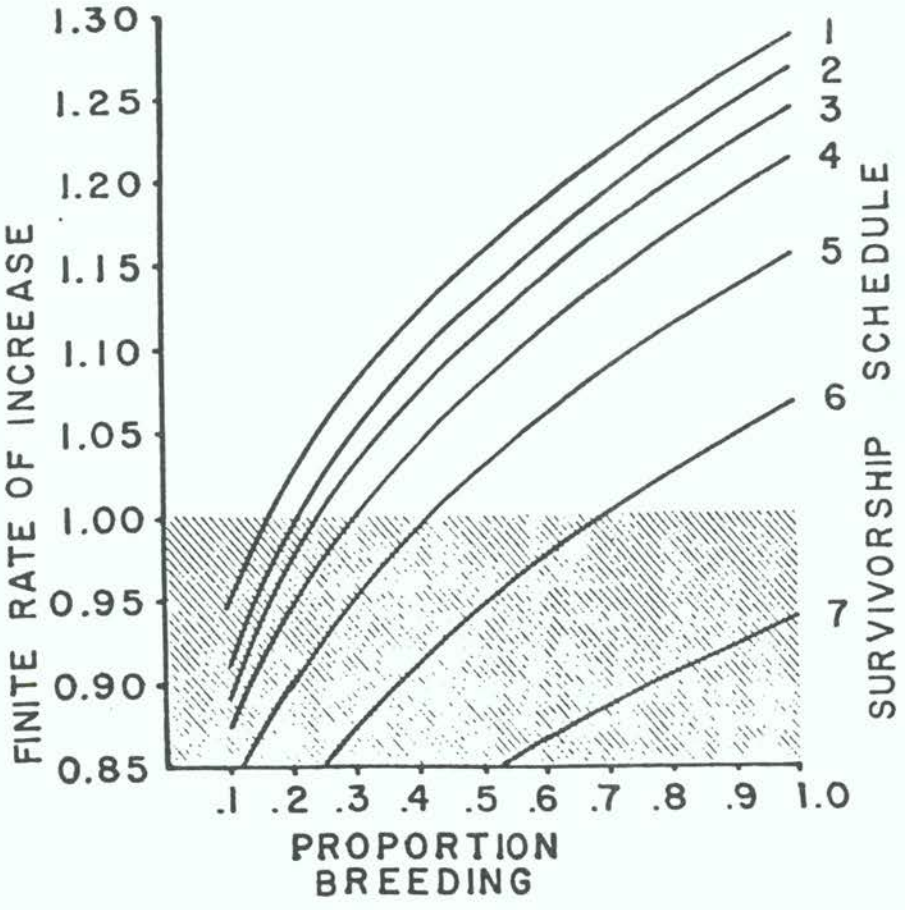



Fig. 8

very vigorous and can eventuate in population explosions that must be regulated.

Rate of growth depends on the patterns of survival and fertility (Figure 9). Ultimately, small populations need to be stablized at the determined carrying capacity (Figure 10). Stabilization of populations can occur by: (i) regulation of reproduction, in other words some kind of birth control, (ii) removal of animals (Foose 1983).




(From Conley 1980)

Fig. 9

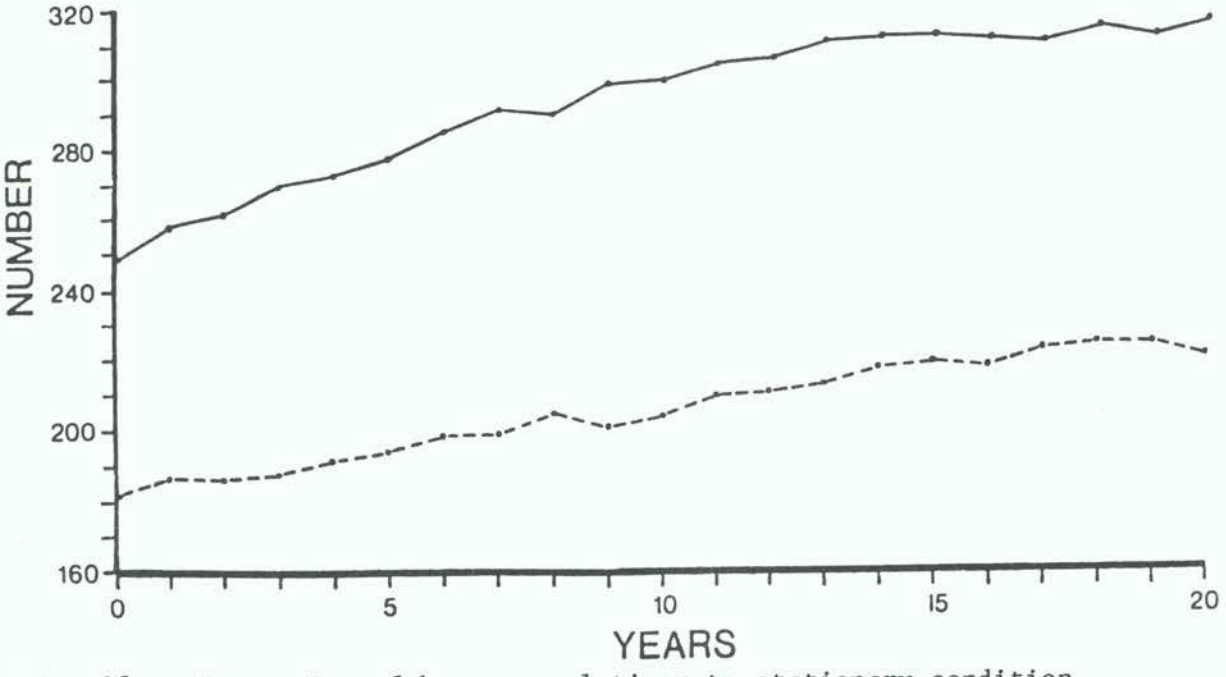



Fig. 10 Conversion of horse populations to stationary condition

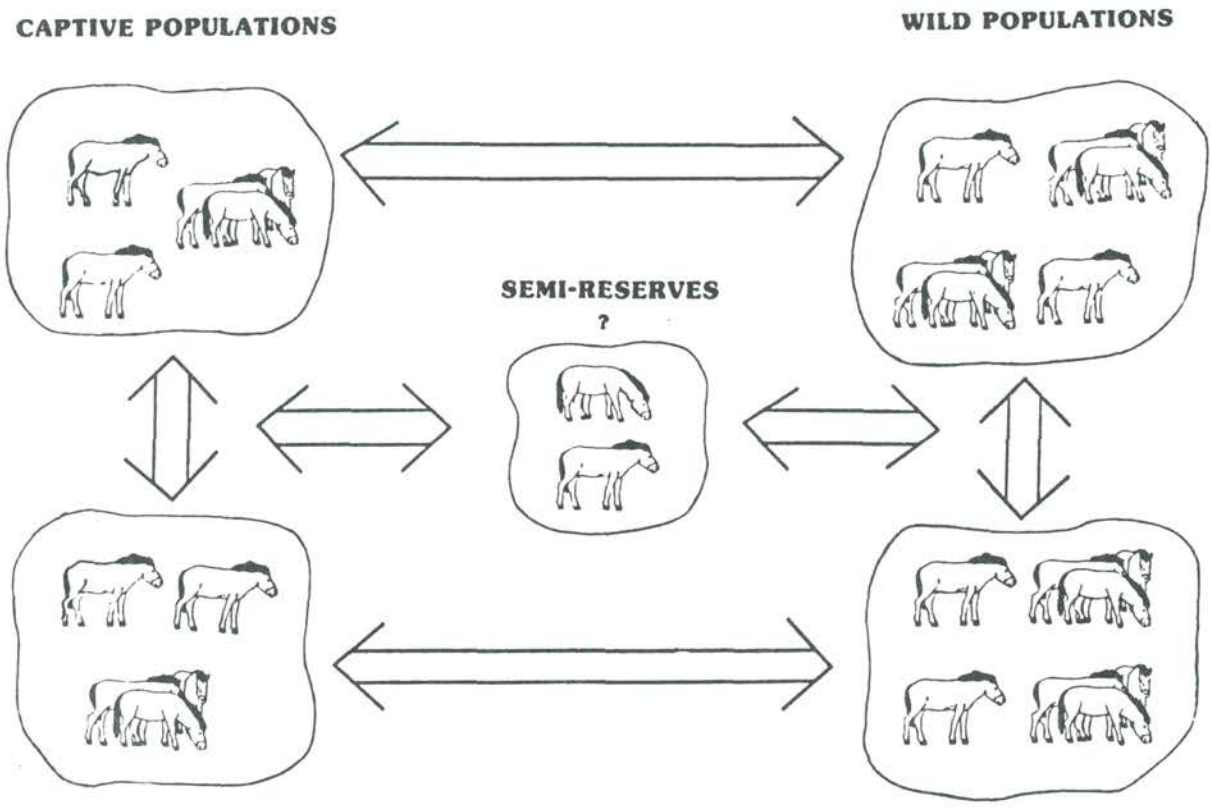



Fig. 11

Table 1 SUSTAINABLE HARVEST OF HORSES FOR REINTRODUCTION

| Annual rate of increase before harvest | Population size | Harvest | Annual rate of increase after harvest |
|---|---|---|---|
| 10% | 600 | 31 | 5% |
| | | 62 | 0% |
| | 750 | 38 | 5% |
| | | 77 | 0% |
| 20% | 600 | 69 | 10% |
| | | 139 | 0% |
| | 750 | 87 | 10% |
| | | 174 | 0% |

However, demographic management must also be cognizant of the age structure of populations. Regulation of numbers is impossible without stabilization of age structures. Populations will normally require some combination of regulation of reproduction and removal of animals for stabilization.

The demographic characteristics of founders will affect rates of population expansion and hence should be considered in selection of animals for reintroduction. A measure of the relevant demographic characteristics is known as the reproductive value (Goodman 1980).

Considering both genetic and demographic concerns, a system of interactively managed captive and wild populations seems optimal (Figure 11). It will be vital to ensure the security and integrity of the captive populations both genetically and demographically while providing viable stock for reintroductions. Sustainable "harvests" of a limited number of horses each year for reintroduction should be possible without preventing the captive population from continuing its growth to and stabilization at the desired carrying capacity or without depriving the gene pool in captivity of essential variation (Table 1).

Indeed, limited and periodic exchange of genetic material in both directions between captive and wild populations will be beneficial to both.

However, it is imperative that genetic and demographic developments in the reintroduced herds be closely investigated by well organized follow-up studies subsequent to release (Price 1986).

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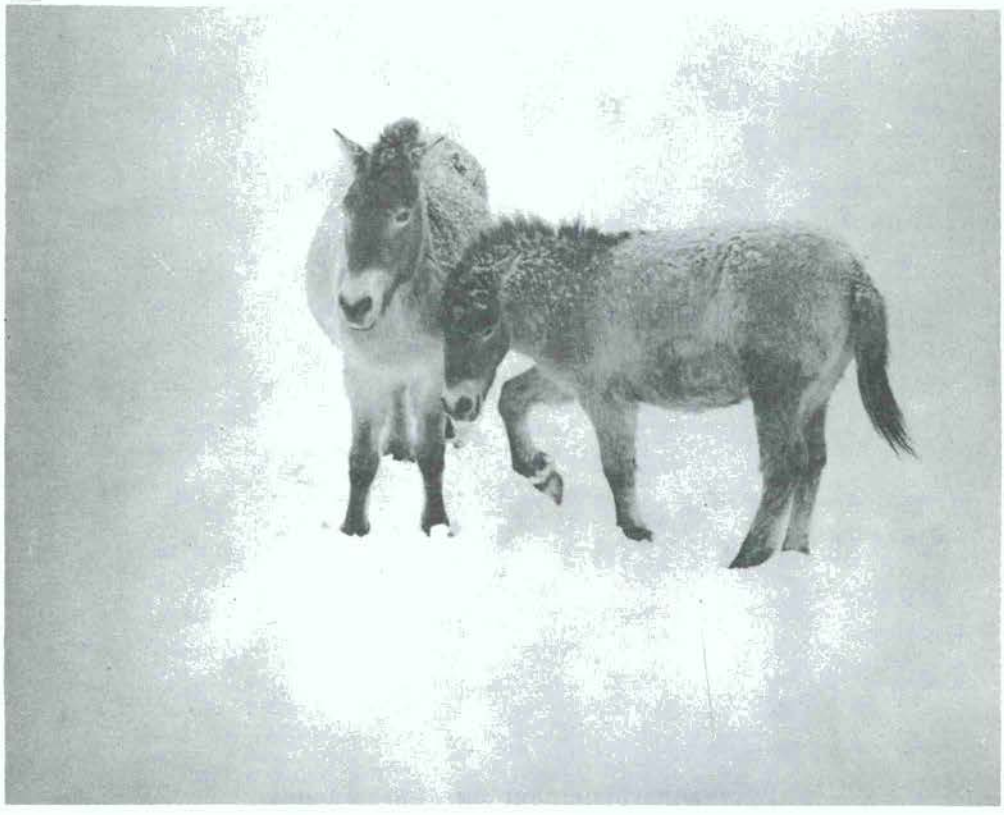
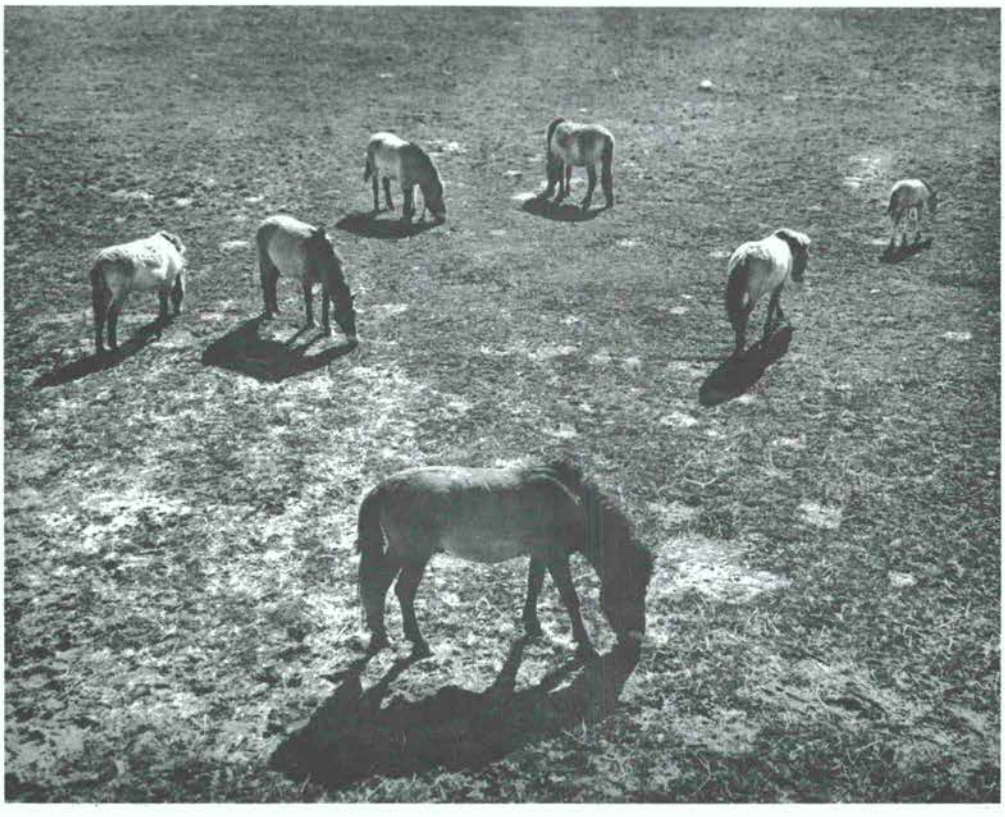
# SMALL POPULATIONS OF PRZEWALSKI HORSE





# GENERAL CARE AND MANAGEMENT OF PRZEWALSKI HORSES IN MUNCHNER TIERPARK HELLABRUNN

H. Wiesner and B. Rau

## 1. HISTORICAL BREEDING SURVEY

Keeping and breeding Przewalski horses have a long tradition in Hellebrunn, going back to the year 1932 when the first 3 animals arrived. From this time up to the year 1984 a total of 98 Przewalski horses were born. No doubt, keeping such a rare animal as the Przewalski horse over several generations signifies a great obligation for a zoo and the main measure of the success of the management of this ancestor of our domestic horse is correlated with the breeding success of the herd.

If we compare the different stages of breeding results in Hellabrunn we will see that these results vary considerably, especially during the last two decades, when we bred only 15 foals from 1965-75 and 28 foals from the years 1975-85. Such results give some idea about the sterility control programme of our group.

## 2. ENCLOSURE AND MANAGEMENT

For the individual care of these precious horses, we keep the animals in an open stable system, protected against wind and rain, which makes it possible to get the horses alone or together in small groups. During the day in the zoo, the horses have access to a large open enclosure of 4400 $m^2$ (Wiesner and Bostedt 1979).

In the years 1979 and 1983, we got two additional paddocks with 2 ha each 30 km outside Munich, that can be used to raise the yearlings under optimal paddock conditions or to establish another stallion group. In these enclosures a separation of the horses is not possible.

In this case we experienced that selective food preference by the stallion and the mares is greater than that of younger ones and leads to uncontrolled feeding. Therefore the stallion and the older mares are inclined to become too fat and the females may become sterile due to this overfeeding.

We have to point out that in any case for adequate housing and management of the mares and the foals the separation possibility during the night is essential. This gives the only possibility to feed each animal individually and also to check and control the health daily.

We assume that this kind of housing also should be recommended

during at least the first two years of the reintroduction, then we would suggest to release the animals in a larger enclosure and finally, step by step to the wild. Only by this controlled possibility, especially with possible predators like wolves in the background, unnecessary losses can be avoided, until the animals are well adapted to the climate.

