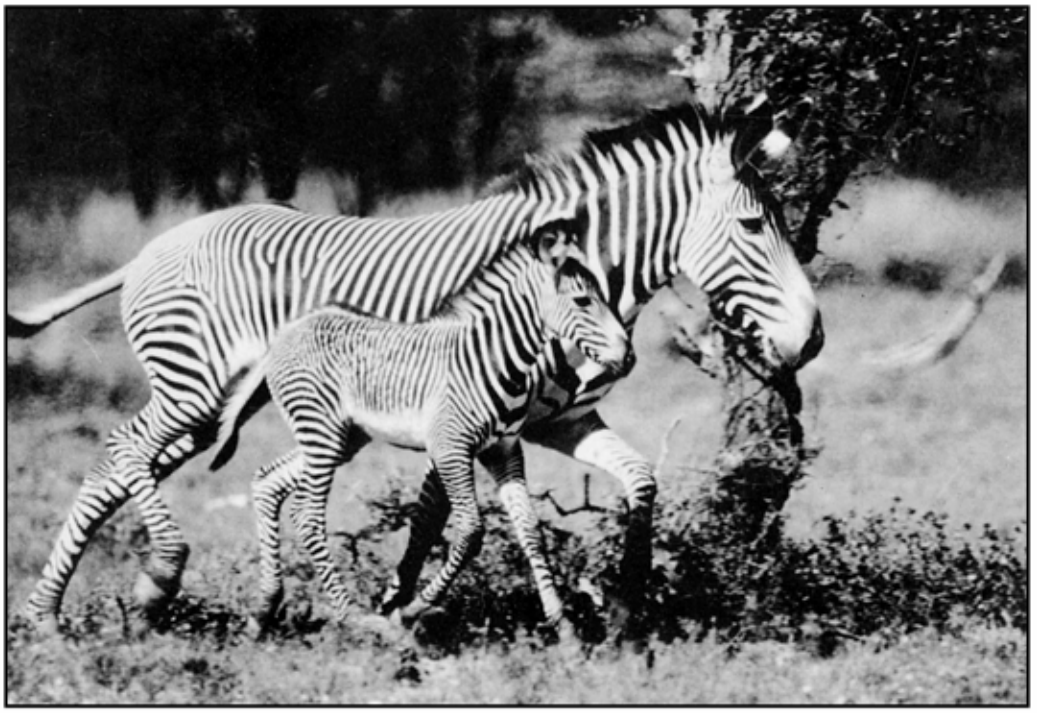
Zebras, Asses, and Horses

An Action Plan for the Conservation of Wild Equids



Edited by Patrick Duncan
IUCN/SSC Equid Specialist Group

Species Survival Commission
IUCN The World Conservation Union
WWF
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Chicago Zoological Society

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IUCN Species Survival Commission: A Global Network for Species Survival

Habitats and their living natural resources are under increasing pressures everywhere from humankind. Species, the basic biotic units, are consequently increasingly threatened with extinction. To protect and conserve biodiversity from species level to ecosystem requires management based on understanding of not just biological sciences, but also knowledge of local cultures, environmental economics, and governmental structures and dynamics.

Among international responses to deal with this complexity is the Species Survival Commission (SSC), a commission of IUCN—The World Conservation Union. Founded in 1949, the SSC network has 4,700 volunteer member scientists, field researchers, governmental officials, and conservation leaders in 155 countries. They provide technical and scientific counsel for biodiversity conservation projects throughout the world, serving as resources to governments, international conventions, and conservation organizations.

SSC works principally through its nearly 100 Specialist Groups, most of which represent particular plant or animal groups. SSC Specialist Groups focus on species either threatened with extinction or of special importance to human welfare. A few groups are disciplinary—veterinary medicine, captive breeding, reintroductions, international trade, and wildlife utilization.

Each taxonomic group is charged to assess the conservation status of the chosen species and their habitats, to develop an Action Plan that specifies conservation priorities, and finally to promote the implementation of the required activities outlined in the Plan. Developing an Action Plan may take several months; full implementation of an action agenda may span decades. Action Plans have been completed by 19 Specialist Groups.

The SSC is the largest of the six IUCN commissions. Founded in 1948, IUCN enrolls sovereign states, governmental agencies, research institutions, and non-governmental organizations to conserve the world's natural heritage. Besides developing general conservation policy, such as Caring for theEarth, and The World Conservation Strategy, IUCN manages conservation projects worldwide, including projects on tropical forests, wetlands, marine ecosystems, the Sahel, and sustainable development.

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SPECIES SURVIVAL COMMISSION

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Foreword

The evolution of the horse family is a familiar story to many biologists acquainted with the fossil record. It is a story of change—the adaptations and extinctions of successive species and genera as environments changed. In recent times these environments, of course, have been changed and dominated by man. Our species has indeed directed adaptation of horses in domestication and at the same time caused the extinction of equids in many places.

This analysis of the status of the wild horses, zebras, and asses clearly shows that if we care not to see these wonderful creatures join their past relatives in extinction then we must substantially enhance our conservation efforts on their behalf. The plight of the few remaining species varies greatly, but we should not be sanguine about the future of any. We know relatively little about the capacity of their social behavior to accommodate to changed environments. Hardy as most of the wild species are, they can and will survive only with control of human pressures.

As large wide-ranging mammals, the living members of the horse family have conservation significance not only for the continuation of a major evolutionary heritage, but also as flagship species for major grassland environments of Africa and Asia. We call upon all governments, agencies, and conservation organizations to mobilize the necessary protection and management regimes to assure the survival of the wild equids and their habitats.

George B. Rabb
Chairman
IUCN Species Survival Commission

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Patrick Duncan
Chairman
IUCN/SSC Equid Specialist Group

Executive Summary

1. The aims of this plan are: to review what is known about the numbers and distribution of the remaining populations (free-living and captive) of wild equids; to identify what needs to be done to conserve the genetic diversity represented by these animals, including building up the free-ranging populations of some species and the captive populations of the most threatened ones, and conserving the species' habitats; and to order priorities so that the most urgent of these issues are dealt with first.

2. Seven species and 20 wild subspecies of equids have been recorded in the 20th century. There are a number of unresolved problems of taxonomy in this apparently simple genus. The genetic differences between the surviving populations are not well understood. As a result there is not an adequate basis to direct conservation efforts where they are needed most urgently. We propose an essential, detailed study of the genus, using the most recent molecular biological methods.

3. Among the wild species, the zebras have the greatest commercial value for their skins, and the meat of all species is eaten by people. Live animals have considerable value for zoos, and for reintroductions in southern Africa. Zebras play an important role in wildlife viewing and hunting by tourists. All the species have cultural values, especially the horses and zebras, which symbolize beauty and freedom in many societies. Many populations play important roles in the conservation of diverse grazing-adapted plant communities in natural and managed ecosystems.

4. The ability of feral donkeys and horses to adapt to harsh conditions is a justification for their preservation, but this needs to be balanced against the damage these animals may cause to native vegetation and wildlife. We propose a genetic survey of feral equid populations worldwide in order to identify objectively those of importance for the conservation of genetic diversity; and a technical manual to disseminate methods of control which are humane, safe, and efficient.

5. The ecological requirements (food, water, shelter, etc.) of equids are similar to those of the abundant grazing ruminants, cattle, wildebeest, and buffalo. Competition appears to play a role in their interactions.

6. Research on the feeding ecology and social behavior of zebras and feral horses has provided a useful, but incomplete basis for conservation actions. Further work is proposed on the roles of food shortage, competition, predation, and disease in the regulation of equid population sizes.

7. There are at least 6,000 Hartmann's mountain zebras in near-natural conditions, virtually all in Namibia. Their exploitation for skins, meat, and live sales is currently closely controlled; nonetheless, their numbers have declined greatly since 1950, and they are Vulnerable. There are c. 600 Cape mountain zebras in South Africa. This subspecies is increasing, but is divided into small, isolated, and enclosed herds: it is Endangered. The conservation of a species with a relatively small, fragmented population is a complex exercise: we recommend four actions, launched by a Population and Habitat Viability Workshop, and coordinated by a Species Management Plan. The key issues will be to build up numbers, especially in the wild, and genetic management of the subspecies' populations.

8. The range of Grevy's zebras has declined in recent years, and their numbers have crashed—there may remain only 5,000 in Kenya and a few in Ethiopia. Though in the past hunting contributed to decline, recently the cause of their decline has been competition with livestock and people for space, food, and water. The species is Endangered: five actions are proposed to maintain, and perhaps increase, numbers inside and outside protected areas.

9. Plains zebras are the only widespread and abundant equid. There are probably over 3/4 million, and they cover a quarter of Africa. Surprisingly, our knowledge of the geographical variations in their abundance and genetic makeup is too fragmentary to provide an adequate basis for determining priorities for action. It is certain that the subspecies of the north and the south are abundant; but those of the center are Indeterminate. Four actions are proposed, aimed at documenting the economic importance, abundance, and genetic diversity of the species, and improving its management.

10. The African wild ass is critically Endangered: there may remain only a few hundred individuals in the Horn of Africa, and the captive population is far too small. The status of this species in the wild will be improved only when peace and stability come to this tragic part of the world. Three actions are proposed to build up the wild and captive populations.

11. Wild asses once occupied the southern half of Asia: today they survive precariously, mostly in small, fragmented populations. Among the hemiones, the onager is critically Endangered, the kulan and Indian wild ass are Endangered, and the North Mongolian dziggetai is Indeterminate (probably extinct); the Gobi dziggetai is Insufficiently known. The Eastern kiang is abundant, but the Western and Southern kiangs are Indeterminate. Five actions are proposed to improve the management of the endangered subspecies and to discover the status of the indeterminate and insufficiently known populations.

12. Przewalski's horses, almost certainly Extinct in the wild, have a large captive population. We strongly endorse the program of the Global Management Plan Working Group to conserve the genetic diversity of the captive population, and to reintroduce this species to the wild.

Introduction

Zebras, asses, and horses are members of the family Equidae, which in the Pliocene and Miocene were the most abundant medium-sized grazing animals of the grasslands and steppes of Asia, Africa, and the Americas.

The extraordinary variety of domestic breeds (horses, donkeys, and their hybrids), and the feral populations which have originated from them, are an important part of the planet's biodiversity. They merit careful conservation, but the urgency of the threats facing the wild populations has meant that the focus of this plan is on the wild species.

Today there remain only seven species belonging to one genus, *Equus*—three zebras and a wild ass in Africa, and two wild asses in Asia. Przewalski's (or Mongolian wild) horses exist in captivity, but are extinct in the wild. Where they are still abundant these equid species play key roles in the functioning of natural grazing systems, and they have significant economic values. Zebras and horses also have strong cultural values—"For the Karamojong (in northern Kenya) the zebra symbolizes one of the four generation sets. In their dances the women paint themselves with black and white stripes, try to walk, jump and even turn their heads in imitation of their beauty and vitality" (Kingdon 1979).

Of the 20 subspecies of wild equids recorded during the 20th century (Table 1), three are considered extinct, and 13 are threatened (for categories see IUCN 1990a). Many occur in protected areas, and there are captive populations of most of the species in zoos, which constitute an important guarantee against extinction.

Traditional approaches to species conservation—the protection of wild populations in reserves and captive groups in zoos—have saved part of the diversity of equids that existed at the beginning of the century. However, their numbers and range are declining alarmingly. Most of the equids face continued losses of their genetic diversity, and some face extinction in the wild. We argue in this plan that the cause is usually not habitat destruction, but competition with people and their domestic stock for space, water, and grazing.

To conserve the surviving equids and their genetic diversity in the long term, new approaches are therefore required. Two which offer promise are:

- to develop economic and political mechanisms which allow local people to benefit from conserving wildlife; and
- to manage the fragmented populations of large mammals, including wild and captive herds, on modern genetic and demographic principles. These are presented in Lande and Barrowclough (1987), Harris and Allendorf (1989), Lande (1992), and summarized in Mace and Lande (1991).

Table 1. Wild equids of the 20th century (Groves 1974, modified after George and Ryder 1986). Przewalski's wild horse is known as *Equus przewalskii* in the conservation literature, and is called so here, though its taxonomically correct Latin name is *E. ferus przewalskii*.

Genus	Subgenus	Species	Subspecies
Equus	*Hippotigris* (Mountain zebras)	*zebra*	*E.z. zebra*, Cape mountain zebra
			E.z. hartmannae, Hartmann's mountain zebra
	Dolichohippus (Grevy's zebras)	*grevyi*	*E. grevyi*, Grevy's zebra
	Quagga (Plains zebras)	*burchelli*	*E.b. boehmi*, Grant's zebra
			E.b. crawshayi, Crawshay's zebra
			E.b. zambeziensis, Upper Zambezi zebra
			E.b. chapmani, Chapman's zebra
			E.b. antiquorum, Damara zebra
			E.b. burchelli, Burchell's zebra (Extinct 1930)
	Asinus (African wild asses)	*africanus*	*E. africanus*, African wild ass
			Domestic donkeys
	Hemionus (Asian wild asses)	*hemionus*	*E.h. hemionus*, North Mongolian dzigettai
			E.h. luteus, Gobi dzigettai
			E.h. kulan, Kulan
			E.h. onager, Onager
			E.h. khur, Indian wild ass
			E.h. hemippus, Syrian wild ass (Extinct 1927)
		kiang	*E.k. kiang*, Western kiang
			E.k. holdereri, Eastern kiang
			E.k. polyodon, Southern kiang
	Equus (Horses)	*przewalskii*	*E. przewalskii*, Przewalski's wild horse (Extinct? 1960)
		ferus	Domestic horses

1. The Nature and Value of Zebras, Asses, and Horses

Patrick Duncan, Oliver Ryder, Cheryl Asa, and Claudia Feh

The oldest equid ancestor, "Eohippus" (*Hyracotherium*), is one of the best-known fossils, and the evolutionary history of the equids has been documented in great detail. From their Eocene origins 55 million years ago, through the browsing *Miohippus* in the Oligocene, the family saw the Pliocene radiation of grazing equids, from *Merychippus* in the Miocene to *Equus* in the Pleistocene, about 1.5 million years ago (Fig. 1). This is one of the best known examples of evolution, and has become a classic in the study of evolutionary pattern and process (Simpson 1951).

The Genetic Diversity of Equid Species and Subspecies

The development of effective priorities for the conservation of the genetic diversity in equids depends on a knowledge of the genetic differences between the surviving populations. Modern techniques of molecular biological methods (e.g. DNA cleavage maps) allow genetic distances between populations to be measured directly: unfortunately these studies do not yet cover all the *Equus* populations (George and Ryder 1986). Therefore, conservationists have traditionally based their studies on the science of taxonomy: the conservation of species has a higher priority than subspecies, between which there are generally fewer genetic differences.

Although the early evolution of equids is well understood, the number of living equid taxa is a matter of controversy. "*Equus*...has developed many distinct forms. The tangled threads of this fabric have not been fully unraveled." Simpson's evaluation in 1951 is still true (George and Ryder 1986). We therefore have no firm basis for deciding which populations are in most urgent need of attention: a project which will provide the basis for a better evaluation of the genetic diversity of the genus is proposed on page 27. It is of great urgency, and should not be considered as an academic exercise.

In this section we provide a "consensus" classification of these populations as the best available basis for this Action Plan. The aim is to conserve the genetic diversity present in equids: we have therefore tended to "split" rather than to "lump" where there is controversy in the specialist literature.

There are qualitative differences between some species in morphological characters such as coat color and skeletal anatomy, but not between all. Fortunately, the Equidae are remarkable for their rapid rate of chromosomal evolution (Ryder et al. 1978). Chromosomal status is a good indicator of gene flow and the evolutionary divergence of populations in that when populations possess different numbers of chromosomes then they are likely to be reproductively isolated.

There is broad agreement between the available information on the equids' chromosomes, morphology, and genetics. A "consensus" classification is presented in Table 1. There is now no doubt that: equids fall into six groups, subgenera; and there are two species of Asian wild asses—hemiones and kiangs.

At the subspecies level for zebras and asses, it is possible that the different sub-populations, which are easy to distinguish as they are now, are in fact remnants of large, continuously varying populations (clines; Groves 1986). Nonetheless, we accept the subspecies in Table 1, including kulan and onager, even though their mt-DNA seems identical, because there are consistent morphological differences between them (Groves and Mazak 1967). There are also important differences in reproductive biology: kulans generally breed every year, onagers do not (see Pohle 1972). Another difficult species is the Plains zebra, in which a number of different subspecies has been recognized, but they have not been thoroughly surveyed (see pages 13-14). In this plan we consider five living and one extinct subspecies (Burchell's zebra).

Domestic asses are descended from one or more of the subspecies of African wild asses, and horses from one or more of the close relatives of Przewalski's horse which were abundant in Eurasia in Neolithic times (*E. ferus*, Groves 1986).

Feral Horses and Donkeys

Feral horses and donkeys (or burros) exist on all the continents except Antarctica, and on many islands. They thrive in grasslands, and are often perceived as competitors of domestic stock. In the United States in 1980 there were 45,000 horses and 12,000 burros (BLM 1982), in Australia in 1976 there were probably over 200,000 feral horses and over 100,000 feral donkeys (McKnight 1976).

In addition to grasslands, feral equids occupy a wide range of habitats, including desert (e.g. Australia and western U.S.), forest (western Canada), salt marsh (U.S. Atlantic barrier islands), and tundra (eastern Russia). There is no reason to believe the animals, particularly horses, prefer these environments; however, feral animals are tolerated in these marginal habitats precisely because these habitats are of little value to people and their livestock. The presence of these animals in some areas causes serious clashes of

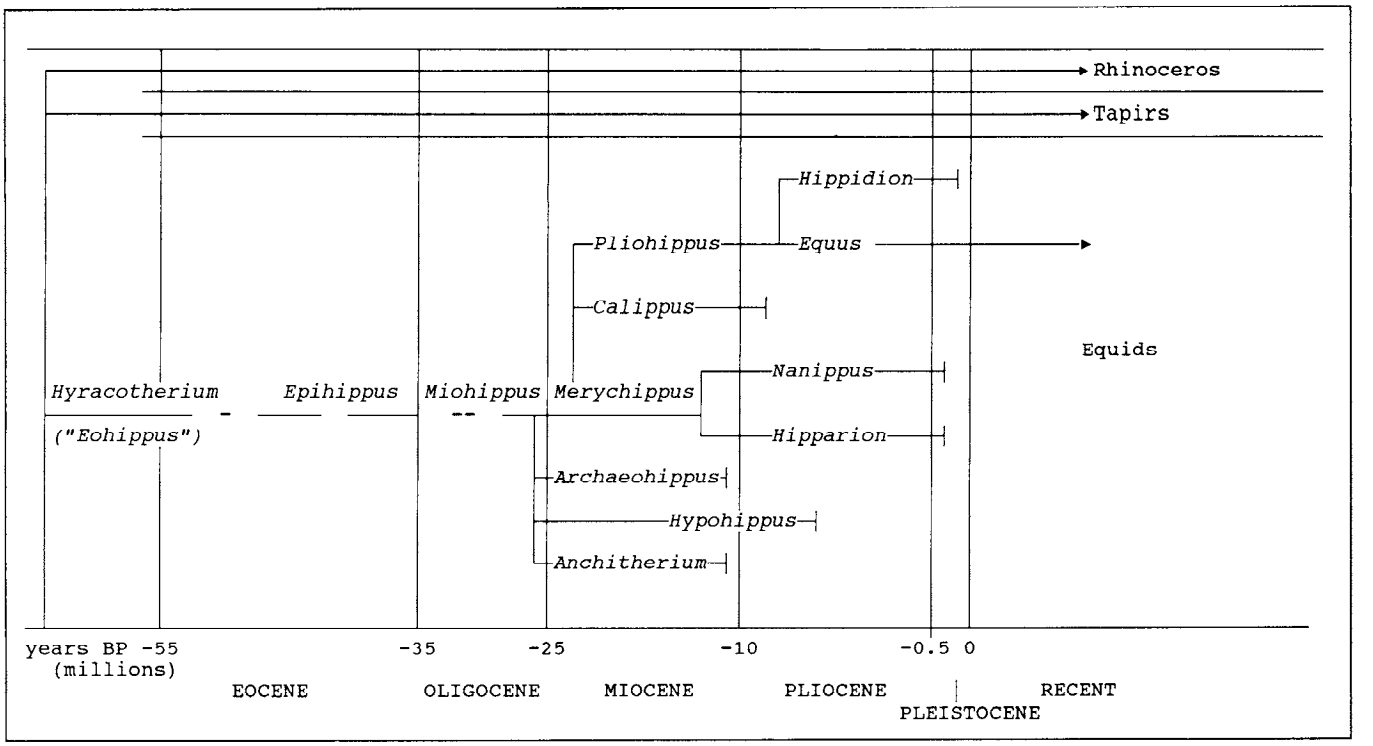


Figure 1. The lineages of the horse family (after Simpson 1951, Kingdon 1979).

interest, but the complex issues involved have not yet been dealt with in adequate depth (but see Munton et al. 1984, Munton 1984).

The animals' ability to adapt to harsh conditions is a justification for their preservation. Though feral horses are not known to possess genetic features (alleles) not found in domestic individuals, the selective pressures they have endured in the wild are likely to be shaping them genetically, producing hardier stock which may prove a useful genetic resource (Mason 1979; FAO 1980). A survey of the genetics of feral horse populations worldwide is urgently needed in order to identify objectively those of importance for the conservation of genetic diversity. Concern about effects of inbreeding resulting from the relative isolation of many herds appears to be unfounded (Bowling and Touchberry 1988). Feral horses preserve ancestral behavioral mechanisms of inbreeding avoidance (Berger 1986). Another important argument for the conservation of feral equid populations is their cultural value (see page 3).

Unfortunately, many of the populations live outside the ancestral range of the genus *Equus*, or in ecosystems where there are no predators, and some have increased to a point where they are regulated by food shortages. This can cause three major types of problem:

- habitat destruction and competition with native wildlife,
- competition with livestock, and
- public disapproval of management.

The abundance of native plants and wildlife has been found to be lower where feral equids are abundant (desert plants, Carothers 1976, Hanley and Bradley 1977; Galapagos tortoises, Fowler de Neira and Roe 1984; kangaroos, Berman and Jarman 1988), especially as densities increase (e.g. Turner 1987, 1988). Though we know little about the ecological mechanisms involved, these problems are important, especially in extreme habitats.

Donkeys produce fertile crosses with African wild asses, and are a threat to their conservation (see page 17). Another valid concern exists regarding the potential interbreeding of feral and Przewalski's horses at sites where the latter are reintroduced.

Numerous studies of foraging by feral horses show that dietary overlap with browsing native wildlife in the northern hemisphere is minimal (moose, Storrar et al. 1977, Salter and Hudson, 1980; pronghorn, McInnis and Vavra 1987; elk, white-tailed deer, and mule deer, Salter and Hudson 1980). However, overlap with domestic cattle (grazers), also non-natives, may be substantial (Duncan 1992), and is usually the main argument for reducing the numbers of the horses, or even eliminating them.

The spectacle of heavily grazed grasslands and starving feral animals is deeply repugnant to most people today, many of whom have been raised in contact with livestock and range managers, whose discipline aims at maintaining abundant grass and fat animals to maximize productivity. Managers of naturally regulated feral herds are perceived as failing in their task of managing the animals correctly.

The possible value of feral populations as genetically adapted herbivores therefore needs to be balanced on a site by site basis against the potentially negative impact of these animals on native vegetation and wildlife (cf. Van Vuren and Hedrick 1989). Further work on these issues is needed urgently.

A wide variety of methods, some of which are inhumane, are currently used to reduce the numbers of feral equids. We recommend the production of a technical manual to disseminate methods which are safe, efficient, and humane (see page 27).

Economic and Cultural Values of Equids

Wild Equids

These animals have a unique set of behavioral, morphological, and physiological characteristics which allow them to exploit coarse grasslands more effectively than other ungulates (page 4). Unfortunately, the economic importance of meat and skin production by equids has not yet been documented in detail.

In China and Mongolia, equids are harvested for their skins and meat, which are prized in some societies. In Africa, zebra hides are valuable, fetching up to U.S. $500 (1990 in Botswana, Vandewalle pers. comm. 1991). The meat of plains zebras, though not particularly sought after, is a product of traditional hunting systems in most of the countries where the animals occur, from Sudan to Mozambique. Mountain zebra meat is prized in Namibia, and is worth 2/3 the price of prime beef.

In countries where trophy hunting is legal, there is a demand for zebras: a permit for a mountain zebra in South Africa costs about U.S. $1,000. In addition, there is a considerable demand for live animals: in 1991, in Namibia and South Africa, mountain zebras were sold live for U.S. $600. Both subspecies of mountain zebras have considerable economic and cultural value in the eyes of landowners, some of whom are prepared to keep them even without economic gain.

Wildlife viewing is an essential part of the economies of some countries (e.g. Kenya, Zimbabwe). The revenue which accrues from tourism is a prime reason for the conservation of ecosystems such as the Serengeti (Tanzania). The "painted quaggas", and the lions that feed on them, are an important attraction to visitors, especially in areas where they provide a mass spectacle, such as the Serengeti or Savuti (Botswana).

Domestic and Feral Horses and Donkeys

From wild asses, people developed donkeys, which serve as beasts of burden all over the world, and have done since the Mesopotamian civilization, 2,500 B.C. Horses have also served people as a swift means of transport in war and in peace for at least 4,000 years. Their importance, cultural as well as military, in the history of the peoples of central Asia, Europe, and North America has been capital. Domestic equids are used for milk production in many central Asian farming systems, and for meat in several others (e.g. France).

In many cultures horses symbolize freedom and strength. In Mongolian folklore the wild horse is depicted as a noble animal, which would die rather than live in captivity; this may have come from the difficulty of domesticating adults. Horses also display the qualities of strength and vigor (Bokonyi 1974). In Mongolia, Przewalski's horses currently have considerable cultural value, and symbolize the country's freedom. There is a strong political will to reintroduce the wild horse there.

In the past, Mongolian horsemen are said to have valued domestic horse x Przewalski's hybrids for racing, because of their stamina. In the future, new techniques of selection and genetic engineering may greatly increase the potential for this kind of use of wild equid genetic resources to improve domestic stock.