## 3. FEEDING

The food consists of 1-1.5 kg pellets (rawprotein 15%; StE 480; rawfiber 22% ca. 1,3%; P 0.5%; 12 500 I.U. Vitamin A; 2000 I.U. Vitamin $D_3$ ; 250 mg Vitamin E per kg), 500 g - 1 kg crushed oats and, depending on the time of the year, fresh lucerne clover hay and lucerne crops.

Two years ago we also started with corn silage with an additional dosage of 300 mg Vitamin E per day. We stopped this type of feeding in the last year, when we got the impression that our animals became too fat, especially in the paddock where individual feeding is not possible.

By the way, we say in our herd of dama dama the same problem and they interrupted their usual breeding for one season when fed with corn silage. Przewalski horses seem to be sensitive to white muscle disease. We provided the animals with 100-150 g of a Selenium containing vitamin - mineral mixture (500 000 I.U. Vitamin A; 40 000 I.U. Vitamin $D_3$; 5000 mg Vitamin E per kg and 10 ppm Selenium). Sine this prophylactic measure we had no more cases of selenium deficiencies in the horses (Wiesner and Bostedt 1979; 1984).

## 4. GENERAL PROPHYLAXIS

According to our general schedule for the prophylaxis of wild animals, we also vaccinate our Przewalski horses but only against such diseases that have already occurred in our herd. All animals are routinely vaccinated via the blow pipe method against virus abortion and tetanus.

The animals in the outside paddocks are also protected once a year against rabies, which occurs in the fox population of this area. There is no special vaccination or serum treatment of the foals against the lameness infections caused by -harmolytic Streptococci and Staphylococco. The normal youngster prophylaxis consists of 10 ml Selepherol$^R$ s.c. on the second day of the birth (1 ml Selepherol contains 0.2 mg Na-Selenit, Vitamin E-acetat 0.04 g; Vitamin $D_3$ 5000 I.E.; Cogluconat 0.02 g; Cu-gluconat 0.02 mg; $B_{12}$-Komplex 0.13 mg). No anitbiotics or sulphonamides are given to the foals for controlling any hypothetical new born diseases. In the last 10 years, we did not lose a single foal by infections or any other disease.

During the first year, the foals are checked for parasites by regular faeces control and treatment. We also deworm our foals with mebendazol (10 mg/kg 3 days) or fenbendazole (5 mg/kg 3 days) every two months, even when the faeces control has a negative result.

Since 1985 we also use Ivermectin by blowpipe darts with good results. The dosage is 1 ml/100 kg, i.e. 0.2 mg Ivermectin/kg body weight. This therapy is efficient and simple if a singular animal or the foals are standing with their mothers instead of treating them alone. No side-effects like muscle swelling or other incompatability reactions have been observed.

Periodically, perhaps every 2-4 years, we have had infestations by Mallophagae (**Damalinia equi**), which we treat by a distance therapy with a motor syringe with 0.2% Hexachlorcyclohexan solution. This should be done once a week for six consecutive weeks, to be sure that all parasites are definitely killed, as all the larval stages like the nymphae do not respond to the HCH treatment. Generally we can conclude that we do not have many infectious diseases in our experience to contend with in the re-establishment of the wild horses in the native habitat.

This corresponds with the results of post mortems from 210 captive Przewalski horses which died from 1943-1980 (Ashton 1984).

It may be that **Malleomuces mallei** could play a negative role in this matter. Of course, the conditions **sine qua non** for the re-establishment, besides top condition, would be for parasite free animals, checked monthly by several faeces samples during 6 months before their transport and given an adequate worm cure in positive cases.

## 5. STERILITY CONTROL

Since the good breeding results we have had after the control and treatment of our mares in the years 1976/77, we check all the mares regularly, which fail to become pregnant after a 3-4 time covering rate. The gynaecological examination is performed after an appropriate immobilization. Dring this examination functioning of ovaries and uteri are rectally investigated and the organs are checked for pathological conditions. For the first several examinations in the lying down position of the skilled operator in rectalizing wild horses some experience of this unusual position is necessary. Therefore we also recommend training on other wild equidae like zebra, kilans e.a. Then in addition to this, due attention should be given to hygiene, the vagina should be examined by palpation and visual inspection in order to obtain a complete clinical picture. Samples from the cervix and uterus can be taken, followed by bacteriological and histological investigation, in order to enable comprehensive judgements of the state of fertility.

For the technical performance a Polanski-speculum with a light source as well as an instrument for taking samples like a knudsen katheder should be used to collect bacteriological and histological material for investigation. All these inflexible instruments can of course only be used on a well fixed animal that has been properly immobilized.

In positive cases, for example, an infection with β-haemolytic streptococci, a treatment with antibiotics is indicated. Also the stallion has to be medicated in a similar way.

According to the International Studbook, only 5 mares from the imported 20.19 Przewalski horses by Hagenback in the years 1901-1902 had become pregnant, the other 14 of them were sterile. Only one other mare "Lori", born 13.7.31, studbook-nr. 198, imported from Askania Nova in the year 1932 had a further influence on the Hellabrunn Line. If we compare the old pictures of these imports with a healthy yearling of today there is no doubt in the mind of a clinically experienced wild horse breeder, that all these animals were in a bad condition probably due to the long stressful transport and due to severe malnutrition. With such animals, you can rarely achieve breeding success and we can be glad that some of these animals have become proven breeders. But on the return trail we want to assure the re-establishment of these wild horses in their native habitat, and we should avoid making similar mistakes like those of 70 years ago.

Therefore only gynaecological and andrological checked animals should be allowed to participate in this project. Maybe the actual inbreeding coefficient in the Przewalski horses of the Hellabrunn Line is quite high, as all our living horses definitely go back to 6.3 individuals (stallions Pascha, Neville, Severin, Sidor, Simon, Sindbad, mares: Lori, Roma Sidney).

That is by the way the reason we exchanged the Prague stallion "Bars" with our "Simon" in the year 1984, to get in the blood of Orlitza III! Further we have to consider that all the living ca. 600 Przewalski horses in the world go back to 5.8 animals, including the Mongolian domestic mare. This fact also results in a high inbreeding coefficient. But before we discuss deleterious genes, first of all we have to check the animals according to the best and most modern clinical methods we have available. Malnutrition, Vitamin or trace element deficiencies, mismanagement, like small enclosures, stress etc. can lead to multi-follicular activity of the ovaries: an untreated mare would be lost for breeding forever, and this we cannot afford. Nobody will refuse biological manipulation to avoid losses in the foals through parasites. Thanks to a problemless immobilization and the progress in sterility control we are able nowadays to avoid the loss of potential genetic material of a single mare suffering from β-haemolytic streptococci infection of the uterus.

According to our good results in Münchener Tierpark Hellabrunn we can demonstrate the effectiveness of this sterility control with 3

females in our herd. The mare "Rocette", born 1965 (studbook-nr. 338), has regularly given birth from 1974-76, but did not foal in 1977. The sterility control showed a disturbance of the ovulation in the sense of multi follicular activity. The vaginalscopy view and the uterine mucus sample pointed to an additional endometritis, caused by β-haemolytic streptococci infection.

The animal was treated and gave birth to a female foal in May 1978. Since this date up to 1984, she has given birth to a foal every year without any more treatment and is highly pregnant at the moment, covered by the Prague stallion "Bars".

The second mare "Silka", born 1965 (studbook-nr. 340), showed at the examination small, almost strophic ovaries. Until the time of examination no one had ever seen her in heat, she had no offspring. After adequate treatment, she foaled regularly from 1977 to 1984 every year except 1981. Her first male offspring "Sindbad", born 10.6.78 (studbook-nr. 777 Hell 77) successfully sired the mare "Siena", born 18.6.79 (studbook-nr. 848) and the female foal "Sierra", born 4.5.83 (studbook-nr. 1115) was born. Also her daughter "Simona", born 8.5.77 (studbook-nr. 703 Hell 74) was successfully covered by "Simon" (studbook-nr. 411) and gave birth on 27.4.82 to "Sikkim: (studbook-nr. 1037), which is now in Leipzig zoo. This proves a normal physiological condition of the reproduction organs in both sexes of the F1 generation of the treated animals.

Even in older mares sterility control can be helpful. In the year 1977 we also treated "Sira", born 1957 (studbook-nr. 173), because of disturbances of her ovarian activity. This 20 year old mare corresponded well to the therapy and gave birth for 3 consecutive years to three healthy foals" Silvio", born 20.7.78 (studbook-nr. 787), "Sigurd", born 4.7.79 (studbook-nr. 853) and "Sitka", born 8.7.80 (studbook-nr. 932) and we are sure that we owe her last three foals only to our sterility control. We can be sure that also in the former breeding decades of Hellabrunn, sterilities caused by multi-follicular activity occurred but have not been reported for lack of an exact autopsy. Only since 1972 regular post mortems have been done. The mare "Sinella" (born 10.6.67, studbook-nr. 378), which died 3.5.73, showed also cysts on her ovaries and had never foaled in her life. No doubt this sterility is a severe problem in Przewalski horses.

In two other mares, "Koketta", born 1963 (studbook-nr. 297) and "Kolette", born 1962 (studbook-nr. 274), which we took over from Copenhagen zoo in the year 1979, the prognosis for a successful treatment has been dubious so far as both mares have never been successfully covered in their lives. There is no doubt that such a therapy for wild horses aged over 15 years is similar to domestic horses, and is quite problematic, but should be performed in any case to utilize the smallest chance in breeding Przewalski horses to keep their gene pool as big as possible.

Therefore, all the mares between 5 and 20 years which show some disturbances or irregularities in fertility, should undergo such a sterility controlled programme.

To conclude our experiences in the sterility control of Przewalski horses with regard to starting a re-establishment programme in their native habitat, we would like to recommend:

i. All the fertile mares which will be used for the re-establishment programme should submit to a sterility control described by an experienced operator.

ii. The younger females, which are still not fertile, should be checked in the 5th-6th year of their lives, in case they have not been successful in breeding.

iii. Only stallions should be used which are from a β-haemolytic streptococci free breeding.

iv. The first and the second pregnancy should be under enclosure conditions, which enable a post parture sterility control.

v. Only mares should be released totally in the wild which are proven breeders.

vi. Only stallions over 6 years of age and proven breeders should be re-established in their native habitat.

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# SPATIAL-ETHOLOGICAL ORGANIZATION OF THE BAND OF PRZEWALSKI HORSES (EQUUS PRZEWALSKII) IN ASKANIA NOVA

V.V. Klimov

SUMMARY

The ethological structure of the band of Przewalski horses includes hierarchic ranks of horses which determine their social roles in the band. Besides the age ranks, the wild horses are characterized by the formation of harem groups, a "leading" group of females, a group of bachelor stallions, groups by relations, etc. The ethological structure determines the spatial one which is the form of distribution of horses over the territory, its assimilation and transformation into a system of informative-spatial units. Under the influence of "internal" and "external" stimuli, the intragroup regulatory mechanisms (social adaptations) manifest themselves allowing the band to function in the complicated situation of the reserve and man to control the band while using these mechanisms. There are grounds to believe that, given the balanced ethological structure of groups, wild horses will be able to become successfully acclimatized in natural biotopes.

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The necessity to preserve genetic pools of rare animal species calls for careful studies of their biology and interaction with the environment. This also holds true in the case of the Przewalski horse (**Equus przewalskii** Poljakov 1881) - the last wild representative of the **Equus** subgenus already vanished from nature. Wild horses preserved and bred in captivity in isolated groups are being prepared for reintroduction into natural biotopes which accounts for the special interest in the least-studied aspects of their vital activity, i.e. the socio-demographic and spatial forms of population organization, as well as mechanisms of population homeostasis in contacts with the changing environment. Especially important are studies into the action of these mechanisms in captivity - that is in zoos and reserves having a specific impact on behaviour, reproduction cycle and morphology of wild horses (Klimov and Orlov 1982).

Rather fragmentary and incomplete data available on the ecology of Przewalski horses in nature can be summarized as follows. Until their migration regime had been disturbed by man, wild horses moved freely across central areas of Asia following precipitation which increased vegetation. In winter, they went to the northern mountainous areas of the Mongolian Altai and in summer they came down to the valleys, choosing foothill steppes, pebble and sand deserts of

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Note: References in this paper are found in the list of papers at the end of this publication.

Jungaria that were most rarely visited by man (Grum-Grzhimailo 1896; Klements 1903). The horses keep in harem groups of 15-20 animals but may also form large herds of 100 and more. Stallions banished from bands form bachelor groups. In the daytime, horses stand waiting for the heat to subside and at dusk and night they begin foraging and watering. Their presence is clearly manifested by noticeable pathways and heaps of excrement (Grum-Grzhimailo 1896). Of considerable interest is the behaviour of stallions, who display force and courage not only in fights among themselves but also attack predators and man being able to find their bearings in complex and continuously changing situations while defending the band and directing it (Grum-Grzhimailo 1896; Klements 1903).

Despite the 80 years of captivity there is a relatively small number of published papers on wild horses' biology and behaviour.

In the Askania Nova reserve, a band of Przewalski horses is kept in a corral surrounded by a 2 m high wire-net fence with a total area of 2660 hectares. The band comprises 40-43 animals, including 3-4 adult males, 2-4 semi-adult (2.5-3.5 year old) males, 3-4 two year olds, 3-4 yearlings and 3-4 newborn males; 14-15 adult females, 3-4 semi-adult and 3-4 two year old females, 4-5 yearling females and 4-6 newborn females.

Permanent observations of activities of the band of wild animals that provided material for the present paper were carried out in 1980-82.

The type of foraging activity and the nature of the use of the reserve's territory by horses depend on a number of factors subdivided by us into two categories. The internal factors include the requirement of horses in forage and the socio-demographic structure of the group. The external factors comprise biotic (neighbouring groups of horses, gnats, the type of rangeland, the stage of vegetation development, etc.), abiotic (climatic conditions, relief features, configuration of the corral) and man-related factors (man's activities, machines and other equipment).

The social or ethological structure of the band is one of the main factors that unite horses into a system of structurally interdependent units, and accounts for their use of land spaces and their functioning in a hostile environment. It consists of a number of structural units, such as age and rank groups, certain temporary and permanent units and modifications thereof. The rank stages, which every animal enters successively over its whole life-period, are determined, largely, by the morpho-physiological and psychic status of each animal. A combination of these factors determines the position of each animal in the system, its rank and the social role in the band.

The present paper does not aim at an individual identification of each animal within the band with its general or situational rank but gives only a general description of the social structure because

each newly-formed group of horses has its own hierarchy depending on age and hence on the individual qualities of the animal, its life aims and strategies.

Of great importance in the hierarchy of rank is the age of animals. Newborns stay together with their mothers and automatically stand beside them in the heirarchy. The more they grow up and start grazing, the more often they leave their mothers, and by two months they may be already included in a separate juvenile rank group - the lowest in the hierarchy. They are followed by yearlings, two-year old animals, semi-adults and adults. This is, so to say, the formal age-based rank structure underlying the hierarchic structure of the band. While animals of junior age groups may be easily identified due to considerable external differences, adult animals show almost no differences in size. However, observations show that each adult animal occupies its own place in the general hierarchy of the band.

At the top of the whole social structure of the band is the band stallion also known as the "leader". For a number of years, the band stallion in the Askania Nova band of wild horses has been Pegasus - the oldest in all the group. It is in the actions of this stallion that all behaviour forms characteristic of males of the **Equus** subgenus find their complete embodiment, their functional and evolution significance. All his actions are subdivided by us into: 1 - methods and techniques for establishing domination; 2 - methods and techniques of guiding the band and defending it; 3 - reproductive function being both the result and means of domination.

The first group of actions comprises mainly aggressive forms and their ritual demonstrations. The methods of guiding the group include the stallion's actions to find the optimum locations for the band, the best pathways, to choose the timing for changing activities and the time for watering. The stallion banishes other males, breaks up fighting ones, keeps order in the band and takes care of females and younglings. He pays especial attention to external stimuli, viz. intrusion of other stallions, animals of other species (saddled horses, carts and motor vehicles). The stallion never attacks a man without a horse or car, and only demonstrates the aggressive ritual and marks the area with excrement. It immediately attacks domestic horses, either harnessed or saddled, and its victim may be saved only by the interference of man. There were cases in zoos, when a stallion attacked a mounted man, grasped him with his teeth and pulled him to the ground. Evidently in such cases, the stallion took the man and horse as one. However, a dismounted man attacking the stallion makes it retreat.

Among adult mares a leading group or "nucleus" may be isolated consisting of (3-5) dominating mares that form the principal structural and functional unit of the band. It is the mares of the "nucleus" that determine the direction of movement in foraging, in passages and in evading threats. In extreme situations, leadership is usually assumed by Volga - the oldest and most experienced mare of the band.

Another factor influencing the hierarchy of horses in the band along with individual qualities of animals is their relations by blood. The lowest kinship unit is the mother with the foal. If a mother has a yearling or a two-year old foal (which is a rare case) we may speak about a family cell within the band or within the general family group in our case - because almost all the members of the band are related through inbreeding. Despite their independent life, young animals do not forget their mothers and one may not seldom observe a mother being sucked by two foals - one newborn and the other one either a one- or two-year old foal. Within this group of relations are relations between brothers and sisters. An example of such relations is the relation between Pegasus and Volga, both being children of the progenitors of the line. They spend long hours together standing either "nose to nose" or "muzzle to withers". The mare also accompanies the stallion while patrolling the range. Due to this relation Volga occupies one of the highest positions in the hierarchic system of the band.

Along with the main structural units, there exist more or less permanent or temporary formations that change the social structure of the band depending on the season, the corral occupied by the band, the ecological situation, the demographic composition of the herd or the physiological state of individual animals. Their permanent formations are the following:

1. Harem groups. When Pegasus is in the band all the mares are members of his harem. When adult stallions previously kept in isolation are introduced into the band in the absence of Pegasus, one of them takes the mares and banishes all the others; if the stallions are of equal strength they divide the band into two parts, which was observed in the spring of 1982 when stallion No. 6 and stallion No. 13 divided the herd into two groups (comprising 17 and 23 animals, respectively). In another case when the first of these stallions had been isolated he jumped to the neighbouring corral and drove away the mares of a Shetland pony. Having joined a Polesskaya domestic mare with a foal to his interspecies harem, he kept that harem over the whole season.