Mustangs in the United States symbolize the freedom of the west, and there is a strong movement to allow them to reoccupy the niche vacated by the wild *Equus* species that became extinct 10,000 years ago (Berger 1986).

Conservation of Near-natural Grazing Systems

The shapes and sizes of plants in communities such as the Serengeti plains are adaptive responses to the grazing pressure exerted by wild ungulates (McNaughton 1984). Conservation of these plant characteristics, which are important components of rangeland stability, is another important benefit of wild ungulate conservation.

Management for the Conservation of Biodiversity in Artificial Ecosystems

The developed parts of the world have seen the extinction of major parts of their biological diversity: most of the large mammal species have disappeared completely from huge areas of western Europe, North America, and Australia. Nature reserves have been set up to stop this process, but the loss of "keystone species" which shape ecosystems (mammoths, bisons, wild horses, etc.) means that many of these reserves require management to succeed in conserving their diverse communities of plants and animals.

Hardy breeds of domestic horses have proved their worth in management exercises of this type (Gordon et al. 1990). Their unique feeding adaptations, their ability to use coarse foods, and their large daily food intake makes them better suited than ruminants for resolving many such problems of ecosystem management. Typically, domestic horses have been used in such projects: in the future these management programs could provide new sites for maintaining captive populations of endangered equids.

Morphology

The early equids were small, browsing ungulates of forest habitats. With the extension of the grasslands in the Miocene, new species evolved which were larger, cursorial grazers (Simpson 1951). Their limbs elongated and toes reduced to the extent that modern forms run on one toe: these changes help them to evade the swift mammalian predators of the plains, such as hyaenas, lions, and wolves.

Equids have also developed high-crowned teeth which better resist the harsh fibrous defenses of the grasses (e.g. lignin, silica). Like other mammals, they are themselves unable to digest the major part of plant tissues, the cellulose. However, like grazing bovids (cattle and their relatives, and the antelopes), equids have large fermentation chambers in their digestive tracts which house symbiotic microorganisms (bacteria, protozoa, etc.) that do digest cellulose. The ungulates are able to digest some of the products of this digestion, and the microorganisms themselves when these die.

Horses, asses, and zebras are so similar in size and shape that it is not possible to classify all skulls into their correct species, let alone subspecies (Eisenmann and Turlot 1978). They measure

120-140 cm at the shoulder, except for the Grevy's zebra which measures up to 160 cm (Groves 1974, Appendix 4). Sexual dimorphism is slight: there is a small difference in weight between the sexes (c.10%), and adult stallions, but not mares, have well-developed canine teeth. All wild equids have short upright manes, and a dark stripe along the back. The body color is dun brown or greyish brown with lighter underparts and extremities for the Asiatic and North African species; only Przewalski's horses have dark legs. Black or brown and white stripes cover much of the bodies of the African zebras.

Feeding and Ranging

Equids and grazing bovids of similar size (wildebeest, buffalo, etc.) use similar food resources (Duncan 1992). It is well known that the ruminant digestive system of grazing bovids is more efficient than the hind-gut fermentation of equids (Axelsson 1941). However, equids are able to live on coarser forage than bovids because they can eat much more per day, and their intake probably does not decline on coarse forage (Duncan et al. 1990). This set of adaptations is unique to equids—they are uniquely effective consumers of coarse plants, more so even than the related rhinos and tapirs, and even elephants, which are also large caecal fermenters (Foose 1982).

In view of the great similarity in the morphology of equid skulls and digestive tracts, it is not surprising that the feeding behavior and digestive abilities of the different species are very similar. All are generalist herbivores, capable of eating the more digestible parts of trees, bushes, and grasses; but the last are always their preferred food resources. Trees and shrubs are eaten in quantities only when the grasses are too sparse or too coarse (e.g. in heavily grazed grasslands, in deserts, or in winter).

Within the grasses, green tissues are preferred to dead, and the availability of green tissues can be an important determinant of the habitats horses use. In wetlands, domestic horses feed up to the belly in water, apparently because it is there that they find the highest densities of green food (Duncan 1983).

Water limits equids' ranges, as they have to drink regularly. Once a day seems to be a minimum during the hot season, at least for lactating zebras and horses (Ginsberg 1989). Asses may be able to go without water for longer periods and may therefore be able to exploit food resources further from watering places.

The sizes of the home ranges of wild equids are principally determined by human land-use patterns. In unfenced pastoral ecosystems, like the Tibetan plateau or Masailand in east Africa, wild equids may have home ranges of thousands of square kilometers. Their migrations take them to the best feeding areas in different seasons. In other areas, especially where high human densities and farming constrain the animals, home ranges may be very small (Duncan 1992, Chapter 5): equids can live and breed in a few square kilometers provided that food, water, and shelter are abundant. Compared with grazing bovids, equid ranging and feeding is characterized by flexibility and adaptability. All the species are generalists, not specialists.

Interactions between Equids and Other Grazers

The browsing equids of the Eocene have been replaced by ruminants (cervids and bovids, Janis et al. in press). Even in the grasslands and savannahs the evolutionarily younger grazing bovids outnumber the equid species in virtually every known community of grazers (e.g. Cumming 1982).

Equids and grazing ruminants may interact facilitatively or competitively. Large grazers such as zebras facilitate the use of medium and tall grasses by smaller species such as gazelles (McNaughton 1979). Zebras may therefore play an important role in maintaining high densities of these species in natural grazing systems. However, the extensive overlap between the diets of equids and sympatric grazing bovids of similar size (wild and domestic) suggests that, when food is limited, competition occurs between them (Duncan 1992, Chapter 9).

It is widely held that the grazing bovids out-competed the grazing equids over evolutionary time, but direct evidence is slim (Sinclair and Norton-Griffiths 1982, Duncan et al. 1990). These animals coexist unless people disturb the equilibrium: in the Serengeti (Tanzania) there are a million wildebeest and 200,000 zebras.

Reproductive and Social Behavior

Male equids are capable of breeding in their second year, but, because of intra-sexual competition, in natural societies rarely do so before four years (Berger 1986, Feh 1990). The timing and rate of breeding in females is closely controlled by their nutritional status. Well-fed females may produce their first foals at two, and later ones at about annual intervals. In feral/free-living horses in the northern hemisphere, births have been reported in the months November-August with a peak in spring (Berger 1986), and there are reports that in autumn/winter reproductive activity of females may cease in domestic horses (seasonal anestrus, van Niekerk and van Heerden 1972). Zebras foal all through the year, and plains zebras have marked peaks in the wet seasons (Grevy's zebras, Ginsberg 1989; plains zebras, Smuts 1976a).

Equids have two types of social systems which are linked to two types of mating systems. In the equids of arid habitats (asses and Grevy's zebras), some males defend territories which confer mating rights over estrous females when these are on their territory. In the other species, dominant males defend and have mating rights over specific females wherever these are. Asses and Grevy's zebras form loose groups, where the only long-term relationships occur between mother and their offspring, until these are aged two years. They may aggregate in groups of more than a hundred individuals (Klingel 1977). Non-territorial bachelors form loose groups (Klingel 1977, Ginsberg 1987). The territories of the breeding males are the largest that have been found in any ungulate. In Grevy's zebras, some territories near waterholes attract mares with young foals for several months (Ginsberg 1987): these mate only with the territorial male. In non-territorial areas, males gather around mares in estrus and

mate promiscuously, none of them having exclusive mating rights. Bonds between adult males may persist outside reproductive periods for several months (Moehlman 1974, Woodward 1979).

The second type of social system described in equids is apparently unique among ungulates: horses, plains zebras, and mountain zebras all form small and permanent family groups (or harems) usually consisting of one male, one to six females (median = 2) and their offspring (Klingel 1982, Berger 1986). Unlike the asses and Grevy's zebras, there are long-term, sometimes lifelong relationships between adult individuals of both sexes. The males of these species defend territory only in very exceptional circumstances. Families with more than one adult stallion have been observed in feral horses (Miller and Denniston 1979, Berger 1986); all-stallion groups occur in all three species.

Offspring of both sexes emigrate from their natal group. This reduces direct inbreeding (mother-son or father-daughter matings), as the length of tenure of female groups by a stallion exceeds the time for young females to reach puberty (Clutton-Brock 1989). Most young horses leave on their own accord and are only rarely expelled by the family stallion. The behavioral mechanism underlying this emigration of females depends on familiarity: young females leave the group they have grown up in, even if the family stallion is not their father (Duncan et al. 1984).

Females generally leave their family groups at puberty, but in horses some may wait until they have foaled. All of them end up by joining another reproductive unit, sometimes after a period of moving from one group to another. Once they are integrated in their new group, they change only rarely. Between the mares of a family, there is a linear dominance hierarchy based on age. The stallion is usually dominant over all family members. Young males first join a stallion group for one or two years before forming their own family at 4-5 years. Most of them try at least once to form a family of their own, but only high-ranking individuals succeed. Lower ranking stallions in family groups may make alliances with other stallions of similar rank, and cooperate to defend a harem against rivals (Feh, 1990). Reproductive success varies widely between males; it is correlated with their own adult rank and with the rank of their mother; but not with either the weight or the size of the stallion (Feh 1990).

Why two such different social systems have evolved in such similar species as equids is not clear. Possibly the distribution and abundance of food in their drier and more unpredictable habitats have favored small groups composed of only mother and offspring in asses and Grevy's zebras. The long-term bonds between males and females in horses and plains zebras may have evolved as a response to predator pressure. Stallions defend their mares and their foals actively. Their main predators are big and hunt in packs (wolves, lions, spotted hyenas), whereas most predators of arid lands are smaller, solitary hunters (leopards, brown hyaenas).

Within species some variations in the stability of interindividual relations and in the defence of territory are found. However, typically the animals do not switch from one social system to another when conditions change, or when they move from deserts to savannahs, unless the ecological conditions are extreme (e.g. Berger 1988). This inflexibility is relatively unusual among ungulates, and must be considered in the planning of reintroduction projects, especially where the harem-forming species are concerned.

Growth, Survival, and the Regulation of Population Sizes

The gestation time of equids, 335-420 days, is 20% longer than that of comparably sized ruminants (Millar 1981). Foals are therefore born at an advanced stage of development: in domestic horses their weight is 9-11% of their mothers' liveweight. As a consequence, when feeding conditions (and the mares' milk production) are good, their growth rates are such that they double their birth weights in a month (Capitain 1974, INRA 1984, Duncan 1992).

The annual survival rate of foals of free-ranging domestic horses can be over 90%, and that of juveniles and adults as high as 98% (e.g. Eberhardt et al. 1982, Duncan 1992). However, survival rates of feral and wild equids are generally lower and can be very low in populations suffering food shortages (e.g. Welsh 1975). The costs of reproduction, due to lactation in females and fighting in males, appear to be the principal causes. The effect of predation on the regulation of equid population densities has not been studied; it is at least sufficient to decrease group sizes, and to bias sex-ratios in favor of females (Smuts 1976b, Berger 1983).

A major problem in the conservation and management of wild equid populations is that virtually nothing is known about the factors that regulate them. In particular, the little information that is available suggests that predation and social factors may be much more important in equid than in grazing bovid populations, where the food supply is known to play a key role (see Duncan 1992, Chapter 9 for a fuller discussion).

Population Sizes for the Conservation of Genetic Diversity

For each of the species we propose actions to prevent extinction, and to conserve the genetic diversity of equids. Since the number and extent of conservation actions is limited by the resources (e.g. space, funds) available, and since large populations consume more resources, a key problem in planning is the choice of goals for the sizes of wild and captive populations.

The theoretical framework we have used is given in Lande and Barrowclough (1987), Harris and Allendorf (1989), Lande (1992), and summarized in Mace and Lande (1991). For captive populations, we recommend a minimum population size (N) of 500 individuals, a studbook, and careful genetic management. Equids have mating systems with relatively little variance in the reproductive success of individual males (cf. Berger 1986); for wild populations we recommend a minimum size of 2,500 individuals.

2. The Status of the Species

Africa

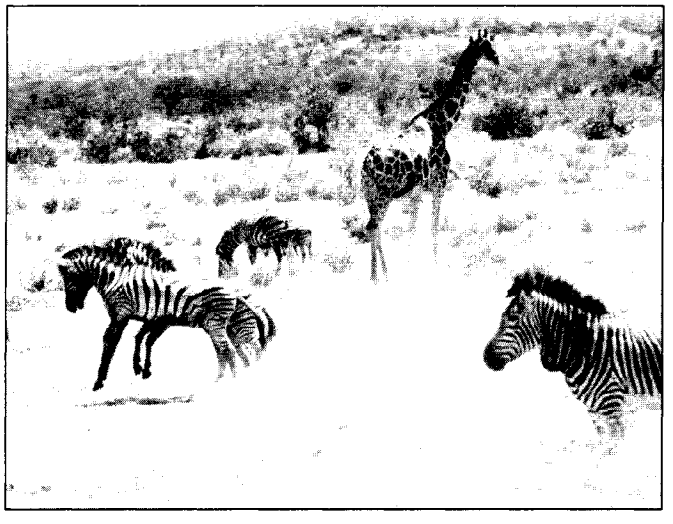
Mountain zebras (*Equus zebra* L.)

Peter Novellie, Peter Lloyd, and Eugene Joubert

Mountain zebras are distinguished from other species by the "grid-iron" pattern formed by the stripes on the rump and the small dewlap on the throat. Two subspecies have been described: Hartmann's mountain zebra (*E.z. hartmannae* Matschie 1898) and Cape mountain zebra (*E.z. zebra* L) on the basis that Hartmann's are a little larger, and in Cape mountain zebra the black stripes on the rump are broader than the white while in Hartmann's some white stripes are broader than the black. These subspecies are generally accepted (Groves 1974, Penzhorn 1988), but we would like to see a thorough analysis of the extent of differences between them, using modern statistical and molecular biological techniques.

The ecology and behavior of the species have been studied in detail (see Penzhorn 1988 for a review of much of the literature). Mountain zebras are found from the edges of true deserts through semi-arid to savannah grasslands. They prefer broken or mountainous country, but also live on plateaus and flats (Novellie et al. 1988; Novellie 1990).

Mountain zebras favor tall to medium height (50 to 200 mm) tufted grasses such as *Themeda triandra* or *Cymbopogon plurinoidis*, and rarely eat browse. The social organization of this species is similar to plains zebras and horses: the males practice mate-defense polygyny and herd harems of an average of 2.4 females (range 1-5) throughout the year. This social system is maintained even in semi-arid habitats, as in the Namib-Naukluft National Park.



Mountain zebras watching two plains zebras fighting (photo by A. Duncan).

Foaling rates are as low as 32 foals/100 females/year in the Mountain Zebra National Park (Penzhorn 1985), but survival rates are high (Joubert 1972, 1974; Penzhorn 1985; Penzhorn and Lloyd 1987) so the populations can nonetheless increase at 10% per year.

Distribution

In historical times the species had a continuous range from about 130 km north of Moamedes in Angola to the eastern Cape Province of South Africa (Fig. 2a). Hartmann's zebras occurred along the mountainous transition zone between the Namib desert and the plateau to the east of it, and the Cape mountain zebra in the mountainous regions of the Cape (Fig. 2b). The limit between the two subspecies was probably the Kamiesberg Highlands (Republic of South Africa, see Smithers 1983), but the zebras from this region had disappeared by 1931 and there is not sufficient material to determine whether they belonged to one of the two subspecies or were intermediate between them. Subspecific variation in this species may have been clinal rather than discontinuous.

Hartmann's mountain zebras occurred in Angola in the Iona National Park in the early 1980s. This was within the war zone, so it is likely that few remain (R. Souter pers. comm. to the World Conservation Monitoring Centre [WCMC] 1986). Though tending to become broken up into isolated sub-populations, Hartmann's zebras are still widespread. They occur from the Angola border to the Ugab River and eastwards to farms in the Outjo district. Further south they are found on and around the Erongo Mountains, and then extensively on the escarpment south of the Swakop River to the Naukluft Mountains and east along the Kuiseb and Gaub Drainages to the Khomas Highland. After a break in their distribution, they occur in the Fish River Canyon and the Huns Mountains near the Orange River. Hartmann's zebras have been reintroduced into various parts of Namibia and the Cape Province, within and outside their historical range.

Natural populations of Cape mountain zebras occur today only in the Mountain Zebra National Park, the Gamka Mountain Nature Reserve and in the Kamanassie Mountains. Populations originating from the Mountain Zebra National Park have been established in various other localities (Fig. 2).

Table 2. Estimated numbers of Hartmann's mountain zebras in different conservation areas and on private land in 1989.

Area	Numbers	Year of Census	Ref.
Angola			
Iona NP	200	1970s	(a)
Rest of country	?		
Northern Namibia			
Kaokoland (5,800 km²)	430±146	1990	(b)
Etosha NP* (22,000 km²)	1,500	1991	(c)
Damaraland communal areas	1,900	1990	(b)
Erongo Mts. and farms	250	1992	(d)
Total	**4,000**		
Central Namibia			
Namib-Naukluft NP*, eastern part (1,300 km²)	2,200	1988	(e)
Farms around NP	800	1991	(d)
S von Bach GR* (43 km²)	136	1989	(d)
Daan Viljoen NR* (40 km²)	34	1989	(d)
Total	**3,150**		
Southern Namibia			
Fish River Canyon R* (4611 km²)	250	1991	(d)
South Africa			
Goegap NR* (150 km²)	24	1990	(f)
Ciskei Tribal RA (3 km²)	45	1990	(f)
Farms in Cape	**300	1990	(f)
Total	**350**		

*Protected areas
**Numbers difficult to determine precisely

(a) Horsten 1982
(b) Carter 1990
(c) D. Gilchrist (pers. comm. 3/1992)
(d) E. Joubert pers. recs.
(e) Boyer 1988
(f) Records of the Chief Directorate of Nature and Environmental Conservation (CDNEC) of the Cape Province.

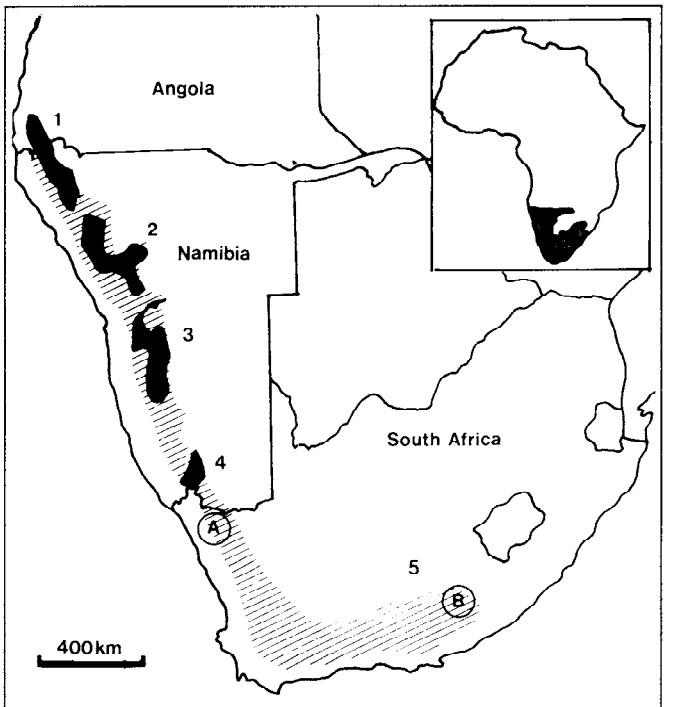
Status, trends, and conservation measures

Hartmann's mountain zebras

Animals on private land are monitored, using ground observations, as part of the permit system by staff of the Ministry of Wildlife, Conservation, and Tourism. In the communal areas there have been periodic counts, but there is no regular monitoring; and in the protected areas aerial total counts were conducted at two-year intervals until 1988. Total numbers in Namibia are about 7,000 (Table 2). Of these, about 4,000 are in protected areas, the remainder being either on private land (c. 1,000) or in Damaraland or Kaokoland (Table 2). Among these areas, which are very large and effectively protected, the Naukluft section of the Namib-Naukluft National Park was acquired by the government specifically to protect the Hartmann's zebra.

In the early 1950s, over 50,000 Hartmann's mountain zebras occurred in Namibia (Joubert 1973). On the basis of questionnaire surveys (Ministry of Wildlife, Conservation, and Tourism), there were an estimated 16,400 Hartmann's zebras on private land in 1972 and 13,300 in 1982. There has therefore been a serious decline in the numbers of Hartmann's zebras in Namibia. Droughts combined with fencing have caused die-offs in the past. In the 1982-1983 drought, heavy mortality occurred among the Hartmann's zebra. Those in the Namib-Naukluft National Park were prevented from migrating by fencing; many others migrated from the Kaokoveld to the Etosha National Park where they were captured and sent to other areas, including the Canyon Colorado Equid Sanctuary, United States, which received seventeen for captive breeding. However, the principal proximate cause of this long-term decline has probably been hunting, legal and illegal, outside the protected areas.

In the conservation areas run by the Namibian Directorate of Wildlife, Conservation, and Research, the status of this subspecies is sound at present. Numbers have probably increased since the drought of 1980-1982. In the Etosha National Park they are controlled to prevent overgrazing. The management plan allows the removal of live zebras in excess of 800: these are sold to private landowners at subsidized prices. In the Namib-Naukluft National Park the abundant zebra appear to compete with other ungulates and to cause overgrazing. Since it proved impossible to



1. Angola and Kaokoland
2. Northern Namibia (Kaokoland, Damaraland, Outjo district, Erongo Mountains, and farms in these regions)
3. Central Namibia (Swakop River, Khomas Highland, Naukluft Mountains, Namib Desert, and farms in these regions)
4. Fish River Canyon and Huns Mountains
5. South Africa (Cape Province)—in addition to the two sites marked there is a large number of small herds. A=Goegap Nature Reserve; B=Ciskei Resource Area

Figure 2a. The distribution of mountain zebras in historical times (hatched) and the present distribution of Hartmann's zebras (shaded).

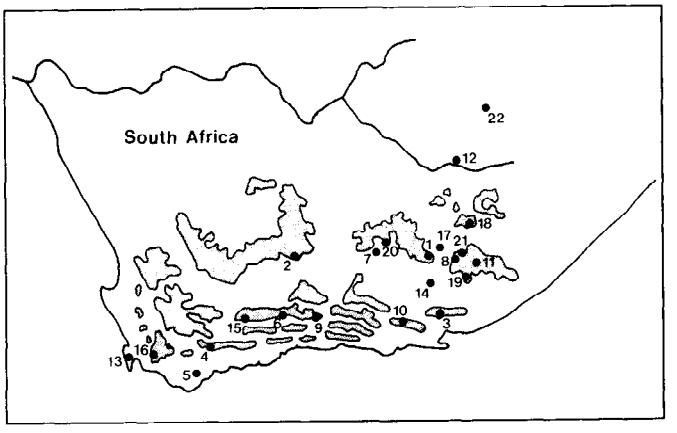


Figure 2b. Distribution of Cape mountain zebras. The mountain ranges are shaded, and the sites where they occur are numbered as in Table 3.

catch them in this very difficult terrain, shooting has been used as a last resort in an attempt to control their numbers. About 1% of the population has been shot annually since 1980.

The decline in the numbers of this subspecies in Namibia outside the proclaimed conservation areas is disconcerting. It is due to pressure on the land from farmers, and will be difficult to reverse. This underlines the importance of the populations that are protected in proclaimed conservation areas. Fortunately these have provided a reliable source of individuals for reintroduction into other areas, and given adequate protection, can be expected to continue to do so. The demand for Hartmann's zebras, both for the sale of live animals and for trophy hunting, is fairly high, and this should help to ensure their survival on at least some private properties in addition to those in protected areas.

In spite of the serious decline in numbers since 1950, this subspecies is not immediately threatened with extinction under present conditions as there are 4,000 in effectively protected areas. However because these numbers are rather low, and because droughts can cause heavy mortality, the protected populations need to be built up.

The large Fish River Canyon Reserve currently has only a very small number, c. 250, probably because of shooting in the past. The Reserve is now properly protected and has the potential to develop a large population of mountain zebras.

A new (multiple-use) protected area of 5,800 km² in Kaokoland is under negotiation between the government and local authorities. The wildlife was heavily shot by security forces in the 1980s: appropriate management could allow a great increase in numbers of mountain zebras here, too.

In the Cape Province of South Africa there are approximately 350 mountain zebras on numerous private properties, and in a Tribal Resource Area in the Ciskei (Table 2). These populations are outside the historical range of the subspecies, and within the range of the Cape subspecies, which is likely to lead to hybridization between them. The Chief Directorate of Nature and Environmental Conservation (CDNEC) of the Cape Province has therefore introduced regulations aimed at preventing the translocation of either subspecies into the historical range of the other. Landowners who have introduced Hartmann's zebras outside their historical range are being encouraged to exchange their animals for Cape mountain zebras at no cost to themselves.

In Angola, mountain zebras are protected from hunting, trade and export by the statutory hunting regulations of 1975. Cape mountain zebras are on Appendix I and Hartmann's on Appendix II of CITES (the Convention on International Trade in Endangered Species). Hartmann's were listed in 1933 as "specially protected game", and a permit system has operated since 1933 (Joubert 1973). In recent years this has been strictly controlled, and the annual legal take in 1983-1988 was 500-1,500 animals, mostly skins with some tens of trophies and a few live animals

Table 3. Numbers and status (i=increasing; d=decreasing; s=stable; u=uncertain) of Cape mountain zebras in different conservation areas and on private land in May 1990.