2. Groups of bachelor stallions and solitary stallions. This is observed when the leader-stallion banishes other semi-adult and adult males that forage some distance away from the band. Sometimes they are on the territory of the band but never mix with it and even without any action of the leader keep in an isolated group. The isolation mechanisms of these two groups were clearly evident when on more than one occasion we tried to join the stallions with the band artificially. Even as far as 100-150 m away from the band they refused to go forward and tried to turn back or to bypass the band. At a distance of 30-50 m, the band stallion sprang into action. It banished the stallions by attacking the oldest and most powerful one ignoring younger animals. Longer-term observations of the

bachelor groups show that without reason for rivalry stallions do not fight with each other and form a "community of equals". With a stimulus for competition, age appears to be the decisive factor in rivalry. The older animal, as a rule, wins.

3. Groups of animals showing personal likings to each other. Here for example, comes the relation between stallion No. 13 (Parade) and mare No. 14. When in June 1981 Pegasus drove Parade away from the band, he was followed by mare No. 14. After that she permanently stayed with Parade and when Pegasus jumped over the fence to their corral and tried to bring the mare back to the band, she refused to do it and again joined with her stallion. The next year the female met with the leader (Pegasus) in the band, and almost the whole season Pegasus was chasing her trying to drive her away from the band. Such relations may also arise between animals of different species. Thus, when the herd was kept in a large corral with Pegasus absent and Parade the leader, Volga together with three young horses and a Polesskaya domestic mare with a foal formed their own mini-band. The non-accidental character of this group is manifested by the fact that in subsequent years the group did not change its composition. The leading element of this group was Volga, whereas all the rest including males were subordinate.

The temporary formations are:

1. Groups of animals that are formed around females in oestrus. Two variants are possible here: first, when a female is followed by a "train" of stallions trying to fecundate her and second, when a female tries to approach a stallion. It was noticed that mares were attracted by "bright" objects such as the band stallion or even a domestic gelding who was an inadequate object for wild horses, when "dressed" in harness and accompanied by man.

2. After mother-mares give birth to foals their temper, behaviour and rank change sharply. They become the most alert and aggressive animals of the band, and having a common desire to preserve their offspring, they have to resort to concerted actions against a threat, another stallion, etc. Their actions are characterized with especial ferocity and perfection of reactions directed against the enemy. Such behaviour ranks them second in the hierarchy after the band stallion who also prefers avoiding conflicts with them.

The age status and the rank of each animal of the population are in a sort of equilibrium. However, a time may come when the limits of its rank become too narrow for the animal and it breaks through these limits by conflicting with animals of the same or a higher rank. Thus, the rank status of each animal is established and maintained by its personal qualities, by animals of the nearby ranks, by high-rank

horses and the band stallion. Changes in the psycho-physical status or rank of individual horses are brought about by their physiological conditions (traumas, illness). These internal causes together with external ones, such as climatic and seasonal factors, appearance of new members in the band or disappearance of old ones, change the ranks of a considerable number of animals, thus disturbing the whole social structure of the band. Such changes take a rather painful course in the presence of increased excitement levels, stresses, etc. The number of aggressions sharply increases - up to 40-50 per 5 minutes. The number of activity changes during the day-time increases from 27-30 to 68-70. The time for foraging and resting decreases (to 46 and 34 percent, respectively), whereas the time for movement increases up to 20 percent (as compared to normally from 8 to 12 percent). After 1-3 days, depending on the factors that had caused the change in the social structure, an equilibrium is established. Each animal occupies its own cell in the social organization which remains stabilized until a new "cataclysm".

Relations within the group are regulated by means of demonstrative and agonistic behavioural forms. At first, the contact between two adult stallions is based on visual stimuli and ritual motions corresponding to their rank, motivation and pretentions. If, at this stage, the interest of males remains non-realized, the contact between them continues with growing excitement. The animals come closer to each other, rear up, bite and kick each other with the fore and hind legs. Fights between wild stallions lead to serious traumas and even the death of one of the rivals. Mares usually do not use rituals and immediately begin aggressive actions (bites and kicks).

The band's type of vital activity and spatial distribution depend on the corral: its area, relief features, configuration of the fenced territory, the availability and location of water bodies, shelters and solonetz patches. Depending on these factors the group forms its spatial structure that comprises the "core" and "marginal" (peripheral) zones, patrolling areas, sites for marking, resting, comfort activities, "toilets", etc. The main territory occupied by horses during the reproductive period (from May to September) is corral No. 3. This is a tract of virgin steppe with an area of 45 hectares situated in the southwestern part of the corral system of the zoo (Fig. 1). The vital activity of horses in this corral has been thoroughly studied and presents a model of how a space may be used by horses (see Fig. 2). It should be noted that corral No. 7 with an area of 1550 hectares is the most appropriate place for horses. However, because of the high aggressiveness of Pegasus it is impossible to keep the band in that corral round the year and the horses are placed there after the end of the active reproduction season without the stallion.

The "core" zone located in the western part of the corral is a hoof-beaten dust patch having 9 m in diameter. This is a so-called "tyrlo" where the horses spend most of the day. This is also a resting and a comfort-activity site. This zone is surrounded by additional sites of comfort activity - dust "baths" with an area of 12-15 $m^2$ and

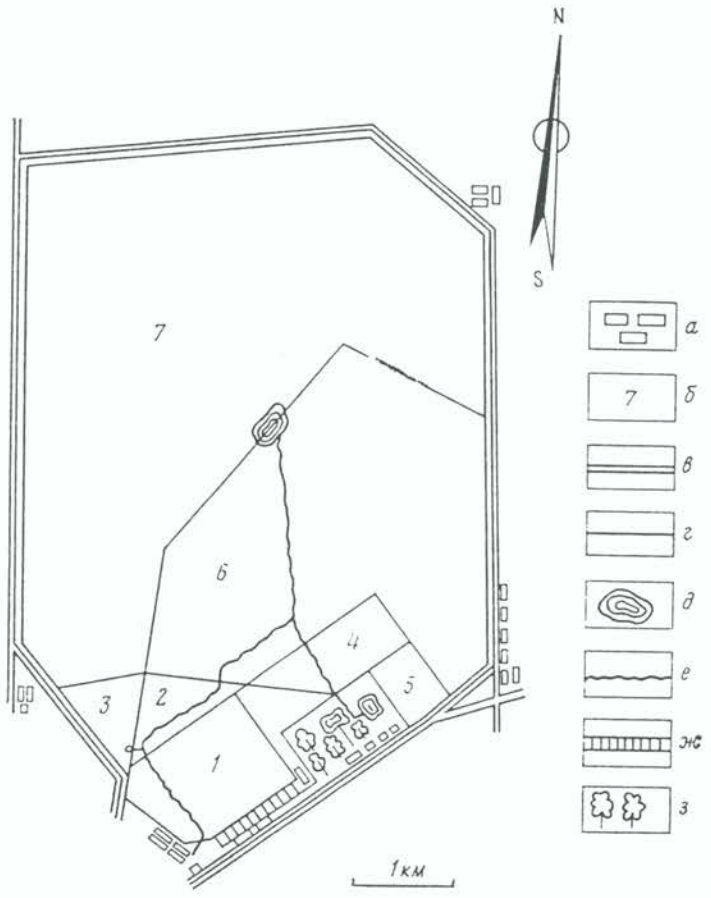


Fig. 1 The layout of corrals in the Askania Nova Reserve:
a - buildings, barns; b - corral numbers; c - roads;
d - fences (wire net); e - water body; f - canals;
g - zoo; h - park

group "toilets" - constantly replenished piles of excrement. The "toilets" are of no small importance in the system of communicative and hierarchic relations of horses. They also play a role in establishing and maintaining the territorial distribution of the group. Additional "toilets" and comfort sites are situated in the most frequently visited parts of the corral (Fig. 2). Fifty metres away from the "core" zone there is another "tyrlo" - a peripheral one with an 8 m radius which is far less frequently used by horses. Both places are trampled out and barren. The "post-watering resting" site is situated close to the watering place and is used by the group, mainly in the evening, and also in day-time when the weather is cloudy. The site has an area of about 140 $m^2$ and comprises several dust baths and 3-4 "toilets" located along the perimeter. The watering place is the

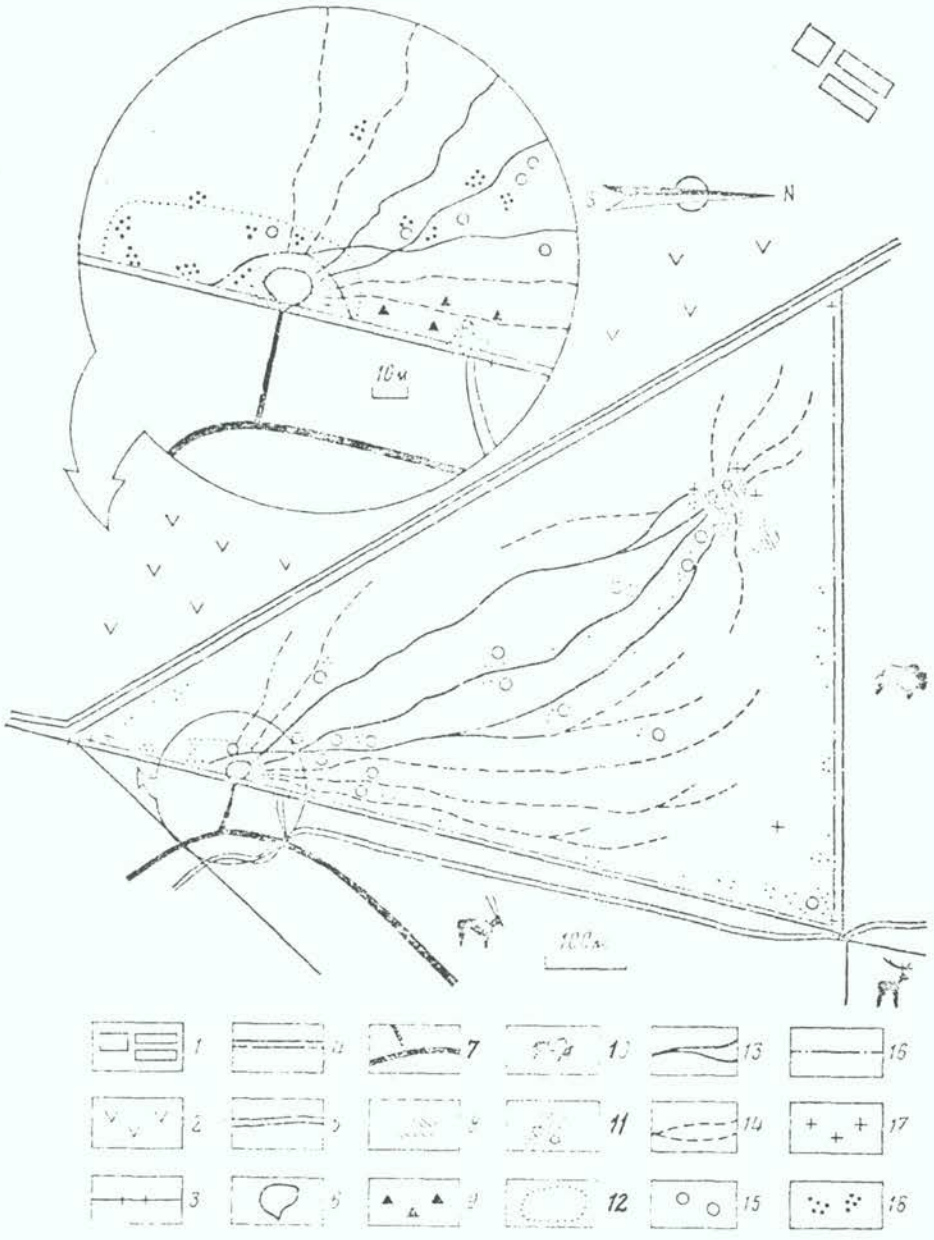


Fig. 2 Layout of Corral No. 3 and its spatial use by Przewalski horses (1-10 - topographic symbols designating terrain features; 11-18 - parts of the corral territory used by horses): 1 - agricultural animal farms; 2 - fields; 3 - fencing (wire net) with gates; 4 - road; 5 - route taken by horsemen; 6 - water body; 7 - canals; 8 - trampled out places; 9 - solonetz patches; 10 - zones occupied by animals of other species; 11 - the core zone; 12 - the post-watering resting place; 13 - main pathways; 14 - peripheral pathways; 15 - dust baths; 16 - patrol pathways; 17 - marking sites; 18 - toilets

beginning of horse pathways which go through the whole corral and end either in the "core" zone or at foraging sites. Observations show that pathways are renewed every spring from year to year and then are used during the whole season. We distinguish between "main" pathways connecting by the shortest way the watering place and the "core" zone that are trampled 3-4 cm below the general soil level, and peripheral pathways that spread over the whole corral and are hardly visible in dense grass. In any case, if an animal is not foraging and is moving either alone or within a group of animals, it prefers to follow a pathway. It is especially clearly seen when horses move in a group and in chains that glide noiselessly across the corral, winding, linking and spreading like ribbons. Movement in chains may be caused by resistance of the grass cover to animal legs when they go through "virgin land" or by the desire to "conceal" the true number of horses in the pathway. Along the pathways, especially along the main ones, there are "toilets" situated 15-20 m apart.

Along the perimeter of the corral lies the area of patrolling. It is especially clearly visible along the northern and eastern fences separating horses from animals of other species. The patrolling area is a pathway duplicating all the curves of the fence half a metre away from the wire net. The patrolling pathway both bypasses the water body and crosses it (Fig. 2). Being calm, the patrolling stallion goes around the water body. When excited by an external stimulus across the fence (another stallion or horsemen) he fords the water body. Marking sites are located near each of the gates, in the northeastern corner of the corral, around the geodesic signpost and at several places of the patrolling pathway. They are small (1-1.5 $m^2$) sites filled with excrement constantly renewed by the band stallion. The stallion marks the sites only in the presence of a possible threat from the neighbouring corrals (wild animals, domestic horses, horsemen). In a peaceful situation without any external factors, he may only smell these sites and go away, since there are no other stallions in the band who could have marked the sites and no mares ever come to peripheral areas which are the areas of action of the stallion.

The southwestern part of the corral bordering on agricultural farms is less frequently visited by the stallion, and there are no clearly-seen patrolling pathways. This may be explained by the fact that disturbing factors present are inadequate and man-related. Different sounds come from the "Krugloye" cattle farm, and tractors, vehicles, bicycles, etc. passing by. All these factors may disturb the band but never influence its social structure and do not come within the range of hierarchic and agonistic reactions of the stallion.

Foraging is one of the main types of activity of horses. Resting areas, standing areas and "toilets" do not come within the domain of their trophic interests, probably because of excrement. Foraging usually starts after the day or night rest and also when externally-caused excitement that consolidates the group calms down. Gradually becoming calm the horses begin foraging. While foraging every animal tries to keep an appropriate distance between itself and

its neighbours depending on the rank of the animal. Distribution of the group over a rangeland is by no means random and has a certain spatial structure and configuration (Fig. 3). Without external factors the horses disperse radially from the centre of the group outwards. This is a so-called "circle". Under the impact of both external and internal factors a group of domestic horses may spread over a pasture in a "horseshoe", an "arc", a "double arc", a "ribbon". etc. (Baskin 1975, 1976). We have registered another type of pasture use when studying Mongolian domestic horses (Mongolia) which may be called formation in "tongues" or "wedges". This formation is explained by foraging in mountains when horses spread along slopes in small "tongues" or "wedges" following one another.

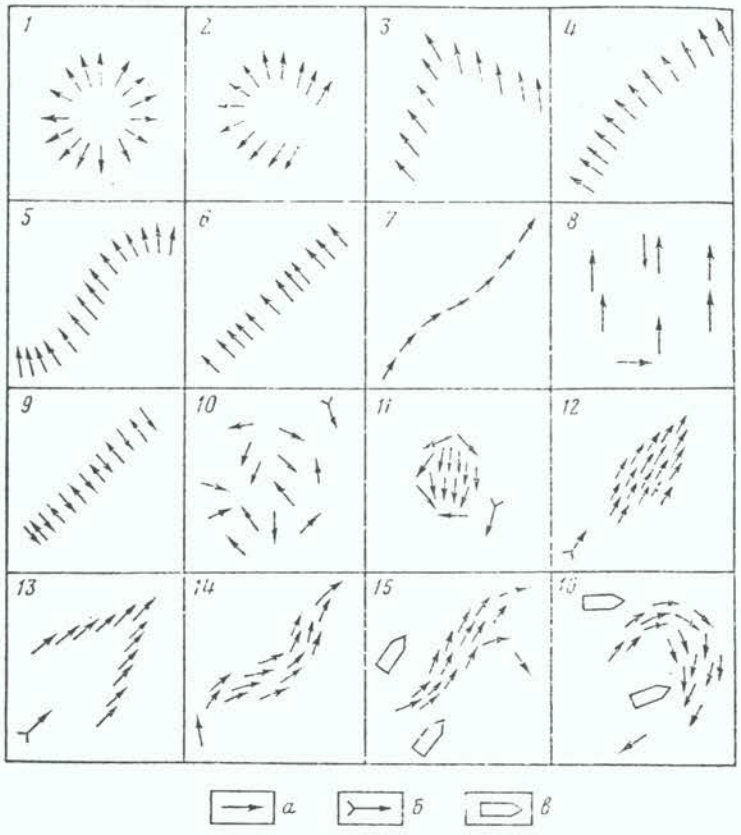


Fig. 3 Socio-spatial formations of Przewalski horses in foraging (1-6), in moving (7), in resting (8-11), being chased (12-16): 1 - circle; 2 - horseshoe; 3 - wedge; 4 - arc; 5 - ribbon; 6 - file; 7 - chain; 8 - variants of "tail-to-head" pairs; 9 - "tail-to-head" file; 10 - random group; 11 - consolidated formation against a threat; 12 - compact group; 13 - wedge; 14 - shuttle manoeuvring; 15 - breakthrough by one animal; 16 - breakthrough by the whole band; a - horse, b - band stallion, c - horseman

The internal factors determining the direction of a band of wild horses are the actions of mares of the "head group" and the stallion who in their turn are guided by external stimuli and the nature of the intergroup hierarchy. The leading group determines the general direction and, with individual distances set, it moves slowly forward. Other animals find their places in vacant spaces and trying to keep with the group they form a "wedge" or a "horseshoe". This formation expands to a certain extent while the animals spread apart setting individual distances (5-7 m). Now that the distances are established the spatial formation of the group stays unchanged for some time. Given a large space (corral No. 7) a "wedge" or a "horseshoe" may transform into an "arc", a "file" or a "ribbon" (Fig. 3). A "double arc" was never observed. Sometimes, a "circle", a "horseshoe" or a "wedge" begin to narrow. This occurs when the animals come to a standstill or begin to turn backward. In this case they graze on the same area which they have already passed. Usually, the group is very compact and never spreads over a distance exceeding 100-150 m. In a large corral (No. 7) a dispersion over a distance of up to 600 m was observed, but in that case the band was without the leader-stallion.