Area	Numbers	Status	Census Year	Size (km²)
National Parks				
1. Mountain Zebra Park	178	i	1990	65
2. Karoo National Park	76	i	1990	327
3. Zuurberg National Park	16	u	1990	171
4. Bontebok National Park	9	u	1990	28
Total	**279**			
Chief Directorate of Nature and Environmental Conservation Nature Reserves				
5. De Hoop	30	i	1990	180
6. Gamka Mountain	16	u	1989	94
7. Karoo	60	i	1989	143
8. Commandodrift	16	i	1989	60
9. Kamanassie Mountain	19	i	1988	245
10. Kouga/Baviaanskloof	12	u	1990	800
Total	**153**			
Ciskei				
11. Tsolwana Game Ranch	49	i	1990	110
Department of Nature Conservation of the Orange Free State				
12. Verwoerd Dam Reserve	25	i	1990	60
Zoos				
22. Bloemfontein Zoo	2	u	1990	—
Local Authority Reserves				
13. Cape Point Nature Reserve	6	u	1990	78
14. Bosberg Nature Reserve	3	d	1990	2
15. Ladismith Nature Reserve	1	d	1990	10
Total	**10**			
Private Landowners				
16. Somchem	11	i	1990	9
17. Mrs. P. Cawood	16	i	1990	10
18. Mr. R. Halse	7	d	1990	30
19. Mr. E. Moorcroft	5	d	1990	4
20. Mr. W. Murray	3	d	1990	5
21. Mr. C. Scott	3	d	1990	6
Total	**45**			

(CITES 1991). This level of exploitation may appear high in view of the numbers in Table 2. However these are certainly underestimates, and the experience of field personnel is that the populations are not declining. Hartmann's zebras have been successfully reintroduced into many privately and communally owned lands in Namibia. However the CITES restrictions are perceived as a brake on the commercialization of the skins. It is our opinion that farmers would tolerate more zebra on their land if it were easier to sell them: consideration should be given to easing international restrictions on their export.

Cape mountain zebras

Individual records for the De Hoop Nature Reserve population are kept by P. Lloyd. Records for the Mountain Zebra Park population, extending from the early 1970s to 1988, and for numbers on private land have been made by staff of the National Parks Board, and are kept by P. Novellie. Owing to a shortage of personnel the collection of detailed studbook records for the Mountain Zebra Park had to be abandoned in 1989.

Once widespread in the mountains of the Cape Province, this subspecies, like all the large and medium-sized ungulates, has been drastically reduced in range and abundance since the 17th century, principally by shooting. The Cape mountain zebra was close to extinction in the late 1940s when not more than 100 individuals survived; today there are nearly 600 (Table 3). The conservation of these animals is a useful case-study, providing valuable lessons for the steps which need be taken to conserve other equids such as African wild asses, Grevy's zebras, and other ungulates.

The key has been the successful protection of the main population in the Mountain Zebra National Park. From a low of 11 in 1950 this population rose to around 200 in 1981, when it was decided that it was safe to begin removals for reintroduction. Since then some 200 zebras have been removed and transported elsewhere. Effective techniques of capture, handling, transportation, and release have been developed by the National Parks Board.

The first sites selected were protected areas (De Hoop Nature Reserve, the Karoo National Park, and the Karoo Nature Reserve), and at present Cape mountain zebras occur in four National Parks, in six provincial nature reserves, and in three reserves run by local authorities (municipalities and regional services councils). Thus, over 500 zebras, more than 90% of the world population, are protected in proclaimed conservation areas. These populations are secure at the moment, and most are increasing (Table 3). In addition, six private landowners have small groups on their land.

The mountainous areas of the Cape Province of South Africa have not, in general, been subjected to extensive man-induced changes, and there are a considerable number of conservation areas with habitat that is suitable for Cape mountain zebras. The detailed information which has been acquired by scientific research on the habitat and food requirements of the Cape mountain zebras (see above), and their behavior (Penzhorn and Novellie 1991) has been a key to the successful choice of appropriate areas for re-establishing the subspecies. The fact that no two zebras have exactly the same stripe pattern means that individuals can be identified by means of photographs. This has allowed records to be kept of the breeding of individual animals. These breeding records are of great value and should be maintained—not only do they provide detailed information on reproductive performance (Penzhorn 1985), but they allow modern techniques of genetic management to be applied to this fragmented population.

There have been no large-scale die-offs in any of the populations. In view of the fact that Cape mountain zebras are well-represented in many different proclaimed conservation areas the current conservation status of this subspecies can be regarded as being good. However, the total population is very small and restricted to one country.

Threats

Although a proximate reason for the decline in numbers of both subspecies has been shooting, the ultimate cause is that zebras compete with livestock for food and water. They have lost access to considerable areas of habitat because of fencing, which cuts off access to preferred grazing and waterholes. In attempts to reach these, zebras break down fences, and are considered pests by many farmers. Much former grazing land has now been cultivated. As a consequence of such conflict Hartmann's zebras were systematically hunted throughout much of their range and were described as having been, since the 1950s, the most ruthlessly persecuted large mammal in southern Africa (Joubert 1973). Animals outside protected areas will always be subject to this threat.

Drought has always been a threat to this species in its semi-arid habitat. In the 1960s and 1970s, water extraction schemes in the Namib Desert, particularly from the Kuiseb River, acutely threatened the future of the Hartmann's zebras in the area. Tapping of underground water supplies likely would have affected the zebras, the most water-dependent species occurring in the Namib. Restrictions on the utilization of underground water have subsequently been introduced and the situation is being monitored by the Directorate of Wildlife, Conservation, and Research.

The introduction of Hartmann's mountain zebras into the range of the Cape mountain zebra means that there is a danger of mixing the two subspecies. Such hybridization would lead to a loss of genetic diversity.

The relatively small numbers which remain in the wild mean that the loss of a single population (e.g. Hartmann's mountain zebra in the Namib-Naukluft Park, 2,200 zebras, Table 2; Cape mountain zebra, Mountain Zebra Park, 178 zebras, Table 3) would reduce the world populations of these subspecies by about a third. IUCN (1990a) classifies Hartmann's as Vulnerable, and the Cape mountain zebra as Endangered.

Captive herds

Hartmann's mountain zebras are held in 41 European and American zoos: in 1991 there were 107 males and 169 females. Their studbook is maintained by the Marwell Zoological Park. There are only two Cape mountain zebras in a zoo (Bloemfontein, South Africa).

The actions proposed for the conservation of this species are given on page 25.

Grevy's Zebras (*Equus grevyi* Oustalet)

Mary Rowen and Joshua Ginsberg

The Grevy's zebra is the largest of the wild equids: adult males weigh up to 450 kg, adult females ~10% less. They inhabit semi-arid scrub/grassland and are roughage feeders, principally grazers, though browse may comprise up to 30% of their diet. They are able to live in deserts if permanent water is available: adults can survive 2-5 days without water but only 1-2 days when lactating. Home ranges for both sexes may be up to 10,000 km² (Ginsberg 1987, 1989, and unpubl. data).

Grevy's zebra (photo by M. Rowen).

Males are physiologically capable of breeding at 2.5 years (King 1965; Bennett & Hayward 1989), but probably do not do so in the wild until much later because of intrasexual competition. Breeding stallions, which have high androgen levels, maintain territories of up to 12 km² near water. A male's reproductive success is related to both the quality of grass on his territory and to the ease of access to water. Lactating females stay near water sources, generally forming mother-infant assemblages, in groups varying in cohesiveness and stability. Females move in and out of male territories in varying but predictable patterns according to reproductive status (Klingel 1974, Rubenstein 1986, Ginsberg 1989, Chaudhuri and Ginsberg 1990, Ginsberg and Rubenstein 1990, Rowen 1992).

In captivity females can breed at 2.5 years, with their first foal at 3.6 years. In the wild age at first reproduction is probably somewhat later. Mares come into estrus at 4-15 days postpartum; if not impregnated, she will continue to cycle every 27-28 days. Gestation in captivity is 387-428 days (mean=409 Iaderosa 1983; Ginsberg 1987, Bennett and Hayward 1989, MR pers. obs.).

Births occur at any time of year. Anestrus induced by poor body condition during long dry seasons and drought may result in peak mating and conception after conditions improve (Ginsberg 1988, 1989). Foals are nursed for 6-13 months, rarely drinking water before they are three months old. During the first three months foals may either be left in groups while the mares go to water, or they may follow their mothers to water without drinking. The impact of predation on this species' demography is not known, but cheetahs take foals, and both crocodiles and lions can take subadults and adults (Klingel 1974, Ginsberg 1987, Becker and Ginsberg 1990, Rowen 1992).

These adaptations to desert life allow Grevy's to survive droughts better than plains zebras (Ginsberg 1987).

Distribution and numbers

Historically the species was found in the Awash Valley, the Ogaden region, and northeast of Lake Turkana (Lake Rudolf) in Ethiopia, south into Kenya east of the Rift Valley and Lake Turkana, north of Mount Kenya and the Tana River, and east into western Somalia (Fig. 3).

Ethiopia

The species used to occur to the northeast of Lake Turkana, in the Ogaden and in the Awash Valley (Fig. 3). It has disappeared from most of this area and survives in and around a small number of protected areas. The Awash population is of particular interest because it has probably been isolated naturally from the rest of the species for a long time (Yalden et al. 1986). Most of the surviving Grevy's are to the northeast of Lake Turkana, Fig. 3 (Ato Tadesse Gebre-Michael and Ato Fekadu Kassaye in litt. 1/90, Hillman in litt. 1/92, P. Ole Syvertsen in litt. 2/92).

- Alledeghi plains—in 1992 about 175 animals still survive northeast of the Awash National Park, but without the benefit of active conservation protection; extirpated in the Park.
- Yabello Sanctuary and surrounding areas, including Sarite Plain—recorded in the Sanctuary in 1986-1989. Road counts vary greatly, with a high of 150 animals. In 1990 recorded only in Sarite Plain, tens or hundreds.
- Lake Chew Bahar (Stephanie)—Abundant (c. 1,500) in the late 1970s, present status unknown.

Total numbers were about 1,500 in 1980 (Klingel 1980, Ato Teshome Ashine in litt. 10/86). There are no estimates for 1990, but they are probably decreasing.

Somalia

The last sightings of Grevy's were in 1973, and the species is considered extinct in this country. It was probably extirpated by hunting for trophies and food (Klingel 1980; Moehlman pers. comm.).

Kenya

Though greatly reduced in numbers, Grevy's zebra occur throughout much of its former range except in the driest areas north of the Chalbi desert and northeastern Wajir district. Densities in the eastern portions of the country are very low, and the numbers of Grevy's have decreased substantially in recent times: Klingel (in litt. 1980) reported observing up to a 90% decline in some areas since the 1960s. Over the past 14 years the Kenyan Department of Resource Surveys and Remote Sensing (formerly the Kenyan Rangeland Ecological Monitoring Unit, KREMU) has carried out a series of aerial counts throughout Kenya. The 1977 survey estimated 13,718 Grevy's zebra (Dirschl and Wetmore, 1978). In 1988, a more intensive aerial survey gave an estimate of 4,276

Grevy's zebra in Kenya (KREMU 1989). This is a decline of 70% in just 11 years.

In the 1980s, Grevy's numbers increased only in the Laikipia district of Kenya, a ranching area bordering Mount Kenya in the southernmost part of the species' historical range. Systematic monitoring of this part of the population needs to be carried out to determine the numbers of individuals involved, and the importance of the ranches in the animals' range.

Grevy's zebras occur in several protected areas within Kenya: Marsabit National Park—low density; Sibiloi National Park—moderate density; Losai National Reserve—low density; and Buffalo Springs, Samburu, and Shaba National Reserves—high density.

During the last 10 years, a series of studies have been conducted in the Buffalo Springs, Samburu, and Shaba National Reserves. Use of known individuals over this time indicates that a relatively stable population of 1,500 Grevy's zebras use these reserves, which are an important source of permanent water and are a key birthing and breeding area for the species (Ginsberg 1987, 1989; Rowen 1992).

Two attempts have been made to introduce the Grevy's zebra to Tsavo West, an area outside the species' historical range. The first introduction, in the mid-1960s, was of a few individuals and failed. A second, controversial introduction of approximately 50 individuals was done in the late 1970s (Reader 1979, Klingel 1980). Since then there have been occasional sightings of zebras which may be either Grevy's or hybrids with plains zebras (pers. comms. to JRG), but there is certainly no evidence that a viable population has managed to establish itself. Assessment of these introductions could be achieved cheaply by the production of a poster explaining the difference between plains zebras and Grevy's zebras and requesting tourists and park staff to report sightings. As Tsavo is well outside the historical and geological range of Grevy's zebra, we feel no further effort should be made at introductions.

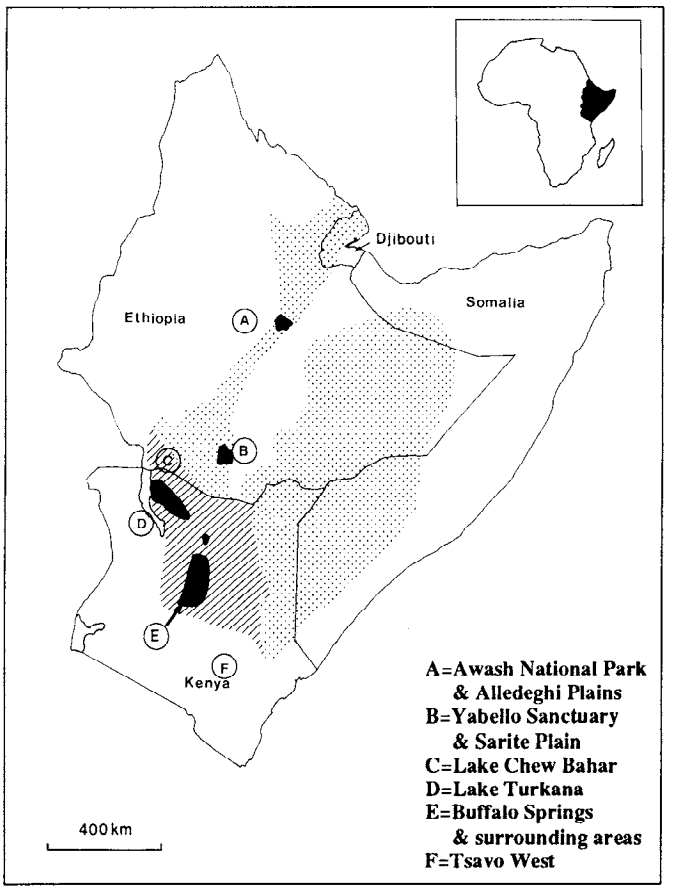


Figure 3. Distribution of Grevy's zebra in historical times (stippled, from Kingdon 1979, Yalden et al. 1986) and at present (hatched=rare, shaded=more abundant, after KREMU 1989, Ato Tadesse G. Michael and Ato Fekadu Kassaye in litt.).

Conservation measures

Grevy's zebras are on Appendix I of CITES; they are legally protected in Ethiopia, while in Kenya they benefit from the current hunting ban. The Buffalo Springs and associated reserves protect the essential core of the remaining population: these reserves are therefore essential to the survival of the species. Grevy's zebras also occur in three proclaimed reserves in Ethiopia. Though law enforcement is currently difficult, these have the potential to make an important contribution to the conservation of the species.

Threats

Though aerial counting of rare animals often provides imprecise estimates, the decline in numbers of Grevy's zebras is so serious that extinction within 50 years is probable if the trend continues at this rate: it is certainly Endangered (IUCN 1990a).

Hunting

Until the mid-1970s there was a large international market for Grevy's skins, which have fine, intricate line-patterns and were therefore highly sought after for rugs, coats, and evening bags. Since listing on CITES Appendix I, the market for skins has disappeared and poaching for skins is not thought to be a problem at present. Grevy's are occasionally caught in non-specific snares and shot for food (MR pers. obs.).

Loss of habitat

Loss of habitat is occurring due to competition with increasing numbers of domestic livestock throughout the areas where Grevy's zebra occur. KREMU (1989) indicates that the decline in cattle numbers since 1977 (-18%), has been outweighed by a large increase in sheep and goats (+53%). Pastoralists are becoming more sedentary around permanent and seasonal water sources, leading to the exclusion of wildlife. In these countries, protected areas are not always a guarantee of secure refuge: much of Losai National Reserve is overrun by domestic livestock thereby reducing wildlife use of the area.

Upstream irrigation projects for agriculture and livestock have limited water flow to low-lying land within the arid and semi-arid regions. For example, before the construction of upstream irrigation projects (1982), the Isiolo and Ngara Mara rivers flowed in Buffalo Springs National Reserve 3-6 months of the year. During the drought of 1983-1984, these rivers were completely dry. Following heavy rains in late 1984, the rivers ran for three days, then dried up. Only with consistent and high levels of rainfall from 1988-1990 did these rivers flow at their pre-1982 levels.

The many water development projects incorporating windmills and hand-drawn wells draw on small natural water sources, and exacerbate the problem. However, perhaps the most serious threat comes from the town of Archer's Post, Samburu District. This town draws all its water from the Buffalo Springs in Buffalo Springs National Reserve in Isiolo District. This situation is potentially explosive, as assured clean water may lead to growth of the town, and thus to greater demands for water. In the long run, it is critical that a limit be set on the amount of water which can be drawn from Buffalo Springs, and that Archer's Post draw water from springs outside the reserves.

Drought

The effects of drought, or extended dry seasons, may be beneficial rather than detrimental to Grevy's zebras. The drought of 1983-1984 resulted in an increased adult mortality of 5-8%; first-year mortality was 60%, while in normal years it is as low as 10% (Ginsberg, 1988). Drought mortality of domestic livestock, however, was far higher (30-75% of adults, 70-100% of juveniles, Sperling pers. comm.). Hence, by reducing livestock numbers, a drought may result in reduced competition following the onset of rains.

Tourism

Tourism, if managed properly, could help in the conservation of Grevy's zebras, but at present, the negative effects of tourism threaten critical habitat. Traffic control and traffic volume are of near-equal concern: off-road driving is a key issue for the welfare of both Grevy's zebra and other species living in protected areas, as it causes obvious erosion and damage to the vegetation. Such driving can also interfere with behaviors such as foaling and drinking. The extent of damage in the Buffalo Springs, Samburu, and Shaba Reserves in the last decade has not been quantified, but is obvious in many of the most frequently visited areas.

The Buffalo Springs group of reserves is the most heavily used part of the species' range, and appears to be critical for breeding and rearing foals. Further tourist development in the area could significantly reduce access to water by Grevy's, and increase their mortality rate in dry periods. Of extreme importance is the eastern part of the Buffalo Springs Reserve, including the Buffalo Springs themselves. Long-term studies (1982-1990) indicate that females return to this area year after year to breed, sometimes to within two kilometers of their birth site. Such natal and breeding philopatry suggests that preventing, or even limiting, access to this critical watering area could result in strongly reduced recruitment into the population (Becker and Ginsberg 1990, Rowen 1992).

Grevy's zebras undoubtedly contribute to the wildlife experience of visitors to these reserves, but few tourists know that the species is endemic to eastern Africa, and endangered. An awareness campaign on these issues could promote both knowledge of the species and tourism in Kenya as the place to see Grevy's zebras. However, with such a campaign must come management for sustainable tourism.

Harvesting

The consumptive use of wildlife can provide economic benefits and protein for people. However, for a species with a population size as small as that of Grevy's zebra there is a real danger of hunting to extinction. Current plans formulated by the Kenya Wildlife Service (KWS) include hunting by landowners on their own land, but not trophy hunting by foreign tourists (KWS 1990). Provided that this harvesting does not cover Grevy's zebras on communally-owned land, it should not threaten the survival of the species in the wild. We do not recommend opening up a market for Grevy's zebra skins, even if these skins are harvested on private land.

Though aerial counting of rare animals often provides imprecise estimates, the decline in numbers of Grevy's zebras is so serious that extinction within 50 years is probable if the trend continues at this rate: it is certainly Endangered (IUCN 1990).

Captive herds

As of December 31, 1988 a total of 543 Grevy's zebras (216 males, 327 females) were living in 109 institutions (Hayward 1989). This population has a large number of founders, 166 wild-caught animals, and can therefore be managed so as to avoid severe inbreeding. The North American population is managed by a Species Survival Plan, the objective of which is to maintain a genetically diverse captive population of 200-250 animals.

Grevy's zebras breed well in captivity, and births have consistently outnumbered deaths. The captive population has enough founders and is large enough to conserve this species' genetic diversity for some time should it become extinct in the wild; it could already provide animals for reintroduction.

The actions proposed for the conservation of Grevy's zebra are given on page 24.

Plains Zebras (*Equus burchelli* Gray)

Patrick Duncan and Chris Gakahu

The plains zebra is the only equid which is still undoubtedly widespread, and it is one of the most abundant ungulates in Africa (Cumming 1982). The species is a useful model for the conservation and management of the other equids, some of which were as abundant and widespread in historical times. An understanding of the economic and ecological factors which contribute to maintaining the abundance and the genetic diversity of this species will help to improve the status of the other equids.

Plains zebra vary in color from the north, where the stripes are sharpest and most extensive, to the south, where Burchell's zebra, like the quagga, had no striping on the legs and underbelly (Kingdon 1979, Groves 1974). Seven subspecies are usually

Plains zebra (photo by A. Duncan).

Table 4. Plains zebra subspecies, their abundance to the nearest thousand individuals, and trends (for details and sources see Appendix 1).

	Numbers	Trends
Grant's zebra		
(E.b. boehmi)		
Ethiopia	2,000	Decreasing
Sudan	present	?
Somalia	?1,000	Decreasing
Kenya	141,000	Stable ?
Uganda	3,000	Increasing
Rwanda	4,000	Stable
Tanzania (N)	390,000	Stable
Upper Zambezi zebra		
(E. b. zambeziensis)		
Zaire	present	Decreasing
Angola	present	? Decreasing
Zambia (W)	>8,000	?
Crawshay's zebra		
(E. b. crawshayi)		
Mozambique (N)	present	?
Malawi	1,000	Decreasing
Zambia (E)	15,000	?
Chapman's zebra		
(E. b. chapmanni)		
Mozambique (S)	?3,000	?
Crawshay's/Chapman's zebra hybrids		
Zimbabwe	6,000	Increasing
Chapman's/Damara zebra hybrids		
Namibia (NE)	300	?
Botswana	47,000	Decreasing
Damara zebra		
(E. b. antiquorum)		
Namibia (N)	9,000	Decreasing
South Africa	42,000	Stable

recognized (Table 4 and Fig. 4). As in many equids, these may represent arbitrary categories in a continuously varying population (cline), but we again use the subspecies denomination as an indicator of genetic differences.

Distribution, numbers, and trends

Two hundred years ago this species occupied the grasslands and savannahs of Africa south of the Ethiopian Massif and the Zaire rain forest (Figs. 5 and 6). There are virtually none west of the Nile today, yet they occurred in North Africa, and presumably in the west, only a few tens of thousands of years ago (Groves 1974, page 46). Why the "painted quaggas" have not occurred in west Africa in historical times is a mystery.

Plains zebras live in all the habitats in Africa from sea level to 4,000 m, except for the rain forests, deserts, and Cape sclerophyllous vegetation. They occur (or occurred) in the Somali Arid, the Karroo, and Kalahari; the woodland/savannahs of east and South Africa; and the miombo woodlands of Central Africa. No comprehensive review of the vast literature on the biogeography of the different subspecies has been published. The information provided here on their distribution (Fig. 6) is only very approximate, and needs to be extended and deepened in the future.

By far the most abundant subspecies, at over 1/2 million, is the northerly Grant's zebra (Table 4), which occurs in the western and southern Somali Arid and the east African woodland/savannah. The species has declined sharply in Ethiopia in recent years: in 1978 there were 9,000 (Yalden et al. 1986), today perhaps as few as 2,000 (Appendix 2). Their range in east Africa has contracted by over 50% in the 20th century (Kingdon 1979), but the total number of Grant's zebras is stable or increasing in the last decades.

Assuming that the zebras in Malawi and eastern Zambia are Crawshay's zebras, this subspecies appears reasonably abundant at the moment with at least 16,000 in the miombo woodland/savannah of Mozambique, Malawi, and Zambia (Table 4).

Little recent information is available on the status of the Upper Zambezi zebra in the miombo woodland of southeastern Zaire, or Angola, where this subspecies was widespread, though not abundant, before 1975. Extinction of the threatened Upemba population (Zaire) could represent a serious loss. The only large population of this subspecies may occur in the Kafue flats (western Zambia); however, it is uncertain to which subspecies it belongs.

Further south no data are available for Chapman's zebra in southern Mozambique. If it is true that all the plains zebras in

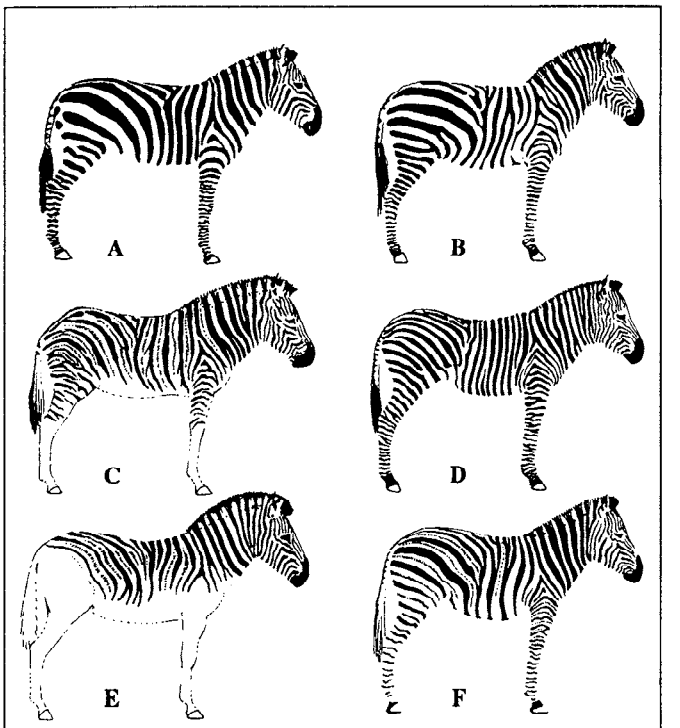
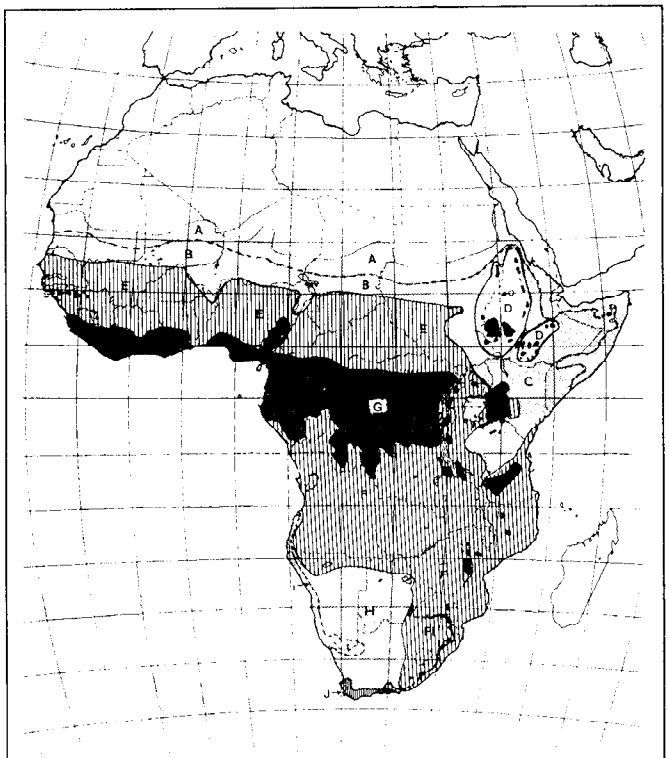


Figure 4. The stripe patterns of the subspecies of Plains zebras (from Kingdon 1979, with permission).