Climate is a factor of no small importance in the life of the band. During the grazing season and especially during the hottest period of summer, animals wait for the day heat to subside on a "tyrlo". In this period (from 11 to 18 hours) short (0.5-1 hour) periods of foraging are possible, but usually the animals rest. Prolonged foraging during that period may be considered as a sign of undernourishment and should cause concern. When standing still in the daytime the horses are affected by sun radiation which influences the activity of insects. Domestic horses have been registered to show collective forms of protection against gnats. They are "compact crowd", "tortoise", "tail-to-head" formations. According to our observations more typical for Przewalski horses are different variants of a formation when two horses stand "tail-to-head" and a "double-file" formation (Fig. 3). Compact crowds oriented inside the group are very rare for wild horses. Animals often stand in "random" groups, horses being oriented to different directions. An advantage of such a formation is a better view of the terrain. The lack of clearly observed social adaptations to gnats that are so common with domestic horses may be explained by a higher individual protection and stability against adverse impacts of the environment. The high protection results from a higher skin thickness and the density and the greater thickness and length of hairs.

The external stimuli that determine the direction of movement of the group are: obstacles, adverse parts of rangeland (silty trampled areas), herds of other animals, man, rainfall, snow and wind.

In low and temperate winds, animals both moving and standing are oriented independently of the wind direction. When the wind rises up to 12-15 m/s spatial distribution of horses changes. In this case the formation of horses is oriented and moves "against the wind". When approaching a fence from the leeward side the group slows down the

movement well in advance and forages almost at the same place. In the immediate vicinity of the fence (100-200 m) the group may either move along the fence or stay at the same place until the time for watering comes or any external stimuli appear.

Unlike domestic horses that are greatly influenced by wind, Przewalski horses do not change their activity under the impact of wind. As a rule, when it starts raining domestic horses moving "against the wind" turn "leeward" holding their backs and croups to the rain whereas wild horses move in the same direction "against the wind and rain". Even foals do not hide under mothers or within the group. Only a sharp increase in foraging activity of wild horses was observed which could be related to a better assimilation of moist grass and an instinctive desire of a desert animal to accumulate moisture. Such differences in reactions of wild and domestic horses demonstrate the better stability and adaptation of the former.

In winter, horses find forage under snow, but in the severe conditions of Central Asia (snow storms, ice crusts), domesticated Mongolian horses died by the thousands. For example, in the winter of 1910, 10 million horses died in Mongolia. But Przewalski horses managed to survive even under such severe conditions. In Askania Nova, snow is seldom deep and seldom stays for a very long time. It usually lasts for 1-2 months. The horses that have not lived in the wild and have no experience in winter foraging, make, nevertheless, scratching "caballoidal" movements with the forelegs pushing the snow apart, digging into it with the muzzle and getting wisps of plants.

The same internal and external stimuli influence the distances covered by the band during different time periods. Thus, in an undisturbed state the group covers 4-7 km in the large corral with a sharp decrease in activity during the hot period of the year. During autumn roundups the resistance of the band decreases sharply after some 10-15 km. This clearly testifies to the lack of movement in their life, since cases were registered when wild horses were chased for 2-3 days by horsemen who had tired out several relay horses only to capture foals (Klements 1903).

One characteristic feature of a band of wild horses is its permanent readiness to react to external stimuli using group adaptation forms. Those group adaptation forms have been acquired by social groups of animals in the severe environment of Central Asia and have been preserved by animals born and grown up in captivity.

In any type of vital activity - resting, foraging or movement, two or three animals are always surveying the surroundings. Thus surveying is facilitated by different spatial orientation of horses during foraging or resting. The band stallion always stays away from the group and spends the greater part of the day surveying the environment. Sometimes, he also makes patrol rounds of the territory.

The animal who happens to be the first to spot the appearance

of an alien object sharply and loudly inhales and exhales and becomes alert. This signal is immediately spread throughout the band and all the horses scrutinize the intruder. As a rule, the stallion is the first to notice the threat and meets the intruder on the boundary of the corral - near the gate or the wire net. The reaction of the band depends upon the nature of the threat. If the object is fairly familiar, or vice versa, completely strange, it may cause curiosity instead of a defensive reaction. When the horses see an approaching observer, they may surround him at a distance of 20-30 m and study him by actively bringing the mares together and driving them away to a safe distance. If the intruder gives grounds for concern the herd after the first warning signals comes together in a compact group ready to follow their leaders. Mares with foals retreat to the rear of the group leaving in the forefront adult animals who assume responsibility for choosing the direction and one- and two-year olds who simply "stand in the way" having no experience in handling emergencies.

The leader usually positions himself between the intruder and the band demonstrating the aggressive ritual and marking the territory. In doing so he and the mares of the front group carefully study the intruder visually ready to react to the intruder's possible actions. If they are confronted by a horseman or a harnessed horse the stallion attacks the horse trying to bite it. If the stallion decides to lead the band away he gives a signal by assuming an indicative "he-goose" stance, lowering his head to the ground and turning it from side to side. The signal is usually received by one of the mares of the "nucleus" who assumes the leadership.

We should note joint and coordinated actions of horses when the band is escaping pursuit. When the band is chased by horsemen during interseasonal roundups the leader or the leading group may be clearly observed to make a coordinated "shuttle" manoeuvre in an effort to deviate from the direction forced on them. The animals make feints and seizing a good opportunity escape the control of horsemen in one rush. Such a breakthrough may be performed not only by members of the leading group but also by any other resolute animals. After even one animals escapes the whole band cannot be checked. At such moments the animals show no former fright for man and do not keep the usual distances (30-50 m). The horseman should bring the band together and start the rounding up from scratch.

This is an example of intergroup mechanisms in action that organize and coordinate the band. These mechanisms may be used for controlling the behaviour of animals and their distribution over the territory.

Here we should note that all the above actions of the group, both of a rangeland and in relation to external objects are characteristic only of a band with a complete social structure formed by a number of generations.

If an experienced band stallion is missing or is replaced by a young and inexperienced one, the perfectly organized and functioning system of the band is immediately transformed into a shapeless mass. Such a group spontaneously changes types of activity, does not develop the territory, shows no stable rotation patterns of daily activities and easily gets confused finding itself in a pessimal situation under the influence of external threats*.

Let us consider formation dynamics of principal adaptation forms of behaviour (or strategies) of different social groupings of the band when they reach the life and reproduction success under typical or close to typical ecological conditions, as these strategies are formed in ontogeny.

Newborns try to keep a constant visual, olefactory and tactile contact with their mothers. Their protection within and without the herd and their individual distances are the responsibility of their mothers. Infantile foals (up to 6-8 months old) continue to follow their mother and seek protection from them. Beginning from the age of 8-9 days they begin periodic foraging and beginning from the age of 10-14 days they establish personal contacts with foals of the same age group and later when they switch over to grazing and more often leave their mothers they begin to establish contacts with adult members of the band. In this case elements of rivalry with foals of the same age and of aggression from adult horses are added to conjunctive contacts. Towards the end of the period a hierarchy is established in the infant rank groups. Individual distances for younglings are determined by adult members of the band.

Juvenile animals (up to 1.5-2 years of age) become separated from their mothers but still maintain relations with them. Personalized contacts are developed through plays and tournaments. Some elements of the future reproduction-behavioural repertory are manifested in plays showing sex-related differences of each animal. Young animals try to keep individual distances.

Two-three year old females automatically (together with their mothers) become members of the general harem or of one of the subordinate ones. Cases were observed when young females were banished from the band. In the harem there are personalized conjunctive contacts and in marriage-family relations - polygynic ones. Adult females may keep individual distances though not always selectively, in foraging, resting, movements and in extreme situations. They do not mark and do not guard the territory. Passive defensive reaction prevails in the presence of external stimuli. They do not drive other females to the band and guide the band passively (by leading it). Without the leading

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* This may be the cause of such a quick disappearance of wild horses in Mongolia and China. It was the stallions whom Mongolian herdsmen tried to kill first because they prevented successful hunting of wild horses. Left without leadership mares could not withstand the environment pressure.

element (the leader stallion) females are incapable of purposefully coordinating the actions of the band and cannot withstand external conditions. Mothers with foals increase individual distances and the share of aggressive actions in their repertory. As they get older mares may obtain higher hierarchic standings and may enter the "nucleus".

Two- and three-year old males develop personalized contacts in their rank group using plays and fights and establish a more clear-cut hierarchy than in the preceding age group. They try to court females, drive them to the band and demonstrate a reproduction repertory. They attract the attention of the band stallion who begins chasing them and eventually banishes them from the band. The banished stallions form a bachelor group with its own inner hierarchy characterized by stable and non-competitive relations (prior to the appearance of reproduction stimuli). Some stallions with the growth of their morpho-psychic status, try to seize females. Bachelors neither mark nor guard the territory. Young stallions are characterized by incomplete performance of individual chains of aggressive and reproductive behaviour due to insufficient development and the lack of certain constituent blocks. Their actions, therefore, do not attain the hierarchic supremacy over other males and females and hence, they cannot take possession of the latter. When the leader-stallion is absent from the band (or due to other reasons) the most dominant of the young stallions seize either a part of the females or the whole band, banish all other mature stallions and try to consolidate their new social and reproduction status. In the period of establishment of the social structure the relations in the band are mainly aggressive since the drive and pretentions of the stallion meet with resistance of dominant mares. After the social homeostasis of the group is stabilized such stallions play secondary roles after dominating mares. They do not mark or guard the territory and do not purposefully guide the band which affects its future. The stallion may acquire the dominating status in the group only after the age of 4-5 years having accumulated experience in possessing a harem (evidently, by the age of 10). Such a stallion is an unchallengeable dominating figure in the band. He patrols, marks and guards the territory occupied by the band. The fact that Pegasus guards the whole corral No. 3 cannot be extrapolated to conditions of the wild since horses are nomadic animals. Nevertheless, the size of the territory, the number of females and the amount of effort to keep them are directly dependent on male qualities and the social experience of the stallion. The band stallion with his potential for socially-adequate actions takes care of the band members, coordinates the activities of the band and withstands the environment thus promoting the flourishing of the population and continuation of his progeny.

Thus, the socio-spatial phenotype of the band of Przewalski horses in Askania Nova may be regarded as an activity of a functional biologic system with a hierarchially-interdependent structure possessing a relatively large diversity of the composition and strategies of each of the social groupings functioning on a certain territory used

and partially guarded by animals. These strategies united by cooperating and coordinating elements allow the system to respond resiliently to a changing environment and to adapt successfully to it in order to continue its existence. At the same time individual elements of the system in isolation cannot react adequately to external conditions and withstand them. This calls for a more purposeful establishment of introduced groups with due regard for all the elements of the band (population) and their importance for its future if wild horses are introduced into the natural biotopes of Asia.

# GENETICS OF SMALL POPULATIONS OF EQUUS PRZEWALSKII:
## The Species Survival Plan for the Asian Wild Horse in North America and Implications for Restoration of Przewalski's Horse to Mongolia

Oliver Ryder

A cooperative breeding programme was organized in 1979 following the World Conference III on Breeding Endangered Species in Captivity held in San Diego, California. An interim breeding plan was adopted taking into consideration the genetic background of the North American population (Ryder and Wedemeyer 1982). According to the plan, males with genetic input from the domestic mare are not incorporated into herds of mares for breeding; in this way the genetic contribution of the domestic mare is being diluted in those collections whose mares include genetic contribution from the domestic mare. Given the size of the population in North America (40.61) and the pedigree relationships of individuals, inbreeding coefficients of new-born foals within the SSP population have actually decreased under the management plan.

The significant exchange of animals that occurred between the Soviet Union and the United States in 1982 furthers the goals of the SSP programme through the introduction of three horses related to only wild-caught individuals #231 Orlica III, #17 Bijsk 7, #18 Bijsk 8, #39 Bijsk A, #40 Bijsk B, #211 Woburn 6, and #212 Woburn 7. Furthermore, the importation into the Soviet Union of three US-bred horses similarly is hoped to enhance the gene pool management of the species in the USSR. All three of the horses exported from Askania Nova to the United States have subsequently bred and as of 1 May 1985 4.4 offspring survive. The stallion, #606 Askania 22, Vulkan, was transferred from New Yrk to San Diego of 16 April 1985.

The breeding programme adopted by the Asian Wild Horse SSP reflects the opportunity for regional cooperation in management of the subset of the toal captive population. Whereas the goal of continued reduction in the genetic contribution of the domestic mare has not been formally adopted by other geographically organized breeding programmes the trend in worldwide reduction of the genetic contribution of the domestic mare to the species' gene pool is consistent with such a plan. In any event, some population subdivision may be useful for retention of genetic diversity. The designation of individuals for a restoration project could be based on differing criteria. As the very process of willfully choosing idividual animals for such a project amounts to selection, the issue reduces to a consideration of what selective criteria should be employed. In the case of the restoration of Przewalski's horses to Mongolia, an appropriate course of action would be to assemble representatives of the entire captive gene pool and provide opportunity for the horses themselves to interact in their new environment and allow selective forces to exert their influence on the variety of offspring produced. Consideration

should be given to the relative founder contributions of individuals designated for restoration to Mongolia in comparison to the relative founder contributions of the worldwide captive population. Thus, the proportion of domestic horse genes present among individuals destined for restoration should be less than or equal to the current worldwide average.

The institutions participating in the Asian Wild Horse SSP have on three separate occasions ratified the concept of designation of individual horses for appropriate restoration projects. However, in consideration of the concern for the continued well-being of the captive population over time every effort must be made to ensure as much as possible that proper habitat, appropriate facilities and trained personnel for oversight of the restoration project are chosen. The comments of Studbookkeeper Dr. Volf concerning the desirability of soliciting the comments of breeders of Przewalski's horses concerning appropriate site and facilities should be heeded.

CONSIDERATIONS FOR RESTORATION PROJECTS

1. The well-being of the captive population with respect to genetic composition and demographic stability must not be jeopardized in any sense by restoration projects. The rationale for this position is that, until there exist multiple, geographically isolated, free-living populations of Przewalski's horses having adapted to the local steppe conditions and having survived for generations in their new environment with ever-increasing numbers, the further existence of the species must be assumed to depend upon the captive population and the gene pool that it represents.

2. The historical commitment of the captive breeders of Przewalski's horses has been to the ultimate restoration of the species to its former range, and specifically to Mongolia. Therefore restoration of Przewalski's horse to the Mongolian People's Republic should not be delayed once suitable facilities are created.

3. The design of facilities and management should be coordinated by an international group of experts with authority for continued monitoring of the site and its facilities. These activities must occur in cooperation with local experts.

4. Monitoring of the progress of the restoration project must include Mongolian experts and also involve the International studbookkeeper, captive breeders of Prewalski's horses, experts in feral horse biology and range management, as well as experts in disciplines such as veterinary medicine, genetics, comparative equid behaviour and pathology.

5. Multiple acclimatizations are to be avoided. Multiple acclima-

tizations produce multiple genetic bottlenecks that can best be avoided by acclimatization **in situ** preceding release.

6. Multiple reserve populations consisting of free-living individuals organized into appropriate social groupings are desirable for preservation of total species genetic diversity.

7. The multiple reserve populations need not be as large as 500 genetically effective individuals. In fact, it is preferable to have multiple groups with effective population sizes in the range of 50-100.

8. Maximal preservation of genetic variation as well as the exchange of previously existing and newly arisen adaptive genetic variation will occur if periodic migrations of small numbers of individuals between the multiple reserve populations are conducted. Similarly, continued bidirectional gene flow between the captive population and the reserve populations - achieved by periodic transfers of individuals (or their germplasm) - is highly desirable.

## SOME CURRENT RESEARCH ACTIVITIES

### Pedigree Analysis

Due in large part to the excellent quality of the data in the International Studbook as well as to the relatively long history of captive breeding of Przewalski's horse, pedigree analyses intended to shed light on the inheritance of particular traits and determine the likelihood of loss of genetic variation are being undertaken utilizing the data in the volumes of the International Studbook. Blood typing and chromosomal studies continue and recently detailed studies of DNA have been conducted.

### Vitamin E deficiency

Following the publication of case studies of Przewalski's horses with significant myelopathies reminiscent of vitamin E-deficient laboratory and domestic animals, a study of serum tocopherol levels was indicative of general deficiency. Most significantly, the horses exhibiting the lowest serum vitamin E levels were the same individuals most severely ataxic. Thus, the "genetic disease" of atxia must be reconsidered in light of this new evidence.

### Embryo Transfer, Semen Collection and Storage

The first transfer of a Przewalski's horse embryo into a domestic pony mare leading to a successful birth took place last year in London. Several zoos in the United States are collecting semen and

experimenting with freezing protocols as well as anaesthesia conditions and electroejaculation techniques. A programme to collect and transfer or freeze Przewalski's horse embryos is beginning utilizing Quarterhorse mares as recipients. The embryo donors are mares that are unable for medical reasons to be in with the rest of the herd.

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# PRZEWALSKI HORSE GENE POOL PRESERVATION METHODS

V. Klimov

As the ever-growing impact of man on ecosystems leads to their gradual depletion and destruction of historically established relationships that ensure biological balance and homeostasis of the system, a problem arises how to preserve both natural biotopes and relevant species of flora and fauna. Ecological conditions favourable for natural evolution and conservation of rare species are now vanishing at a higher rate. But these species can be maintained in reserves and zoos. In doing so, it is essential to define a direction in which a given species will evolve. Przewalski horses extinct from the wild served as a model that allowed some aspects of vertebrate preservation to be defined. Living captive wild horses trace their ancestry to eleven Przewalski horses (**Equus przewalskii**) and one domestic mare (**Equus caballus**). Though the current captive population exceeds 400 individuals, the observations of this species have shown reduced genetic variability, higher levels of homozygocity, decreased frequency and loss of particular alleles. Zoo management of the horses results in depression of their reproductive system, relevant processes, fertility and viability as well as juvenile mortality and neonatal abnormalities. Concurrently a variation in the phenotype and loss of species-typical status (both behavioural and morphological) occur. These processes have been caused by ecological and genetic problems. The former relate to inadequate conditions in the zoos and reserves while the latter concern progressive inbreeding due to a small number of founders and difficulties in handling the horses since they are distributed over 70 management centres. In addition, the gene pool of general population is affected by a genetic drift leading to allele loss in isolated minipopulations natural and directed breeding minimizing the number of individuals involved in reproduction and elimination of genes when certain lines vanish. As far as the Przewalski horse gene pool goes, microevolutional processes, therefore, influence the captive population in a negative way and are practically beyond our control.

Techniques used in the management and preservation of the Przewalski horses and their gene pool may be roughly divided into methods of genetic and ecological monitoring. The first are aimed at preservation and enrichment of the gene pool of the wild horses, avoiding the inbreeding, maximum genetic diversity and involvement of every available animal in reproduction:

1. Total account of the recent horses.

2. Identification of relations and genealogy of all the captive horses.

3. Annual publication of International Studbook in Prague.

4. Marking of horses where possible and necessary. In small populations animals can be detected by individual features. The Askania Nova zoo maintains 50 animals marked by hot branding on the shoulder.

5. Genetic marking and genetic monitoring of genealogy involving electrophoresis of serum proteins, isoelectric focusing, determination of blood groups, cytogenetic studies. The world's zoos consider such studies as a major method in registration of the horses, identification of genetic variability level and genealogy of groups and individuals, detection of phylogeny and taxonomy within Equides. The similar studies in Askania Nova have shown that 20% of horses bear 70% of genetic variability, with the herd's homozygocity constantly increasing. Homozygocity of each succeeding generation is much higher than that of the preceding one. Mean group heterozygocity makes 0.1071 $\pm$0.0169.

6. Selection of reproductive groups, pairs and individuals based on the above stated principles.

7. Selection and reproductive culling. It is rather controversial whether selection should be employed at this stage since it minimizes the number of animals involved in reproduction and makes low heterozygocity of the lines even lower. But as (a) there is a domestic mare among the founders of the present captive population affecting the general gene pool, (b) inbreeding and inadequate environmental conditions result in abnormalities in the animals' development and phenotype, selection is necessary. This promotes consolidation of the wild horses' gene pool and phenotype. Due to a high value of the animals, reproductive rather than physical selection can be discussed which, in its turn, should be employed in extreme cases only. Wild-caught animals and first captive generations can serve as a standard of phenotype.

8. Formation of intralinear groups with horses with differentiated gene pool and their breeding, with particular intralinear groups being able to form other lines in future.

9. Intralinear replacements. They are made within independent intralinear groups to increase genetic variability and obtain new gene combinations.

10. Exchange between lines. In 1982 horses were exchanged between USA (San Diego and Bronx) and USSR zoos (Askania Nova). Each side delivered a stallion and two mares that formed new reproductive groups in the zoos.

11. Establishment of stallion pools, i.e. centres that concentrate and distribute stallions among other institutions for breeding

purposes. Such pools of stallions unused in reproduction are being set up in the USA.

12. Taking account of the animals incapable of reproduction, their prophylaxis and treatment.

13. Cryoconservation of sperm, creation of gene banks, experiments on collection of sperm and artificial insemination of mares.

14. Employment of computerized analysis in elaboration of breeding plans. It includes not only computation on inbreeding coefficients and heterozygocity indices but also salection of potential pairs and reproductive groups with lowest level of inbreeding, high fertility, vitality, etc. Combinations of particular groups can be established with the help of such analysis.

15. If horses capable of reproduction are sufficient in number (over 50), it is possible to let them function on their own, thus making use of natural social processes (rotation of stallions, reproductive success of stronger individuals that are replaced by successors when exhausted, formation of several harems, rotation of mares between harems, etc.) to obtain genetic diversity.

The objective of the propagation of rare species, **Equus przewalskii**, in particular, is to promote natural evolution of the species and can only be attained under specific environmental conditions. A model set of these conditions is represented by methods of ecological monitoring. Since, in our opinion, a species can be properly preserved only with its specific historical biotope and ecological relationships being conserved, it is necessary to introduce the animals into their biotope or simulate this biotope. When there are no opportunities of preserving the entire biotope, species representatives can be maintained in captivity under the following conditions:

1. Management of the species by a population rather than in singles or pairs that represents an organized system from spatial, social and genetic points of view and ensures preservation of the species' complete genetic information.

2. The population should be placed under conditions similar to those of its original habitat - physical, geographic, climatic, landscape soil and trophic complex.

3. The population can be productive and functional only when provided with a required area. Wild horses need 20 ha per animal.

4. The animals should be isolated from allied taxons, domestic in particular, that may become sources of nonself genes, infections, invasions, etc.

5. In restricted areas additional exercises are needed that consist in riding the horses. Time and pace of riding are determined for each animal (availability of lactating, brood mares, etc.).

6. Intervention by man involving supplementary feeding, protection from weather, invasions, etc. should be minimized to let them function on their own. Only this approach can be followed to stabilize the population's functioning in the biotope.

In doing so, one should make use of models the size of which can provide the species with required ecological components and conditions and partially substitute for natural regulatory mechanisms. Establishment of the systems that make it possible to concentrate horses from the European and American zoos with a view to their primary acclimatization before the reintroduction is possible in the steppe reserve Askania Nova or Altai region. In due course the second and third generations of the horses can be reintroduced to Mongolia. Conditions and techniques of transit, distribution and management of the horses being introduced were defined by our expert group in Mongolia in 1980. Upon placement of a project order, Mongolian specialists in cooperation with the Soviet ones set up and equipped a reception station in the Bogdo-Una Reserve that will initially manage the horses. When the delivered animals get adjusted to climatic and environmental conditions, their offspring can be transferred to large reserves in the country's steppe zone, with their group dislocations being limited in optimal biotopes.

# REVIEW OF FERAL HORSES

# A REVIEW OF FERAL HORSE RESEARCH PERTINENT TO THE REINTRODUCTION OF PRZEWALSKI'S HORSES

Richard Miller

## HABITAT USE

In the United States, Canada and Australia feral horses are most often considered to be important as competitors with the livestock and wildlife. Hence, much of the research is directed toward understanding and reducing this competition. There is a volume of feral horse food habits studies (Hubbard and Hansen 1976; Varva and Sneva 1978; Salter 1978; Salter and Hudson 1979; Hanley and Hanley 1982; Krysl **et al.** 1984a, 1984b). These studies have found feral horses are primarily dependent on grasses but do use some forbs and shrubs depending on the habitat where they are feeding.

Habitat use by feral horses has also been well studied in the attempt to understand competition between horses and other animals. The availability of water is important in determining the distribution of feral horses (Pellegrini 1971; Welsh 1975; Hansen 1976; Keipner 1976; Green and Green 1977; Miller 1983a). Where the water supply is limited, intensive competition for water may occur. In the Red Desert, when water was scarce, most horses (60 to 100% of all locations) were within 4.8 kilometres of water (Miller 1983a). The same study found temperatures are the most important factor influencing use of free water.

Shelter, particularly wind cover, is important to feral horses during severe winter weather (Welsh 1975; Salter and Hudson 1978; Miller 1983a). The areas used for wind cover are often the lea side of ridges, which are also used for feeding if the wind keeps them snow free. Eighty to ninety percent of horse locations in the Red Desert during winter were within 1.6 kilometres of ridges. Duncan (1983) found wind blown sites were used to avoid biting insects in summer. Selection of protected micro climates in winter may be an energy conservation mechanism (Malechek and Smith 1976).

Feral horses select different vegetation types by season (Welsh 1975; Salter and Hudson 1978; Duncan 1983; Miller 1983a). This selection may be related to diet, availability of water and cover, or as Duncan (1983) found, concentrations of high quality foods.

## HOME RANGE AND MOVEMENTS

Feral horse home range size and movement patterns appear to be determined by the distribution of resources needed by the horses (Miller 1983b). Home range sizes have been reported (ranging from 90

ha (Welsh 1975) to 30 300 ha (Miller 1983b). The size of the home range extent of movements both daily and seasonal reflect the needs for food, cover and water previously discussed.

Ideas from several theoretical ecologists can be used to predict the home range size and movement patterns to be expected in a reserve for Przewalski horses: Clutton-Brook and Harvey (1977 and 1978) have suggested large home ranges result where resources are strongly clumped, widely dispersed or unpredictable in abundance. Altmann (1974) and Crook **et al.** (1976) predicted extensive home range overlap where essential resources have very restricted distributions. Denham (1971) argued clumping of populations should be high where predictability of resources is low.

A variety of movement patterns and home range sizes have been shown or suggested for feral horses (Pellegrini 1971; Welsh 1975; Berger 1977; Green an Green 1977; Miller 1983b). The patterns observed seem to fit those predicted by theory. The movements and the size of the use area for reintroduced Przewalski's horses may be determined by the distribution and predictability of resources in the release area.

## SOCIAL ORGANIZATION

Like the home range data, social organization and behaviour of feral horses have also varied a great deal from site.

Feral horses social organization are generally variations of the family groups described by Klingel (1974) for Plains Zebra. The basic structure is bands made up of one mature stallion and several mares with their offspring. Groups of bachelor males are also found in the vicinity of the breeding bands. This basic type of social organization is widely found in feral horses (Pellegrini 1971; Hall and Kirkpatrick 1975; Feist and McCullough 1976; Berger 1977; Green and Green 1977; Salter 1978; Miller 1980). However, variations from this basic pattern are also common. Breeding bands containing more than one mature male are found in many areas (Hall 1972; Welsh 1975; Keipner 1976; Salter 1978; Miller 1980). Pellegrini (1971) and Berger (1977) reported bands of horses rarely associated with each other. Pellegrini (1971) suggested that horse bands in the Wassuk Mountains of Nevada might be territorial. All other studies have found that bands frequently associate with one another and are non territorial. Dominance hierarchies are reported within bands for males (Hall and Kirkpatrick 1975; Welsh 1975; Green and Green 1977; Salter 1979; Miller 1981) and for females and young (Boyd 1980). Interband dominance hierarchies are found in feral horses in the Red Desert which determined access to a limited water source (Berger 1977; Miller and Denniston 1979).

The adult membership of feral horse bands is generally quite stable averaging 0.75 adult changes per year in the Red Desert (Miller 1980) or 11.6 adult changes/100 horses/year in Nevada (Feist and McCullough 1976).

Breeding bands vary widely in size from two horses to more than twenty horses.

Breeding bands containing multiple adult males are more stable and larger than single male bands (Miller 1980).

Rates of exchange between bands, average band size and proportion of multiple male bands can change from year to year (Miller 1980).

A social unit made up of breeding bands and bachelor male groups has been suggested by Miller and Denniston (1979) and Miller (1983b). It was defined as follows: "a herd is a structured social unit made up of bands following similar movement patterns with a common home range". An examination of data presented by Green and Green (1977) and Feist and McCullough (1976) also suggests the existence of herds.

Like home range and movement patterns social organization may be a result of the action of resource distribution on the inherent behaviour patterns. Theoretical ecologists have explained both large band size (Altmann 1974; Clutton-Brock and Harvey 1977) and multiple male bands Bourliere and Hadley 1970) in other animals as a reponse to clumped and/or separate resource distribution.

## BREEDING BEHAVIOUR

In single male bands the band stallion does the majority if not all breeding (Feist and McCullough 1976; Hall and Kirkpatrick 1975; Salter 1978; Miller 1981). Band stallions from single male bands also breed females in other bands (Miller 1981) sometimes with great frequency (9 of 19 copulations, Nelson 1978). In multiple male bands dominant males may be doing all the breeding (Welsh 1975) or the majority of the breeding (Salter 1978; Nelson 1978; Miller 1981). Within multiple male bands at least three breeding systems are found: (i) several stallions breeding with one mare, all from the band; (ii) consort pair formation; and (iii) the dominant stallion doing all or most of the breeding (Miller 1981). Additionally as in single male bands some breeding is done by males from outside the band. In the Red Desert 13 of 22 mares observed being bred more than once in a season were bred by two or more stallions (Miller 1981).

## DEMOGRAPHICS

There has been considerable disagreement among researchers regarding rates of increase in feral horse populations. Field researchers have proposed rates of increase approaching 20% per year while population modelers have generally suggested much lower rates of increase. Conley (1979) reported the conditions necessary for rates of increase approached 20%: (i) the proportion breeding must be 0.8 or

greater across all age classes; (ii) age at first breed must be 3 years or younger; and (iii) breeding must extend to age 8 or 10. Additionally adult mortality rates must be very low. Boyd (1980) found 53 to 78% of mares 3 years old and older foaled, and mares were foaling first at 3 years. Seal and Plotka (1983) found pregnancy rates in feral horses in Idaho to range from 35% in 2 year olds to 85% in 6 to 15 year old mares. Lactation rates in that study were 25% for three year olds and 50 to 100% in mares 5 years old and older. Eberhardt **et al.** (1982) documented populations in which apparent rates of increase were 18% and 20%.

The best available information seems to indicate that in populations with adult survival rates around 80%/year and less than 80% of mares three years and older foaling each year, rates of increase may be between 5% and 10% per year. However, if adult survival approahes 95% and 80% or more of 3 year old and older mares foal rates of increase may reach 20% per year. If young horses are used in the Przewalski horse reintroduction, and if habitat or weather conditions do not limit reproduction, rates of increase may approach 20% until adult mortality rates increase with old age.

## CONCLUSIONS

All aspects of feral horse behaviour and ecology which have been studied have varied from site to site. It is reasonable to expect the characteristics of the release rate such as the availability of forage, cover and water to influence the movements, behaviour and perhaps the social organization of reintroduced horses. Habitat and weather conditions were not severely limiting. High rates of increase may occur often on initial adjustment period.

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## MUSTANGS OF THE MANYCH LAKE

V. Klimov and N. Paklina

Feral horses, mustangs ... These words make anyone imagine blue boundless prairies with galloping free wild horses, riding cowboys and Indians. Mustangs are a part of the history of North American prairies and pioneering of the Wild West. They are newcomers to America for the second time. In the pleistocene era, it was from America that the ancestors of horses, asses and zebras crossed the Bering Straits in several streams and populated Europe, Asia and Africa. Then they became extinct in their native land and returned only in the latter centuries, accompanying the whites in developing the vast territories of North America and the natives. Having played a great role in the pioneering of America, the horses gradually lost their former significance and fell into the background, failing to compete with motor vehicles. They were set free and allowed to be on their own. That is how mustangs appeared in America.

Feral horses not only live in the prairies of America but also in the USSR. A few small populations are scattered over the areas, difficult to access. Such a population has existed in one of the islands of the Manych-Gudilo or Great Manych lake (region of the city of Rostov-on-Don) for about 30 years.

The island Yuzhny or Vodny, the topic of our talk, is the largest on the lake. It is 12-13 km long and 2-4 km wide, with the total area being 2658 ha. The island stretches from west to east, its southern shore is steep, while the northern one is sloping. From west to east the island is cut out up to the centre with a bay; the southern shore, being a water-meadow, consists of sand-bars, small islands, reedy bays and serves as a refuge for numerous birds - herons, stints, swans, ibises, etc. A great number of grass associations are represented in the island. Moderately dry sod-wheat grass steppe covered with sheep's fescue and feather grass prevails. There is a great variety of meadows on the island. Such species rare for the Rostov Region as splendid meadow saffron (**Colchicum**), tulips (**Tulipa biebersteinniana** and **Tulipa shrenkiana**), licorice and feather-grass (**Stipa zalesskiana**) are preserved there.

But the main beauty and boast of the island are feral horses. They were experimentally released into the island in the middle of the fifties. The horses survived and reproduced. In some years they numbered 80 individuals. Last summer, when these observations were undertaken, there were about 40 horses: 12 stallions, 14 mares and 14 foals. Regarding their exterior aspect, these are sturdy red and brown horses of the Budyonny breed. The horses were named at the beginning of the observations.