Arid zones (light shading)—Sudanese Arid (A, B), Somali Arid (C), South West Arid (H), Namib Desert (I)
Savanna zones (hatched)—Northern Savanna (E), Southern Savanna (F, F1)
Forest (dark shading)—Lowland Forest (G)
Southwest Cape Zone—Cape macchia or *Fynbos* (J)
Highlands—Ethiopian Highlands (D)

Figure 5. Vegetation zones of the Afrotropical realm (from Smithers 1983 with permission from the University of Pretoria Press).

Zimbabwe are intermediates (Wilson 1975, Smithers 1983), then this subspecies is seriously endangered. In the southern African woodland/savannah of Namibia, Botswana, and South Africa, plains zebras, mainly Damaras, are abundant, Table 4.

Burchell's zebra, the plains zebras of the interior of South Africa, became extinct in the 20th century (Smithers 1983). The proximate reason was apparently overshooting, but the ultimate reason is likely to have been competition with livestock.

There is a general pattern to the status and trends of plains zebra populations: in the protected areas, numbers appear to be stable. Outside protected areas, in some of the more economically developed countries the populations on privately owned land are stable or increasing (e.g. South Africa, Namibia, Zimbabwe), while on communally owned land in parts of these countries and generally in the less developed countries, the populations are declining, very fast in cases such as Zaire.

Conservation measures

In some countries plains zebras are protected by law outside conservation areas (Malawi); in others trophy hunting is illegal (Kenya). In other countries both cropping and trophy hunting is legal, and effectively controlled to a large extent (South Africa, Botswana, Namibia, Zimbabwe). While there is no hard proof, it is likely that these measures have beneficial effects on trends in the zebra populations on farmed land. However, there is little documented information on the economic benefits from sale of plains zebras, their hides, and meat; or on the social mechanisms which allow these benefits to be channelled to the users of communally owned land.

All countries where plains zebras occur have created or are in the process of creating protected areas for wildlife which benefit zebras. Though law enforcement works to varying extents, most individuals of all the subspecies live in protected areas (Appendix 1). The large ones, such as the Serengeti-Mara ecosystem and the Kruger National Park, are of particular importance because they conserve tens or hundreds of thousands of zebras in populations whose processes are close to natural. The importance of the many small protected areas for conservation of the population variability, and thus the genetic diversity of this remarkable species, cannot be overestimated.

Threats

Zebras are water-dependent and require large quantities of forage per day (page 5). Outside protected areas it is likely that they compete with people and livestock for space, water, and forage; furthermore, they damage fences and crops. On farmed land they will always be threatened unless the economic benefits which they provide compensate the farmers for the use they make of water and forage. In some areas, shooting to reduce competition with livestock, for profit, or both is a cause of declines in zebra

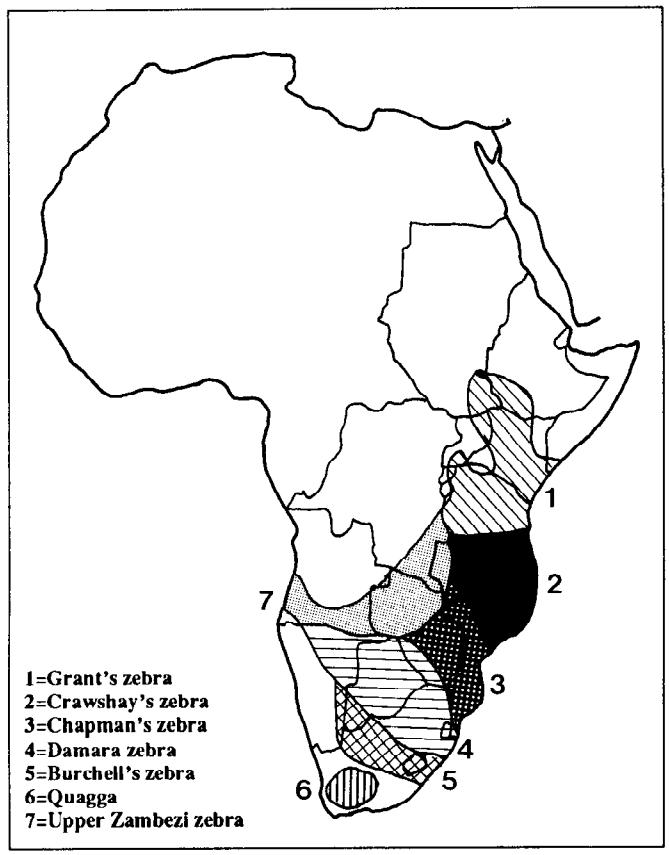


Figure 6. Approximate historical distribution of the subspecies of Plains zebras (after Groves 1974, Kingdon 1979, Smithers 1983).

numbers (Namibia, Ethiopia). By cutting migration routes, fencing aimed at solving problems of wildlife management (e. g. to limit the spread of diseases, or to maintain ownership or control over wild animals) has apparently caused serious declines in the zebra populations in some countries (Botswana). Such fences are still being built (Namibia). In some protected areas (Malawi) the small population sizes are a threat to the conservation of the genetic diversity of the zebras.

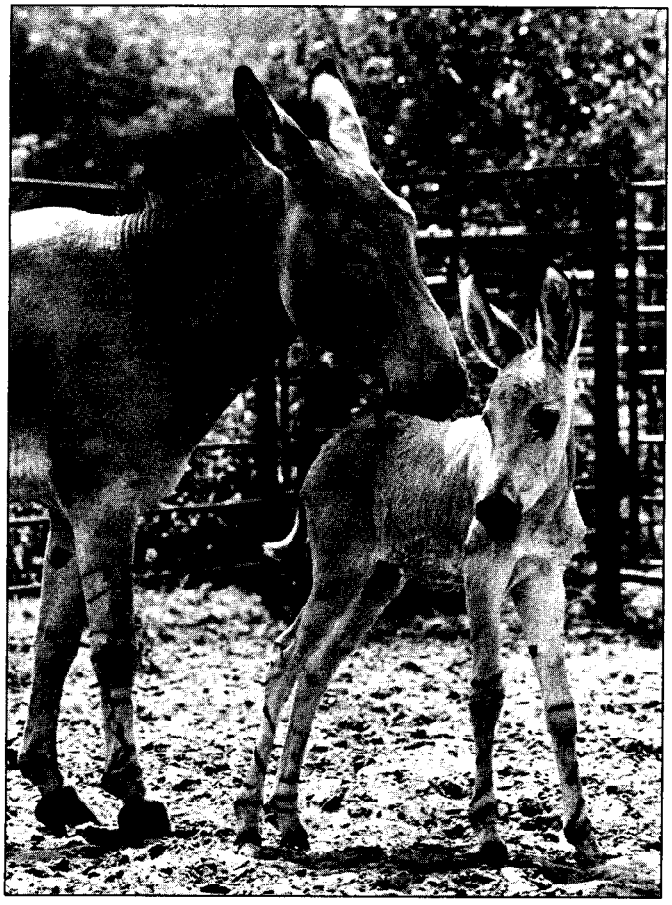
Though little is known about the natural regulation of zebra populations, zebras have been successfully conserved within most well-managed protected areas without special measures. Nonetheless, in some ecosystems (e.g. Etosha National Park, Namibia), numbers have declined for reasons which are not understood. Further research is required on the importance of the food supply, predation, and disease in the regulation of zebra numbers, and particularly on the role of migration in maintaining large populations.

In conclusion, although there are at least 3/4 million plains zebras, the species' genetic diversity is endangered. Though their range is contracting rapidly, Grant's zebras in the north and Damara zebras in the south are not currently threatened. However, with the notable exceptions of Kenya, Zimbabwe, South Africa, and perhaps Tanzania, the densities, like the ranges of these populations, are declining. The Upper Zambezi, Crawshay's, and Chapman's zebras are Indeterminate.

Captive populations

There are plains zebras in many zoos. These are of significance for public education, but currently make little contribution to the conservation of the species. Their precise geographical origins should be ascertained, so that if any come from an Indeterminate subspecies, existing zoo herds can be used as starting points for a captive breeding program.

The actions proposed for the conservation of the plains zebra are given on page 27.



The first Somali wild ass foal born in Tierpark Berlin in July 1979 (photo by K. Rudloff).

African Wild Asses (*Equus africanus* Fitzinger)

Patricia Moehlman

African wild asses live in hilly and stony deserts. Three subspecies have been accepted (Table 5), but very little material is available for study, so the geographical variations may be continuous (clinal), and there may be only one subspecies. This is the latest opinion, so we use the common names "Nubian" and "Somali" to describe the different populations (Groves 1986, Yalden et al. 1986)

Donkeys originated from African wild asses, possibly from the Atlas wild ass (Groves 1986), and are sympatric with them throughout their range. Unlike Przewalski's and domestic horses, feral and wild asses have the same number of chromosomes and look very similar. Nonetheless, there are consistent differences in their skulls and shoulder crosses, and usually differences in their ears, leg color, and countershading (Groves 1966). In some areas (Hoggar mountains, Algeria) herdsmen tether estrous females on the range so that they are mated by wild (or feral) males. It is therefore probable that the genomes (genetic material stored mostly in the DNA contained in the chromosomes) of wild and domestic asses are extensively mixed. This process (introgression) is very likely a prime cause of the disappearance of wild asses from the northern parts of their range (Groves 1974, Yalden et al. 1986), and is a serious threat to the surviving wild asses.

Much less is known about the wild populations of these shy animals than about the zebras (but see Klingel 1972, 1977). However, detailed studies have been made of the behavior and ecology of feral animals, which seem to live very much as the wild asses do (Moehlman 1974, 1979; Woodward 1979). African wild asses are strikingly similar in their ecology and behavior to Grevy's zebras and Asian wild asses. They live in remote, arid and semi-arid bushlands and grasslands, feeding mainly on grasses and forbs, although browse may be an important part of their diet in some circumstances. Wild asses are often found on flat "playas", silty flats between broken low hills and fields of boulders. They appear to use rocky areas to a greater extent than Asian wild asses (Groves 1986, Clark pers. recs., desert Hai-Bar, Israel).

Like Grevy's zebras, males defend very large territories, often around water supplies, but also as far as 20 km away. Females may associate with individual males and other females for months when lactating, but otherwise live with their recent offspring in unstable groups of up to 50. They can foal at two years, but typically do so only at four (Moehlman 1974).

Distribution and numbers

Originally widespread from the Moroccan Atlas across northern Africa to the Sudanese and Somali arid zones (Sidney 1965, Ansell 1974), this species may also have occurred on the Arabian Peninsula (but see Groves 1986). Because wild and feral animals are difficult to distinguish in the field (see above), the historical record needs to be treated with caution.

The northern part of the range was occupied by the extinct Atlas wild asses (Groves 1986); though there are asses in northern Chad and the Hoggar Massif of the Central Sahara today, these are probably feral donkeys.

The Nubian wild ass lived in the Nubian desert of northeastern Sudan in historical times, from east of the Nile River south to the Atbara River and east into northern Eritrea. The wild asses on Socotra Island may be descendants of Nubian wild asses introduced by the ancient Egyptians many centuries ago (Harper 1945), but their morphology today is indistinguishable from that of feral donkeys (Groves 1986). Klingel (1980) made aerial sightings of Nubian wild asses in 1971 in the Baca (Barka) Valley of Eritrea. In 1975-1976 M. Watson (in litt. 1982) saw hundreds during aerial surveys in the border areas between Sudan and Eritrea. Watson cautions that the populations that he saw in the Sudan, Eritrea, Ethiopia, and Somalia were "mixed" in the characteristics that differentiate domestic from wild individuals, e. g. shoulder stripes. There are no recent sightings of wild asses in the range of the Nubian wild asses, so the free-living asses in northern Ethiopia and adjacent Sudan are probably feral or crossbred, and the Nubian population is probably extinct (Ansell 1974, Yalden et al. 1986).

Table 5. Subspecies of African wild asses (Groves 1966).

Latin name	English name	Status
E.a. africanus	Nubian wild ass	Endangered
E.a. atlanticus	Atlas wild ass	Extinct c. 300 A.D.
E.a. somaliensis	Somali wild ass	Endangered

Wild asses are still found in Ethiopia from the Danakil Desert, along the Awash River and into the Ogaden as far south as the Shebele River, in the western portion of Djibouti and east into northern Somalia (Fig. 7). Aerial sample counts in 1970-1971 of this area (12,000 km²) provided an estimate of approximately 3,000 (Stephenson 1977, Klingel 1980), though M. Watson thought that they had undercounted and that there were 6,000-12,000 (in litt. 1982).