The island herd consists of three bands, i.e. harems, two bachelor groups and four solitary bachelors. The largest band is led

by Bury. It includes 5-7 mature mares with young stock. Bury is a sturdy dark-brown stallion of 7-10 years of age. He is an initiator and winner of all ritual contacts in the island. These contacts do not usually turn into real fights since his authority is rather high. For a long period of time Bury had tolerated the claims to superiority in the band by a two-year stallion Adyutant whom he banished later on; he also tolerated a small band of Ryzhy consisting of two mares and a yearling who constantly ranged on Bury's territory. The bands met on grazing land and at watering sites. But in every case the satellite showed respect for the band stallion, and Bury was patient with the presence of the satellite. It is worth speaking in detail of Bury's group since it is the largest band on the island. The first assistant of Bury in guiding the band was Gryaznulya, a massive light-brown mare. She led the band in all the cases when it was necessary to change rangeland or go to the watering site. In doing so, she asked for permission from Bury who himself decided the usefulness of the band's moves and actions. Varvara is a mature red mare and the stallion's favourite lady who enjoyed special privileges. Stesha is a friend of Varvara and due to this fact she had certain privileges in the band. Schuka is an old hairy mare and a regular initiator of quarrels with other horses. She was inclined to make friends with Gryaznulya and Sivka-Burka who had two foals: a newborn and a yearling. This fact explains the attraction that Sivka-Burka drew from other mares who spent a lot of time petting the foals. A mare Chernoburka played a specific role in the band. She made no friends with the others and devoted all her time to her foal. Why was Adyutant banished from the band? In moving in the rangeland he tried to lead the band, guide the juniors, smell the excrements. Since such behaviour characterizes a sexually-mature stallion, this proved his claims for the territory and leadership in the band. In the middle of May Bury banished Adyutant from the group. Analysing the relationships in this group, it can be said that all the threads of superiority, leadership and guidance of the band are within the power of the leader that is a band stallion. As mentioned above, among mares an indisputable leader was Gryaznulya, and the band stallion did not interfere with her attempted leadership. A certain agreement was observed in the actions of these two animals: the mare led the band while the stallion was urging the others, she tried to lead the band but he did not want to move, and the mare returned. When one of them came to a stop, the other also stopped. So, she is a business lady but not a lady of the heart.

The other group is a band led by Pogorelets.

This mature red stallion was named after a small island located near the northwestern shore of the island that was called Gorely (burnt) after a steppe fire.

His band included three mature mares, four two-year foals and two sucklings. Beloglazka, a mature red mare with a star, had a one-year daughter. Polnoch, a mature light brown mare, had a small foal, and Taina, a dark brown female, took care of a newborn foal. In this

group Beloglazka was a leader in all the movements while Pogorelets drove the group from the rear, marked the territory, protected the band. He was on friendly terms with one-year Zolushka, Polnoch's daughter, and Kometa, Beloglazka's daughter. These three animals constantly kept together and followed each other. Pogorelets like Bury had his satellites. This was a group of Gomon. It occupied the same territory and accompanied Pogorelets' band as his subordinates. Gomon, a mature dark red stallion, had two mature mares in the group: Bolshaya Medveditsa and Malaya Medveditsa.

Gorely island was also occupied by a bachelor group consisting of Ilya, Dobrynya and Alyosha. A dark brown stallion Ilya is a senior in this group. He marked the territory, fought with stallions from other groups. The other two were 2-3 years old. These three stallions were in Pogorelets' territory though they kept a distance necessary for peace and did not claim for his mares but, when water in the Manych lake reached critical salinity, they followed Pogorelets' band to the rangeland where a fresh water source was available.

In addition to group bachelors, the island housed solitary stallions. Dik, Kavaler and Stas held aloof from other horses.

It is interesting to analyse the way the territory was divided between the horses' groups. As would be expected, the strongest bands occupied the best portions of rangeland on the island. Bury's band settled on the most remote, western portion where sheep did not graze. This is a grassy water-meadow with fresh water puddles and previous year's haycocks. Pogorelets' band also occupied a grassy rangeland far from people. Other groups and solitary bachelors found themselves under worse conditions. They had to range in the areas where sheep were grazing.

The largest area was occupied by Bury's band, stretching from the western shore inside the island by 2 km. In the daytime the band used to stay on the water-meadow, resting and drinking. When it was getting dark, the leader took the horses to the higher southern shore. The view was better here (horses see very well at night), south winds in the spring and summer blew midges off. In spring the horses ranged in dusk hours and in summer they foraged throughout the night, resting in the daytime only. One of the sand-bars was their resting and watering place. In the hot season they stayed with their bellies in the water for a long period of time to protect themselves from heat and midges. When fresh-water puddles near the resting site were dried up, the leader took his band to the Sheep Water Source. All the family territory is spotted with numerous paths that connect sites of resting, ranging and watering. The paths go along the sand-bars and reeds, cross bivouac and ranging sites. In some places heaps of excrement can be seen on the paths that are regularly replenished. These are so-called horses' toilets that also serve as markers to show that the territory belongs to a particular group. In addition to the common toilets, the stallion usually has his own markers and patrol paths that go along the borders of the territory and are marked with

excrements. Bury uses an earth road laid out by mowers. Only a mature stallion included in the population's hierarchial structure has the right to leave his patrol marks. Young stallions and mares leave their excrements in the common toilets or in the grass near the road but never on the road that is a patrol path of the stallion. The observations helped detect other bands' ranging and watering sites, directions of moves, resting places in the daytime and at night.

Comparing the use of territory by horses' groups with that by solitary stallions, one could indicate that family groups (bands) get acclimatized to their territories more properly. They have fixed resting, watering, toilet sites, etc. They move along permanent paths, mark and patrol their territory. Naturally, the bachelor groups and solitary stallions use rangelands which are much worse and they patrol their territory from time to time.

THE EDITOR'S COMMENTS: The article covers rather valuable evidence on behaviour of feral horses living in one of the Manych-Gudilo lake islands. The observations undertaken are of scientific and practical value for productive distant-pasture horse rearing involving all-the-year round ranging of horses. They prove once more that the horses can be preserved as a zoological species without man's intervention. Besides, it is possible to make use of remote rangelands with the help of horses for man's benefit - the production of the cheapest meat.

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# TECHNIQUES FOR REINTRODUCTION

# TECHNIQUES FOR RE-INTRODUCTION OF EQUUS PRZEWALSKI

J.M. Knowles

There are few precedents for the re-introduction of wild animals into their former habitats. Those that have taken place to date with large ungulates have been in warm climates in desert or semi desert. The re-introduction of the Arabian Oryx (**Oryx leucoryx**) into Oman, and the introduction of this species and Scimitar horned oryx (**Oryx dammah**) and Addax (**Addax nasomaculatus**) into the Hait Bar reserves of Israel offer limited guidance, as may the so-called semi reserves established to date in Europe for **Equus przewalski.** The experience of the management of the large herds at Askania Nova, in extensive conditions, will be invaluable to the project.

Because of this paucity of historical experience, it is most fortunate that we have the feral horse examples from North America and elsewhere from which information may be gathered for comparison with records of Przewalski Horses in those zoos where the animals live in social groups as would be expected in the wild, even though movements in and out of the herds are constrained by barriers.

There will, therefore, be some guidelines of value to our planning, but all concerned with this most exciting project should be aware that we are at a frontier of knowledge.

What follows therefore cannot be a scientifically developed plan, but rather a series of suggestions based on assumptions. As sites have yet to be chosen and a budget agreed and allocated, the field of assumption has to include the following:

1. Re-introduction sites will have similar climatic extremes and vegetation resources as those of the last known habitat of Przewalski horses - the Takhin Shara-nur mountains.

2. Finance on an adequate scale will be available for the potentially high costs of the necessary fencing and buildings for:

   a. Horses (in the initial stages)
   b. Staff accommodation
   c. Laboratory
   d. Feed and equipment storage

   Similarly that funding will be available for technical and non-technical personnel, transport to the various site stages and the means of monitoring the various project stages. It is not a function of this paper to discuss the question of finance, though it will be fundamental to success. A commitment of funds for at least 25 years will be necessary to ensure success of

the project and the detailed monitoring needed to validate scientifically its problems and successes.

Aspects of re-introduction are discussed under appropriate headings below.

VETERINARY

As the constituent animals of release groups will come from diverse breeding centres it will be necessary to have a very full understanding of their health status, particularly in terms of immunology. Insofar as veterinary science can achieve this, it will be necessary to ensure that none of the constituent animals represent a disease threat to others, or is itself threatened by others. Similar knowledge of the health status of any domesticated or feral equines which may have direct or indirect contact with animals in the various stages of this programme will be vital. More easily accomplished but equally vital will be thorough physical examinations of all participant horses before they leave their original home and on arrival at the various "staging posts" in the programme. The stages of re-introduction for zoo-bred animals will be individually rigorous and will call for the same degree of veterinary care as that given by medical practitioners to athletes.

CHOICE OF PARTICIPATING ANIMALS

Genetic planning will play an important part in these choices, and this will be discussed in other papers. There will be some important additional considerations to those and to the veterinary aspects already referred to.

Broadly, these are temperament, which must not be either timid or excessively aggressive, and social experience (having lived in a stable mixed age and sex herd will be an advantage). History of ancestors will be a further cosideration with physical, physiological, psychological and behavioural abnormalities being carefully scrutinized for possible genetic origins. One to two years of age would seem to be best for animals entering the programme.

RE-INTRODUCTIN BY STAGES

All this is of course subject to the limitations referred to at the beginning of this paper.

Stage 1

Where possible, bearing in mind international health regulations and geography, animals for the programme should be grouped "en

route" and given time to develop social bonds before onward transit. This will facilitate transport, which may be lengthy, in twos or threes. Time should also be given to small constituent groups to be accustomed to their travel containers and be prepared for any significant change of diet.

Stage 2

Arrival at the chosen sites. At least 2 of these should be constructed at strategic points on the edge of the chosen range and should at minimum be out of sight and hearing distance of each other. Each site should have basically zoo conditions for the acclimatizing of the animals. These should consist of a partially open fronted shed capable of protecting the animals from the worst climatic extremes and be large enough to avoid overcrowding of temporarily incompatible individuals and consequent damage to each other. This house would have direct access to isolation stalls for the variety of purposes for which animals may need to be separated from the main herd. These should be at a distance from the main group as the herd instinct in Przewalski horses is stronger than with most other wild equines and isolation is consequently more difficult. The house would open on to a "yard" or "hard standing" which is well drained and has an abrasive surface to avoid hoof troubles during confinement in the early stages of re-introduction programmes. Continuous water supply and food distribution points sufficiently separated to avoid damaging agression at feeding times will be needed. The above described complex should open to an enclosure containing the kind of habitat that the animals will eventually find themselves living in. This enclosure will serve two important functions in addition to habituating the animals to new food plants. The first of these will be a physical toughening process for more stringent exercise than will have been experienced during the times of assembling, transport and settling in and (in the case of some individuals) than they have experienced in their place of origin. The second will be a period of further social adjustment.

Suggested sites for the enclosure would be approximately 100 to 200 hectares (depending on group size). This will be large enough to meet the requirements listed above and yet small enough to enable observation. In the context of observation clear freeze branding of all individuals is recommended so that intensive observation may be carried out from an observation tower with the aid of binoculars. Observation will be assisted by establishing a routine of returning to house and yard daily for supplementary feeding.

Stage 3

The stage (2) complex should lead to a large fenced area where the horses can be released after the criteria suggested below have been met. Here the animals will live as nearly naturally as possible but still be protected from contact with other equines (and conse-

quently disease) and man, and can still be observed at least daily. Size of enclosure should be large enough to accommodate a self-sustaining herd, with opportunity for young males born in the group to form their own bachelor herds and stay in the enclosure. Another possibility is for 2 "bands" to be released into the same enclosure allowing for eventual social re-structuring in a natural way. Of additional importance to size of enclosure will be the nature of the terrain. Valleys and hills allowing visual escape of antagonistic individuals will be as important as space alone. A minimum of 20 000 hectares will be needed.

Stage 4

When the first three stages have been completed satisfactorily and the required knowledge accumulated, it should be possible to release entirely animals of the second generation into nature which will be free in every sense except that the animals will need to be guarded from human interference and that of domestic animals.

COMPOSITION OF GROUPS

If, as suggested above, two sets of facilities can be made available, it would be desirable to import an equal number of males and females and establish these in single sex groups, with ten animals (plus or minus 2) in each group. The females when they reach Stage (3) should be joined by a selected male for breeding to commence providing all has gone well with the preceding Stages and the mares have reached sexual maturity at this time. For this reason and one other it would be desirable for the male to be one year older than the females and arrive one year sooner. The second benefit of this arrngement is that valuable lessons may be learned from having the more expendable males testing the facilities and systems suggested. As near as possible all males should be of genetically desirable composition for mating with the females, so that eventual selection for the first "herd male" can be based on successful adaptation to the environment of the restoration site.

TIMING AND AGE OF ANIMALS

The least stress during transport and arrival would be in Spring when the animals would experience the least climate change. Animals should be approaching their second birthday at this time and therefore reaching the age of natural social adjustment.

LONG TERM

When the first animals reach Stage 3, a review of progress to date should be made and consideration given to the importation of

further animals, which in their turn would follow the already suggested Stages. Changes in the methods used and the general plan will then be instituted in the light of previous experience.

It is impossible to anticipate how long after the beginning of the programme this review will take place, as this will depend on the successes and problems experienced.

## DISCUSSION

The above suggestions represent a very preliminary view of how this exciting challenge may be approached. These are offered without the necessary detailed knowledge of the area and facilities available for the programme and without adequate knowledge of the climatic variations and their annual dates and duration.

Most importantly this paper has been attempted without knowing the ultimate stocking density of **Equus przewalskii** which the chosen site or sites may be able to sustain. It will be vital to establish at an early stage what our numerical goals will be, and in what time frame these should be set. The captive breeding community has successfully brought the **Equus przewalskii** from the point of near extinction to a poulation size which allows a restoration programme to be begun. A well-conceived and energetically pursued plan will receive the full support of those institutions which breed these animals, that of the wider community of conservationists and from the still larger part of the human population that are known as "horse lovers".

# TECHNIQUE FOR RESTORATION OF THE PRZEWALSKI HORSE IN THE WILD

C. Pohle

The Zoological Garden of Berlin welcomes and supports the project to restore the Przewalski Horse to its original native environment in the People's Democratic Republic of Mongolia, using animals from captive environments.

This restoration to the original environment is needed to conserve the performance of these wild horses, which is otherwise endangered and will alter after several decades of keeping these animals in zoo environments. As a result of good breeding results in the zoos, it is now possible to provide animals out of these descendants for the project. The Zoological Garden of Berlin is willing to take part in the project.

Younger animals up to an age of 5 years seem to be most suitable for adaptation in the wild. The transport to Mongolia could be done by having the Przewalski Horses packed in crates, and accompanied by a horseman who will be responsible for adequate feeding and watering of the animals on the long trip.

The Zoological Garden of Berlin has no experience in the restoration of horses. However, experiences with cattle, coming from an area without vegetation, into an area with natural vegetation, indicate that the animals born in captivity had problems in grazing at first. Although offered a rich source of natural feed, the animals got poorer. Therefore additional feeding for the restored animals must be provided for a lengthy period.

Depending on the number of animals available for the project, one or two female herds with one stallion each and a separate herd of young stallions should be established. Each group should be kept in large enclosed areas. The size of the area will depend on the location but should not be too small. A restoration into the wild should only be done when it is clear that the animals are able to thrive on naturally grown vegetation and when the herd structure has been established and strengthened. A most favourable time would be when the first foals are born in the enclosure where adaptation is taking place.

To keep the animals in the adaptation enclosure (or semi-wild enclosure) offers opportunity for regular care and necessary control which includes feeding and watering.

After liberation from the enclosure of adaptation, observation of the freed groups is important in order to obtain information about nutrition, movements and herd behaviour. It is necessary to make sure that the restored Przewalski Horses are not endangered by large wolf populations and that there is no possibility of contact between the liberated wild horses and domesticated horses.

# TECHNIQUES USED TO REINTRODUCE UNGULATES IN ARIZONA WITH POSSIBLE APPLICATION FOR PRZEWALSKI HORSES

Richard Miller

The State of Arizona has been involved in ungulate reintroductions since 1913 to supplement or replace populations decimated by livestock disease and habitat destruction. Some techniques have been developed which may have application to the proposed Przewalski horse reintroduction.

A set of criteria which are used to evaluate potential release sites have proved valuable in avoiding costly mistakes. The criteria we use are:

1. Historic occurrence - Has the animal been found here in the past?

2. Land Status - Who controls use of the land?

3. Topography - Is the topography suitable to the animal?

4. Cover - What is the vegetative cover?

5. Range condition - What is the condition and trend for forage plants?

6. Presence of domestic animals - What domestic animals are present and are they competitors or carrying diseases to which the animal in vulnerable?

7. Presence of wildlife - What wildlife species are present and are they competitors or disease sources?

8. Human disturbance - What level of human use does the area receive?

9. Available water - What quantity and quality of water is available and at how many sites?

10. Dispersion and size of habitat area - What is the size of the available area? How are the resources such as food, cover and water dispersed? How much of the area will be unavailable due to topography, etc.?

11. Potential for expansion - Is there a potential to expand the area if the population does well?

12. Fencing - Are there potential problems with existing or planned fences?

13. Seasonal habitat - Are the seasonal needs of the animal such as wind cover, available?

The majority of our recent experience in Arizona has been in transplanting desert bighorn sheep (**Ovis canadensis**). Since 1979 we have reintroduced 384 bighorn to 28 separate sites. Along the way we have learned some lessons which may be useful in planning the Przewalski horse reintroductions. When we began reintroducing bighorn sheep we were concerned they might scatter widely or completely leave the area. First we built very large enclosures and left the sheep in them for up to fourteen years before releasing them. Mortality rates have been high and reproductive rates low while animals were held in enclosures. For example the Aravaipa herd increased from 16-22 sheep while held in an enclosure from 1958 to 1972. This herd was released in 1973 and by 1983 numbered about 100 sheep (Dodd 1983). Dodd (1983) also found these sheep failed to utilize all the area available to them and concentrated lambing sites near the old enclosures. He suggested that transplants be made with small groups of animals (6-10) at several locations, and that lambing sites be established by transplanting ewes late in their pregnancy. This technique has been used to supplement a declining sheep population with dramatic success. Sheep transplanted in late pregnancy are using an area approximately one quarter the size of sheep transplanted in winter and have scattered much less (Remington and deVos, in press). In almost all releases some bighorn rams have left the transplant site some travelling up to 75 kilometres (Dodd 1983; Miller and deVos, unpublished data).

The Arizona Game and Fish Department has also been actively transplanting javelina (**Tayassa tajacu**) moving over 400 animals (Day 1985). In order to promote herd formation we have been placing javelina into artificial herds and holding them together for a minimum of six months in enclosures before release. Although the effort is considered important because of low reproductive rates in small javelina herds, all released javelina herds have fragmented badly following release. No technique we have yet tried has solved the problem.

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# PRACTICAL EXPERIENCES IN IMMOBILIZING AND TRANSPORT OF PRZEWALSKI HORSES

H. Wiesner and G. von Hegel

## 1. IMMOBILIZATION

Since the introduction of the synthetic morphine derivate, Etorphine hydrochloride in zoo medicine the immobilization of specimens of the equine family has lost its horror. This very highly potent drug made obsolete all previous methods using the high risk drug Succinylcholin chlorid and the oral application of 30 g Chloralhydrat per animal. However whilst these old methods have only been used in emergency cases, they have afflicted a high risk on the live animals and the health of the personnel involved. Thus we have with the blowpipe and M99 a new method for a safe and effective immobilization of wild horses.

However, in using Etorphine alone like M99 crystal powder or even the combination of Etorphine with Acepromazin, registered as "Large Animal Immobilon$^{R}$" C-vet, England (1 ml contains 2.25 mg Etorphine per ml combined with 10 mg Acepromacin used as tranquillizer), we must await severe side-effects. About 6-10 minutes after the injection severe excitation, violent muscle-tremors, collapses, sweat spasms, cramps, blind forward moving and an increase of the pulse rate up to 200/minute were observed. These side-effects can be reduced with the combination of Xylazin or, in a short operation, by a direct intravenous injection of 1/10 of Diprenorphin of the Etorphine dosage (Wiesner, Rietschel and Gatesmann 1982).

With this combination we have had good results in the last years in immobilizing wild horses. From 1975 to 1984 we immobilized 188 times Przewalski horses without any mortality (Wiesner and von Hegel 1985). The recommended dosage for an adult Przewalski horse would be 2.5 ml of Immobilon$^{R}$ combined with 50 mg of Xylazine **in toto** on average. That corresponds to a dosage of 0.019 mg/ka of Etorphine (Wiesner, Rietschel and Gatesmann 1982; Wiesner and von Hegel 1985). In some animals a higher dosage up to 3 ml of Immobilon$^{R}$ may be necessary, depending not on the body weight but on the nervosity of the animal. Therefore, the dosage can vary individually. We have practised this immobilization not only in emergency gynaecological examinations of our Przewalski horses but also in other cases (Wiesner and Bostedt 1979). However, the immobilization stage of this combination is not sufficient for painful operations. When we had to perform a tail amputation in our mare "Sitka" (born 8.7.80, Studbook No. 932/Hell.84) in the year 1984 after an injury from the stallion, we had to give some Immobilon$^{R}$ (0.5 ml) by slow direct means intravenously to get surgical tolerance. No doubt, this tolerance can also be reached by an adequate i.v. injection of Ketamine.

The big advantage of this immobilization is the reversibility by i.v. injection of the antidote diprenorphine, registered as "Kevivion" (1 ml contains 3 mg diprenorphine hydrochloride per ml).

Especially in the family of equinae, the so-called "hepatocyclic effect" may occur. In this case it means no metabolized Etorphine passes the liver via the bile and is reabsorbed in the duodenum. Therefore 6-10 hours after the injection of Etorphine heavy excitations may occur, that may lead to a self-injury risk of the animal. To avoid this side-effect, half the i.v. applied dosage is additionally given subcutaneously.

In the year 1984, a thesis was written about the change of the blood parameters during the combined immobilization with Immobilon® and Rompun®. During the experiment three blood samples were taken of 20 immobilized Przewalski wild horses every 10 minutes within a period of half an hour, starting 10 minutes after the Immobilon®-Rompun® injection (Kuttner 1985).

The samples were analysed for red and white blood cells, hematocrit hemoglobin, chloride, sodium, potassium, calcium and phosphorus, GOT, GPT, AP, LDH, CK, GLDH, G-GT and cholinesterase, bilirubin, creatinin, total protein, urea and glucose.

The results were statistically evaluated.

Changes in blood levels within 30 minutes after the narcotic injection were analysed. Basic data were the first samples, which were taken 10 minutes after injection.

Table 1 shows mean values and standard deviations of Przewalski horses 10 minutes after injection.

Thirty minutes after injection hemoglobin, erythrocytes, hematocrit, glucose and potassium changed significantly.

Glucose increased heavily, the other parameters were diminished.

Leucocytes, calcium, phosphorus, TP, GOT, GPT, AP, LDH and GLDH decreased not significantly but notably.

Bilirubin, creatinin, chloride, sodium, CK, G-GT, cholinesterase, MCV, MCH and MCHC remained nearly constant.

Urea was individually different, so a narcotic-caused change could not be observed.

It may be concluded that blood values taken under narcosis, which differe from reference values, did not change because of the narcotic drugs but on account of pathologic reasons as soon as they leave the physiologic variances. Excluded are the values of red blood

Table 1 FOUND PARAMETERS IN PRZEWALSKI HORSES n = 20

| | | x 10 min. p. inj. | ±s | x 30 min. p. inj. |
|---|---|---|---|---|
| RBC | ($10^6/\mu l$) | 8.9 | 0.9 | 7.9 |
| Hemoglobin | (gm/dl) | 15.5 | 1.7 | 13.8 |
| Hematocrit | (%) | 43.7 | 3.7 | 39.5 |
| MCV | ($\mu^3$) | 51.0 | 8.0 | 49.0 |
| MCHC | (%) | 35 | 2 | 35 |
| MCH | (pg) | 18 | 2 | 17 |
| WBC | (°1) | 8257 | 1684 | 7871 |
| Lymphocytes absolute | (µl) | 2798 | 809 | 3112 |
| Lymphocytes relative | (%) | 34 | 9 | 40 |
| Segments absolute | (µl) | 5184 | 1444 | 4393 |
| Segments relative | (%) | 62 | 10 | 56 |
| Chloride | (mg/dl) | 94 | 4 | 93 |
| Natrium | (mmol/l) | 138 | 4 | 136 |
| Calcium | (mmol/l) | 3.0 | 0.2 | 2.8 |
| Kalium | (mmol/l) | 4.7 | 0.8 | 4.3 |
| Inorganic phosphate | (mg/dl) | 4.7 | 1.3 | 4.2 |
| Glucose | (mg/dl) | 112 | 21 | 166 |
| Bilirubin | (mg/dl) | 0.98 | 0.36 | 0.87 |
| Creatinine | (mg/dl) | 1.12 | 0.29 | 1.05 |
| GOT | (IU/l) | 208 | | |
| GPT | (IU/l) | 8 | 3 | 6 |
| Alkaline phosphatase | (IU/l) | 355 | 132 | 323 |
| LDH | (IU/l) | 579 | 141 | 540 |
| GLDH | (IU/l) | 13 | 12 | 11 |
| G-GT | (IU/l) | 17 | 6 | 17 |
| Cholinesterase | (IU/l) | 7245 | 1118 | 7313 |
| Total protein | (gm/dl) | 6.9 | 1 | 6.4 |
| CK | (IU/l) | 142 | 54 | 141 |

cells, hemoglobin, hematocrit and glucose, which have changed significantly during the 30 minute experiment.

We have to point out the fact that Xylazin alone is not an adequate drug to get a sufficient immobilisation stage in the Przewalski horses, even if this drug is only administered to handle the animals for the transport. Two fatality cases with Xylazin first and a following injection of Etorphine are reported. The animals died by shock syndrome in the transport crates (Müller **et al.** 1980).

## 2. TRANSPORT

With a dosage of ca. 12 g Vetranquil Granulat$^R$ (Fa. Albrecht) (i.e. ca. 220 mg Acepromacin per adult animal) Przewalski horses under zoo conditions can become sufficiently sedated to handle them easier for the transport.

After 10-20 minutes the horses show uncoordinated movements and are in most cases able to be driven into the transport car or crate.

Nevertheless, like all oral drug intake, the reaction of the animals can vary considerably and the Acepromacin should not be used in very shy and timid animals. In these animals, the darting with Immobilon®/Rompun®-combination shows greater advantage and preserves the animals from self-injuries. For this matter, the animals become handable, before the complete immobilization of the Etorphine takes effect. The stiff-legged animals can be quite easily led into a crate, where the antidote injection is given (Heck 1980). The crate should be narrow enough that the animal cannot turn during the transport and broad enough to be comfortable for the animal. A sufficient air conditions especially at the ground of the crate is absolutely necessary. If the animals can be transported by car and not by aircraft the transport without crates in a convenient lorry for horse transport is preferable. According to our experience the animals will remain much calmer in these special transport vehicles than in the crates. For longer distances in the crates, water and food supply should be arranged regularly. In all types of transport only animals in a standing position should be moved.

The animals should starve the day before transportation, even if they are not fully immobilized but only slightly sedated. Chasing wild horses with the object of capturing or immobilizing or netting can easily lead to myoglobinurie of the captive animal with fatal results. In any case, a safe immobilization has the preference to all other handling methods.

For that reason, the staff of the re-establishment programme of Przewalski horses should be specially trained for the immobilization of these animals and a blow pipe and blow gun equipment seems to us to be as necessary as the use of Etorphine and Xylazin, at least during the first period in the arger enclosures before the horses can be successfully released in the wild.

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# ECOLOGICAL CHARACTERISTICS OF THE PRZEWALSKI HORSE AND THE PROSPECTS FOR ITS ADAPTATION IN THE WILD

V.V. Klimov

SUMMARY

The social and spatial phenotype of the band of Przewalski horses in Askania Nova is a functional biological system with a hierarchic type of structure, having relatively great diversity in its composition and displaying the strategy of social formation in a partially protected territory. The combination of such strategies, with their cooperating and coordinating links, allows the system to respond elastically to the fluctuations of the outer environment and to adapt to it successfully ensuring its survival. At the same time, some elements of this system, when existing separately, are not able to provide the adequate response to the environment and to withstand the external factors.

Therefore it is necessary to form full-value social groups when introducing the horses into the wild: such groups will ensure the regulation of the intra-band relations, hereditary formation of agonistic and reproductive behaviour patterns, the establishment of a specific structure and organization assisting in responding adequately to the environment and to the further propagation of the species. Such groups shall be formed by themselves, on the basis of personal sympathies and abilities of stallions in the territories able to carry several functional units, i.e. harems, bachelor groups, etc. In these conditions, under natural selection, the natural mechanisms of improving the consequences of inbreeding will be developed, such as reproductive success of more experienced and strong stallions, rotation of males and females, formation of new harems.

All activities on the creation of horse groups should be carried out beyond the active reproduction period, i.e. in late summer or in the fall. Sexual activity is reduced at this time; the sired mares reject stallions and the young stock that were born in the spring grow older. When forming the bands and shipping the horses to other regions, the foals should be kept with their mothers. Moreover, the horses should be transported by harem groups. When the horses have to be transported in cages, the presence of familiar animals that are sensed acoustically, or by smell, will allow them to tolerate better the extreme conditions and avoid stress.

It should be kept in mind that when Przewalski horses are introduced into the natural biotopes, the presence of the domestic Mongolian horse in these regions will lead to the formation of mixed harems and to cross-breeding. In order to avoid this it is necessary to remove the domestic horses from the introduction areas, preferably in the spring, during the active reproduction period. In wintertime,

the domestic horses may be of great help, teaching "the newcomers" to get food from under the snow cover. In this situation they will serve as ethological "mentors".

Thus, there is every reason to assume that the reintroduction of wild horses into nature will be a success if they successfully pass the period of primary adaptation to the climatic conditions of the steppe area in Askania Nova or in some other steppe reserve in the territory of the Soviet Union.

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The study has been made of Przewalski horse behaviour in the steppe reserves of Askania Nova from the aspect of its follow-up reintroduction into the wild. Taking into account the major problem, namely whether the horses will manage to withstand the environmental pressure in the severe conditions of Central Asia, the study was focused on individual and social behaviour of the free-ranging populations of horses. The adequate response of the wild horses to environmental fluctuations can assure that their reintroduction into the wild will be a success. The study was carried out in 1980-1984. The band of Przewalski horses is maintained year-round in large enclosures of **Stipe** and **Festuca** steppe with the area ranging from 45 to 1550 hectares. In these conditions the horses are under the effect of abiotic factors of the environment (climate, relief), biotic (other animal species, steppe associations of plants) and of man-induced factors (automobiles, aircraft, people).

## 1. ECOLOGICAL PREMISES

Askania Nova is situated in Europe, near the southern border of the Sivash steppe plain, between the West Sivash and the flood-plain of the Dneiper river. Not long ago this plain was characterized as a virgin **Stipa** and **Festuca** steppe with vast depressions, or "bottoms" that were characterized by specific associations of wheat grass, sedge, and motley grass. The solontshaks with their parts on the surface are frequent in the Sivash steppe, near the shores of Sivash, in particular. At present all virgin steppes here are developed. Askania Nova is the only place where the intact plots of steppe have been preserved, their total area is about 11 000 hectares, and they are characterized by specific vegetation.

The geophysical situation of Askania Nova is at latitude 46°28'N. The low position above sea level and abundant solar radiation result in a mild climate. The total number of sunny hours per year is 2255, and 1000 out of this number are registered in June-August (Babich 1960). The absolute maximum air temperature in the summer is 38°C. The summer season lasts for about 140 days, from mid-May till the end of September The summer is dry and hot. The average winter temperture is 1.2-3.3°C; occasionally it can be as low as minus 30°C.

Such temperature fluctuations with a range of 41-49°C point to instability of the weather in winter, that is characterized by sharp falls in temperature and by unexpected thaws. Low temperature is accompanied by the growth of air humidity up to 80% that results in formation of winter fogs and glazes, as well as of continuous winds, blowing mostly from the north or northeast with an average velocity of 5.3 m/s. During occasional storms the wind velocity can reach 25 m/s.

The snow cover in Askania Nova is formed in December and melts in early March. Nevertheless, this cover in the steppe areas is not more than 10 cm thick and it can disappear in mid-winter as the result of thaws. Only in most severe winters the snow cover may exist for 60-70 days in a row. In such cases its thickness may reach 40 cm and more.

One of the most unfavourable meteorological factors that is observed from early spring is cold dry winds of the northern quarter that bring back the cold weather, impede the vegetation growth, and reduce soil humidity. Occasionally, spring winds turn into storms, with a velocity of 25 m/s.

Overall the climate in Askania Nova may be defined as dry, with a long hot summer and a short unstable winter, with the prevailing dry winds; the annual precipitation is 376 mm; the solar radiation is high.

The horses, ranging on a year-round basis, can successfully tolerate the Askanian climate as a whole. Their skin is 5933±199 microns thick, i.e. 37% more than that of the domestic horse in Europe. The length of hair in the summer is 15.0 mm; it increases up to 20 mm and more in wintertime. The hair cover comprises pop-hair of the first degree (82.6%), pop-hair of the second degree (13.2%) and underhair (4.2%). In wintertime the mane grows from 126 to 140 mm (Katsy and Klimov 1983). It should be stressed that the horses imported from the USA in 1982 that lived in the conditions of city zoos managed to overcome successfully two winters, the last one being extremely severe. Moreover, they produced offspring that points to their successful acclimatization. The horses in the wild used to get food from under the snow cover, pawing and digging with the muzzle. The horses in Askania Nova do not have that skill since they have not been taught by their parents as happens in nature. Nevertheless, the horses demonstrate scratching movements that are characteristic of caballus in the attempt to dig snow and get the plants that are hidden under it. This behaviour pattern is not yet formed completely, but there is a hope that availability of "mentors", i.e. the animals that possess this skill, will help the others to master it. The wild horses are unpretentious as regards the botanical composition of forage, they eat both wheat grass (**Festuca**, **Stipa**, **Bromus**) and various sagebrushes, pod-bearing plants, etc.

Automobiles, tractors and people moving by the road behind the network fence make the horses withdraw only by 20-30 m. The aircraft flying over the enclosure do not produce any defensive response.

## 2. ETHOLOGICAL PREMISES

### 2.1 Formation of Behaviour Patterns

The newborn foals strive to maintain permanent visual, olfactory and tactile contacts with their mothers. Their mothers ensure their protection within and beyond the band, and they control the observance of individual distances. The infant foals (till the age of 6-8 months) follow their mothers, seeking protection. They start periodic grazing at the age of 8-9 days, and at the age of 10-14 days they begin to establish personal, competitive contacts with other foals of their age group. When they shift from suckling to grazing, their alliances with the mothers become weaker, and they try to establish contacts with older horses. An element of competition among contemporaries and a certain degree of aggression on behalf of the mature horses are observed at this period. By the end of this period the social ranking is clearly seen. Older band members define individual distances between the infants.

Juvenile horses (till the age of 1.5-2) separate from their mothers but maintain links with them. Personal contacts are strengthened as a result of playing and competitions. The future reproductive behaviour pattern begins to be displayed by individual elements of their play, the division of their roles according to their sex being observed. The juvenile horses try to keep individual distances.

The females at the age of 2-3 years, along with their mothers, automatically become the members of a general or of a specific harem. Cases of ousting of the young mares from the band were observed. They are fully subordinate to the stallion and mate with "their" stallions, when reaching sexual maturity. The alliances within a band are personalized, competitive or polygenic when the family is formed. The mature mares are able to keep individual distances when ranging, recreating, when the band is moving, or in dangerous situations, but they do it selectively and not always. They do not mark their territory, and do not protect it. The passive defensive response to the effect of outer factors prevails. They do not involve other mares into their band and perform passive control over the band. Without a leading stallion the mares are not capable of coordinating the band activity and providing adequate response to outer factors. The mothers with foals increase individual distances and their degree of aggression. In the course of time the mares may change their social ranking and join the leading group.

The males at the age of 2-3 years develop the personalized contacts in their group with the use of grooming, playing, fights and their ranking is more pronounced as compared with the previous age group. They try to court the females, to involve them in their band, demonstrating reproductory behaviour. They get into the focus of the leading stallion's attention and the latter starts to pursue them and eventually drives them out. The ousted stallions form a bachelor group with its own ranking, but the relations within such a group are not

competitive till the reproductive stimuli appear and then some stallions try to take hold of a mare The bachelors neither mark, nor protect their territory. The young stallion actions are characterized by incomplete performance of aggressive and reproductive behaviour due to underdevelopment of some parts of these patterns. As a result, they fail to reach the top rank, and consequently cannot take hold of mares. When the leader is absent in a band the most dominant stallions take hold of several mares or the entire band, ousting other mature males, and try to secure their social and reproductive status. During the period of social structure establishment the relations within a band are mostly aggressive, since the possessive efforts of a stallion are repulsed by the dominating mares. Upon stabilization of the social homeostasis in the group such stallions take secondary roles after the dominating mares. They neither mark, nor protect their territory; they perform no goal-oriented control of the band that has its adverse effect. A stallion may occupy the leading position in a group only after it has gained the experience of leading the harem, approximately by the age of 10 years. Such a stallion becomes unquestionably dominant in his band: he patrols, marks and protects his territory. The size of such territory, number of mares and the quality of efforts needed to hold and protect the mares are directly dependent on the masculinity and social experience of a leader. The leading stallion with socially adequate actions displays the concern of the band members, he coordinates all its activities and counteracts the environmental pressure that eventually leads to the prosperity of the population and further propagation of this species.

## 2.2 Reproductive Behaviour

The growth of reproductive activity, as regards Przewalski horses in Askania Nova is observed in early spring with its warmer weather, long days and sunlight. The young animals at the age of 1-2 years begin to involve each other in active play that results in expanded and strengthened links between the horses. The sexual character of their play, that increases by the summer, is clearly seen. In May the mares start to produce offspring and that leads to the change of their position in the group. They display no interest toward males and other horses, become aggressive and cautious. Mothers aggressively defend their foals, attacking everybody in their vicinity, striking them with their hind legs. The stallion stops his efforts to approach such a mare but resumes his efforts more persistently on the 6-8th day. Copulations are observed 11-15 days after confinement.

A certain peculiarity is observed when the stallions of various ages are mated to mares. Young stallions display inadequate behaviour and their helplessness is characterized by a series of chaotic, unfinished movements. The older stallions are able to perform successful copulation; they court a mare displaying the entire range of sexual behaviour. Nevertheless, the mares probably feel uncomfortable and often reject the stallions. Mature experienced stallions (e.g. Pegasus) do not waste time on preliminary courting but mount the mare

without any preparations. In such cases the mares are submissive and obedient. There were no registered cases of rejecting Pegasus. The frequency of mating depends on the age of a stallion. Young stallions, placed in the herd after a long period of rest can copulate once per hour for 4-5 hours in a row. Their activity increases if the mares are receptive. Moreover in some cases when a stallion had a surplus sexual motivation he managed to mount the mare that was not in sexual heat and displayed vigorous resistance. At the expense of his physical strength he managed to neutralize her actions, pressing her croup to the ground and managed to cover her (Klimov and Paklina 1983).

Within the framework of sexual behaviour a number of anomalies and inadequate actions can be outlined:

Group 1: Anomalies caused by incomplete formation of young horse sexual behaviour, their response to animals of the same sex, the disrupted chain of actions in a sexual ritual, absence of certain links in this chain, by the absence of social skills to behave with partners and ignoring them when physical strength prevails.

Group 2: Preference of interspecific sexual relations, i.e. mares in heat prefer domestic stallions of the Reserve workers, or formation of a harem that consists of other species representatives (Shetland pony, domestic mare) by a stallion.

It is our view that such phenomena are caused by the following factors: incomplete formation of social behaviour patterns of stallions due to their frequent isolation from mares and grouping with other stallions; mares have no contacts with stallions which results in the absence of social knowledge; maintenance with representatives of related species (domestic horse) that leads to a breach of adequate behaviour patterns, of social skill formation.

## 2.3 Social Structure and Organization

One of the major factors of uniting the horses in the structural system, of their distribution in a given area and functioning in a strange environment, is the social, or ethological band structure. It comprises several structural units, i.e. age and hierarchic groups, permanent or temporary formations and their modifications. The hierarchic steps that are passed consecutively by each animal in the course of life are defined, in major part, by the morpho-physiological and psychological status of the horses. The position, ranking and social role in a band are formed due to the combination of these factors.

Age factor is of great significance for social ranking. Newborn foals stick to their mothers and occupy the same position in the ranking system. While they are growing and begin to graze the distance between mother and foal increases and by two-months of age they may be included into the lowest ranking group of juvenile horses. This group

is followed by yearlings, two year olds, semi-mature and grown-ups. This formal age ranking is the basis for the band hierarchy. The animals of the junior age groups may be easily distinguished due to their considerable differences in physical features; however the mature animals have almost no visual differences between them having approximately the same size, etc. Nevertheless observations proved that each animal occupies its own position in the general hierarchy of a band.

A band's stallion, that is also called a "leader", occupies the top position in the social structure of his band. For a number of years the Askanian band of wild horses was headed by Pegasus, the oldest stallion in the group (22 years old). The activity of this stallion is characterized by the full range of behaviour patterns characteristic of the males of the **Equus** species, that have its functional and evolutionary meanings. All his actions may be divided into the following: (i) ways and methods to establish his dominant position; (ii) ways and methods to control and defend his band; (iii) performance of a reproductive function that is both the result and the tool of his dominance. The first group of activity stipulates, in major part, the aggressive forms of influence, and their ritual meaning. When performing control over the band the stallion searches for the optimal location of his group, defines the routes of their movement, controls the activities within the band, sets the "schedule" of visiting the watering sites. The leader drives out other stallions, stops fighting, maintains order in his group, takes care of the mares and the young stock. The external factors, such as appearance of other stallions, of other species, of people and their objects (e.g. domestic horses, a cart, automobiles) become the area of its special concern.

A leading group, or "the nucleus" can be distinguished within the herd; such a group comprises predominant mares (3-5) that is the basic structural and functional unit. The mares of the "nucleus" define direction at grazing, when on the march, or escaping from danger. In extreme conditions the lead is often taken by the oldest and most experienced mare, Volga. Besides individual qualities, the family ties are one of the factors that have an effect on a band hierarchy. A mother and foal are the primary family unit. When a mare has a yearling, or two year-old foal, which is less frequent, it is possible to regard it as a family cell inside the band.

Along with the basic structural units within the band, other, more or less permanent and temporary formations are observed that introduce changes into the band structure. The presence of such formations depends on the season, this or that enclosure, ecological situation, demographic composition of the herd, and on the physiological state of individual animals. The permanent, or stationary units are as follows:

1. Harem groupings. When stallion Pegasus is present in the band, all mares are members of his harem. When this stallion is

absent and other mature stallions are released into the herd that were in isolation prior to this, one of the newcomers takes hold over the mares driving out the others; when two stallions are similar, as regards their physical strength, they can divide the herd into two parts.

2. Bachelor groups and solitary horses. Such groups are observed when the band has a leader that ousts other semi-mature and mature stallions that are grazing at some distance from the herd. They can occasionally occupy the herd's territory but never mix with it and stick to their individual group.

3. Groups of horses with personal bonds. Such bonds may exist for a number of years. Such bonds can form between the animals, representing different species.

Temporary formations are as follows:

1. Groups that are formed during a mare's cycle. Two options are possible; first, when a mare has a "train" of courting stallions striving to sire her, and, second, when a receptive female is striving to copulate with a stallion.

2. When foals are born, the character, behaviour and rank of their mothers changes radically. They become the most cautious and aggressive animals in the band and since they are motivated by the same drive, that is to preserve their offspring, they undertake joint actions when in an emergency, or a strange stallion penetrates their territory, etc. Their actions are characterized by extreme cruelty and completeness of reactions toward the enemy, that allows them to occupy the second position after the leader in the band's hierarchy, the latter often preferring not to have any conflicts with the mothers.

The age status and the rank of each horse that makes up a population are relatively balanced but the time comes when some horse upsets this balance and tries to change its rank. Such actions are accompanied by conflicts with the animals of the same rank and with those of higher ranking. Thus, the rank of each horse is defined and preserved by the individual qualities of each animal, by the horses of the adjacent ranks, by high-ranking horses, and by the leader. The change of psychological and physical status of individual animals is caused by their own development, reproductive processes, and by their physiological state, e.g. injuries, diseases. Along with external factors, such as climate, season, new horses in a group, or removal of some old ones, the internal reasons change the ranking of many horses eventually upsetting the entire band structure. Such changes are very painful, they are accompanied by increased excitement, stress, etc. The number of aggressive actions sharply grows, up to 40-50 per 5 minutes. The number of activity shifts grows from 27-30 to 68-70 during the light hours. The time spent on grazing and rest sharply decreases (46%, 34% correspondingly), the time of marching increases

up to 20% of the total, while the normal indicator is 8-12%. Depending on the factors that have caused the change in social structure, the balance is reached in 1-3 days, each animal occupying its own cell within the general structure that remains stationary till a new "coup".

The relations within the group are regulated by the demonstrative and agonistic forms of behaviour. At the initial stage the contact between two mature stallions is based on visual stimuli and ritual movements, characteristic of their rank, motivation, and claims. If the stallions' interests remain unrealized at this stage their contact continues with increasing excitement. The stallions draw closer to each other, rear, start to bite each other and to hit with the front and hind feet. Such fights may lead to serious injuries. It is not characteristic of mares to use ritual actions, they just start aggressive actions.

## 2.4 Spatial Organization

The mode of behaviour and the spatial distribution of a band depend on the enclosure where it is placed: its size, topography, locality, configuration of the territory position and availability of water reservoirs, shelters and saline plots. According to these factors, the group forms its spatial structure, i.e. the "central" and "border" zones, the area to be patrolled, marking places, areas for rest, activities, "toilets", etc. The principal territory where the horses are maintained during the reproduction period (May-June) is enclosure No. 3.

The "central" zone is situated in the western part of the enclosure and represents a dusty plot of land, 18 m in diameter. This plot is a so-called "tyrlo" used for rest and recreation where the horses spend most time of the day. Along its boundaries this plot is surrounded with auxiliary "services", e.g. "dust baths" with an area of 12-15 $m^2$ and "public toilets" with heaps of horse faeces, that are regularly supplied with new portions. The "toilets" are an important part in the system of communicative and hierarchic links between the horses, they are also significant for establishment and maintenance of the territorial principles in this group. Additional "toilets" and "recreational facilities" are situated in the most frequently visited parts of the enclosure. There is another "tyrlo", an outlying one, with a diameter of 16 m that is visited by horses less frequently; it is situated at a distance of 50 m from the "central" one. Both plots are overgrazed and lack vegetation. The plot for "after-watering rest" is situated near the watering site and is used by horses only in the evening or in the daytime when the weather is cloudy. The area of this plot is 140 $m^2$; it has several "dust baths" and $3\pm$ "toilets" along the boundary. The horse paths start directly from the watering site. They cross the entire enclosure and end in the "central zone" or by the grazing areas. According to observations, such paths are renewed every spring and used during the entire season. The paths are divided into

"arterial" ones that link the watering site with the "central" zone by a straight line, and they are 3-4 cm lower than the soil surface, and the outlying paths that cross the enclosure in every direction and can hardly be noticed in the thick grass cover. In any case when a horse is not grazing and is moving alone or with a group it prefers to move by path. There are several "toilets" along the paths, especially the arterial ones, that are situated with a distance between them of 15-20 m.

The patrolled zone is situated along the boundary of the enclosure. It is especially well pronounced along the northern and eastern fences behind which other species are managed. This zone consists of a similar path along the fence, with all its curves that is 50 cm from the net. The patrol path skirts the water reservoir and at the same time crosses it. The patrolling stallion usually goes round the reservoir; when he is in an excited state, following an external irritant (other stallion, riders) that are behind the fence, he can cross the reservoir directly. There are marking places near each gate, in the northeast part of the enclosure, around the geodetical column and in some sections of the patrol path. Such places represent small plots with an area of 1-1.5 $m^2$ that are filled with horse faeces, periodically renewed by the leading stallion. It should be stressed that he does so only in the case of a threat coming from the adjacent areas (wild animals, domestic animals, patrol men). In a calm situation when the external irritants are absent he may only study such a plot and leave it since there are no other stallions that could leave markings and the mares are not allowed in these patrol areas.

When calm, the group of horses managed in enclosure No. 3 covers a distance of 4-7 km per day, in the large enclosure the horses move by 8-10 km; on hot days this distance is sharply decreased. During the driving of the band to another place in the fall, the resistance of the band is sharply decreased after 10-15 km of driving. It indicates that the horses suffer from lack of movement, as compared with the horses in the wild when the riders could follow a band for 2-3 days, tiring out several horses and managing to obtain only foals (Klements 1903).

## 2.5 The Band as a Functional System

The peculiar feature in behaviour of the wild horse band is its permanent readiness to respond to external irritants, with the use of group forms of adaptation that are characteristic of the social animals that lived in the severe conditions of Central Asia; these forms are clearly seen when studying the animals born and maintained in captivity. Thus, when ranging the horses display social constructions, such as "circle", "horseshoe", "wedge", "arc", "rank", "band", etc. In hot weather they protect themselves against midges, using the coupled modifications of the "tail-head" stand, or collective ones standing by a double rank, horses waving the faces of their neigh-

bours. In some cases the band is concentrated in an amorphic or dense group. When on the march the horses move in a chain, when each horse strictly follows the front one. There may be several such "chains" when the band is moving.

During any function, rest, ranging, marching, 2-3 horses study the environs, assisted by different spatial orientation of horses when resting, or grazing. The leader is always at some distance from the group and spends most time of the day observing the surroundings. Occasionally he patrols the territory.

When a strange object appears it is marked by a loud "inhalation-exhalation" and alert of the horse that was the first to notice it. This signal is passed over to all band members in a radial direction, after which all horses cautiously watch the object. The leader is the first to see danger, as a rule, and he meets the object at the boundary of the enclosure, near the gate or the net. The response of the band depends on the nature of the irritant. When the object is familiar enough, or totally unfamiliar, it can cause curiosity and not aggressive actions. Thus the horses may approach an observer and stop at a distance of 20-30 m, surround him and watch for 2-3 minutes. The leader usually prevents such actions, and actively grouping the mares drives them to a remote area. When the object causes alarm, the band consolidates into a solid group, upon the first warning signals, and is ready to follow the leaders. The mares with foals are placed in the rear of the group, the mature animals are responsible for choosing the direction and the young stock that are "in the way" and have no experience in extreme situations remain in the front of such a group. The leader usually stands halfway between the band and the object, demonstrating the aggressive ritual behaviour and marking the territory. Both he and the mares in the front thoroughly study the object (visually) and are ready to respond to its possible actions. When this object is a rider, or a man in a horsecart, the leading stallion attacks the domestic horse, trying to kill it. When the leader desires to drive the mares away, he makes a signal, taking a "goose-like" stand, lowering his head to the ground and waving the head and the mane sideways. The signal is usually received by one of the mares in the "nucleus" that takes the lead. There is a need to stress the joint coordinated actions of the horses avoiding the pursuers. When pursuing the band during the inter-season drives it is clearly seen how the leader, or the leading group perform a "shuttle" manoeuvre, in an attempt to change the route, imposed by the pursuers. The animals make false movements and at the right moment make a spurt and get beyond control. Such a breakthrough may be performed not by the members of the leading group alone but also by other, most resolute, animals. After a single horse breaks out it is impossible to hold the band anymore. Like an avalanche the horses follow the leader, passing the riders. At this moment the animals do not display the former fright of man and do not keep the necessary distance (30-50 m). Only after the horses are grouped again may their driving be resumed, starting from the very beginning.

Thus we observe the functioning of the intra-group mechanisms that coordinate and organize the band's actions; we can use them to control the horses' behaviour and their territorial distribution. It should be stressed that all activities of a horse group described above, both on the range and in response to external objects, are characteristic only of the band with a full-value social structure, formed in the course of several subsequent generations. The absence or replacement of an experienced leading stallion with one which is young and inexperienced will turn a well-organized functional band system into a chaotic mass. Such a group changes the activity patterns spontaneously, does not develop its territory, does not display stable rhythm in its daily activities, and when exposed to the strange, threatening irritants finds itself at a loss and gets into an impasse. It is possible to explain the rapid extinction of the wild horse in Mongolia and China by this very factor. The Arats (local residents) shot the stallions in the first place, because they caused damage and prevented the successful hunting of the wild horses. Without a leader the mares failed to withstand the pressure of the environment.

As part of the stallion exchange programme, stallion Sigor was imported from the USA. He used to approach a man, allowed him to pat, etc. When he was given an opportunity to form his own band in a separate enclosure he failed to do so, even in the absence of competition with other stallions. Having no skills of aggressive or reproductive bahaviour he failed to become dominant and to take hold over the mares. When he made an attempt to copulate with them they rejected him. Later, during the second reproductive season, he managed to form a harem and tried to protect it, attacking people in a horse-cart in 1984 when he also started to protect his territory. Despite imcompleteness of these behaviour patterns, we may hope that in the course of time this stallion will gain all the social skills that are characteristic of stallions in the wild.

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