Aerial total counts of part of the same area in 1978 (J.G. Stephenson in litt. 1990) led to estimates of: 675—Yangudi-Rassa NP; 725—Southern Danakil, outside Yangudi-Rassa NP; and 75—Danakil depression.

These figures are not comparable, because they are based on different survey methods: they nonetheless suggest that the population may be declining sharply. No recent aerial censuses have been done, but ground observations show that there are at least a few left (Ato Tadesse Gebre-Michael and Ato Fekadu Kassaye in litt. 1/90).

In Somalia, systematic aerial sample counts of the northern region in the late 1970s provided estimates of 4,000-6,000 asses (M. Watson in litt. 1982). Ground observations have been an order of magnitude lower. An area where they are regularly seen is the Nugaal Valley: there were believed to be 250 in 1970 (Hunt pers. comm.), and similar numbers in 1979-1982 (Simonetta and Simonetta 1983). In 1988-1989, even with some aerial observations, it was estimated that there were rather less (100+ Moehlman 1989).

In conclusion, there is a very slight possibility that there are still some wild asses in the northern parts of the species' range, in the Hoggar, Sudan, or northern Ethiopia. The numbers of wild asses in eastern Ethiopia and northern Somalia are not known accurately—there may be only a few hundreds left in the wild.

Conservation measures

The species was legally protected in Sudan in 1963 (Schomber 1963); the present status is unknown, and no wild asses are known to live in any protected areas. In Somalia the species is legally protected by Law No. 15 of 25 Jan 1969, Schedule 3, Part A. As in Sudan, it does not occur in any protected area.

In Ethiopia the species has been protected since 1969, and occurs in the Yangudi-Rassa National Park (not yet gazetted) and the associated Wildlife Reserves and Controlled Hunting Areas. These wildlife conservation areas are currently inaccessible for conservation actions, but have potential, given adequate government and international support.

Threats

Small populations and interbreeding with donkeys

The small remaining populations are intrinsically at risk of

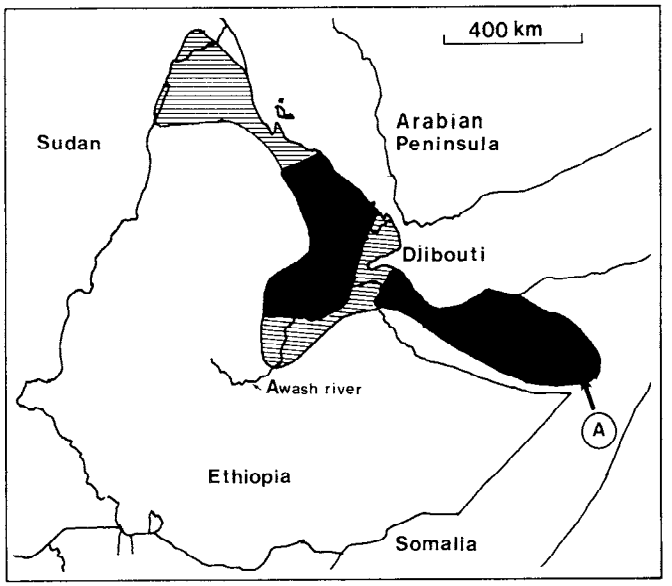


Figure 7. Distribution of African wild asses in the 19th and 20th century in the Horn of Africa (hatched, Yalden et al. 1986), and the aerial census blocks where they have been seen since 1975 (Klingel 1980, Watson in litt. 1982). A=Nugaal Valley.

extinction, and their genomes are also threatened by introgression of domestic genes.

Hunting
In both Ethiopia and Somalia the wild ass is hunted for food and for medicinal purposes. In the Nugaal Valley, elders thought that poaching was the work of a few people, for income. In recent years the political instability and military actions in both countries mean that automatic weapons and bullets are more easily available.

Loss of access to food and water resources
In the central Danakil Desert and elsewhere wild asses may compete with livestock for limited grazing, and may be excluded from water in some areas because of agricultural development.

Drought
Droughts may cause increased competition with livestock for water and forage (Moehlman 1989). Elders in the Nugaal Valley thought that the wild ass population had been severely reduced during the 1974 drought, but if survival is better in asses than in livestock (c.f. Grevy's zebras, page 12), then the effect of droughts may be positive in the medium term.

In conclusion, the African wild ass is critically Endangered (IUCN 1990a), and is the equid for which conservation action is most urgently needed.

Captive populations

The world captive population on 1 Jan. 1992 consists of some 70 African wild asses (Pohle in litt. 5/92):

Somali wild asses
1. North America—6 males, 3 females
2. Rest of the world—25 males, 26 females

A population of Somali wild asses has been set up in the desert Hai-Bar from individuals caught in the Danakil Desert, Ethiopia. The population went up to 26 individuals, but some foals have birth defects and the breeding rate appears to be depressed. A male from Nurenberg Zoo (of another origin, the Nugaal Valley population) was acquired in 1988. In 1992 only 18 remained.

African wild asses, mixed origins
North America—January 1st 1991 (Pohle in litt 5/92)
10 males, 19 females (at Catskill and Waters Ranch, United States)

The captive population is therefore far too small to conserve the species' genetic diversity, for which an effective population of c. 500 of each subspecies would be needed (see page 5). In view of the precarious status of the wild population, these captive herds are of the utmost value. They should be managed under a captive propagation program which conserves their genetic diversity and prepares them for interactions with the remaining wild populations.

The actions proposed for the conservation of the African wild ass are given on page 24.

Asia

Asian Wild Asses—Hemiones and Kiangs (*E. hemionus* Pallas and *E. kiang* Moorcroft)

Bill Clark and Patrick Duncan

There are at least eight subspecies, and many more geographically distinct populations of Asian asses, with different local names. The taxonomic classification we use (see page vii) is given in Table 6. Since hemiones and kiangs are taxonomically and ecologically so close, and the data on their numbers and distribution are sparse and sometimes mingled (see below, Table 7), we treat them together.

The Asian asses vary little in size, from the dziggetais in the northeast, 140 cm at the shoulder to 120 cm in the southern subspecies (Onagers, Groves 1974). The skeletal and color differences do not necessarily follow this pattern, but allow the subspecies to be distinguished easily (Groves 1986).

Asian asses are in a different subgenus from African asses (Table 1), and produce a sterile hybrid with donkeys (Ryder et al. 1978).

Table 6. Subspecies of Asian wild asses.

Equus hemionus	
E.h. hemionus	North Mongolian dziggetai
E.h. luteus	Gobi dziggetai
E.h. khur	Indian wild ass
E.h. kulan	Kulan
E.h. onager	Onager
E.h. hemippus	Syrian wild ass
Equus kiang	
E.k. holdereri	Eastern kiang
E.k. kiang	Western kiang
E.k. polyodon	Southern kiang

Distribution and numbers

In historical times, Asian wild asses covered most of the continent's steppe and desert regions from the Black Sea to the Ural Mountains in the north, through Kazakhstan and Siberia, east to the Gobi Desert and almost to the Pacific Ocean (Fig. 8). In the south, they occurred in Anatolia (900 B.C.), south to the Negev and through the deserts of the Arabia, Persia, Afghanistan, and Pakistan to the Thar Desert of northwestern India (Wolfe 1979).

In this century their range has declined to a fraction of what it was. Except in Mongolia, Xinjiang, and Tibet, increasingly intensive land use by man and domestic animals has pushed these animals into protected areas and pockets of little-used land. Numbers of most of the subspecies have declined from tens of

Table 7. Information available on the numbers in the wild populations of Asian wild asses.

Dziggetais	Mongolia (Gobi NP)	2,500	A. Avirmed pers. comm. 5/92
	Mongolia (elsewhere)	?5,000	V. Sokolov in litt.
	China	2,000	Gao and Gu 1989
Kulans	Turkmenistan and Kazakhstan	c. 2,000	Wolfe 1979
Onagers	Iran	<400	C. Groves in litt. 1991
	Israel	42	W. Clark pers. recs.
Indian wild asses	India	2,072	S. P. Goyal in litt. 6/91
Eastern kiangs and western kiangs	China	tens/hundreds of thousands	Gao and Gu 1989 and Butler et al. 1986
Western kiangs	Nepal	c. 500	Fox et al. 1991
	India	c. 1,500	Fox et al. 1991
Southern kiangs	China	present	W. Clark pers. recs.
	Sikkim	tens	W. Clark pers. recs.

Table 8. Recent population trends in the Asian wild asses.

North Mongolian dziggetais	Russia	Decreasing ? extinct.
	Mongolia	Decreasing ? extinct.
Gobi dziggetais	Mongolia	Decreasing (Bannikov 1975).
	China	Sharp decline in the past ten years (Gao and Gu 1989).
Kulans	Turkmenistan and Kazakhstan	Sharp decline to 1941, increased to c. 2,000 since then (Wolfe 1979).
Indian wild asses	India	Declined to 3,000-5,000 in 1964, 860 in 1962, and 362 in 1967; increased to over 2,000 at present (Goyal in litt. 6/91).
Onagers	Iran	Declined to c. 300 in 1964, increased to c. 1,000 in 1974, since then seriously declined; introduced to Israel (Makhtesh Ramon Nature Reserve in 1983), 42 in 1991 (W. Clark pers. recs.)
Eastern kiangs	China	No information.
Western kiangs	Nepal	No information.
	India	No information.
Southern kiangs	China	No information.
	Sikkim	No information.

thousands, to a few thousand or more frequently a few hundred in each pocket. The Syrian wild ass became extinct in 1927.

The available estimates of the abundance of the different populations, often neither recent nor accurate, are summarized in Table 7. Of the eight subspecies two (Southern kiang and North Mongolian dziggetai) may be extinct. Accurate information on their status is urgently required.

Three more have less than 2,500 individuals (onagers, kulans, Indian wild asses). Of these, onagers are critically endangered with a declining wild population of less than 400 individuals restricted to three protected areas in Iran and Israel. The Bahram-e-Gour is a 3,8500 km² Biosphere Reserve (Category IV, IUCN 1990b) and Touran is a 12,954 km² Category V protected area. There are problems of competition for grazing by domestic stock and poaching.

Kulans now number more than 2,000 after a major conservation effort in Turkmenistan and Kazakhstan. Fifty years ago they were close to extinction. Since 1941 they have been protected in the Category I Badkhyz Nature Park in the south of Turkmenistan (IUCN 1990b). A notable increase in the population has allowed individuals to be translocated to other protected areas e. g. Barsa Kelmes Island, Aral Sea, to create new populations (Wolfe 1979).

In 1982, there were 280 Kulan on Barsa Kelmes. From here the species was reintroduced to the Ily Valley (southeastern Kazakhstan) where the population had reached 121 in 1990. A similar exercise led to the establishment of a population of 160 (1990) in the Andasai Reserve in the Betpac-Dala desert. There are still c. 100 on Barsa Kelmes Island (Blank in litt. 3/92).

The Indian wild ass occurs only in the Little Rann of Kutch, on the Indo-Pakistani border. Its population is c. 2,000 (Smielwski and Raval 1988).

The dziggetais were shot out in Kazakhstan in the 1930s. They were still numerous in Mongolia with some 15,000 in 1974, and widespread (Bannikov 1971, 1975). Today Gobi dziggetais still occur, at least some thousands, in the Great Gobi Desert National Park (Category II, 53,000 km², IUCN 1990b), but no information is available to us on their status elsewhere.

The Kalamaili Mountain Ungulate Fauna Nature Reserve in Xinjiang, China (Category IV, 170,000 km² IUCN 1990b) is reported to contain a large population of western kiang (Gao and Gu 1986), and some 2,000 western kiang occur in Jammu and Kashmir (eastern Ladakh), and Sikkim.

The eastern kiang in Xinjiang and Tibet is the only one which is definitely common: 30,000 are reported from the Arjin Mountains Nature Reserve in China (Categories I and IV in different zones, 45,000 km², Butler et al. 1986). Further survey work using modern techniques is required to provide accurate estimates over these huge areas of central Asia.

Table 9. Legal status of the Asian wild asses.

Dziggetai	International CITES Appendix I. China—"First Class" protection. CIS—Fully protected.
Indian wild ass	Mongolia—Fully protected. International CITES Appendix I. India—Schedule 1 of the Wildlife Protection Act 1972.
Kulan	International CITES Appendix II. CIS—Fully protected.
Onager	International CITES Appendix II. Iran—Fully protected. Israel—Fully protected under the Nature Reserves Law of 1964.
Eastern kiang	International CITES Appendix II. China—"First Class" Protection.
Southern kiang	International CITES Appendix II. China—"First Class" protection. India—Schedule 1 of the Wildlife Protection Act 1972.
Western kiang	International CITES Appendix II. China—"First Class" protection.

Recent trends

The available information on most of the populations is too sparse (Table 8) to allow accurate conclusions to be drawn, but it is clear that in the first half of this century there were major declines in virtually all the populations. In the latter half of this century the situation has varied considerably among them.

The Iranian populations (onagers) have decreased dramatically to less than 400, and are restricted to two protected areas. Though the Israeli population is increasing, the subspecies is critically Endangered.

The populations of kulans (Table 8) were at least maintaining themselves in the 1980s, but their small sizes mean that the subspecies must be considered Endangered.

Indian wild asses are on the increase after a decline from 3,000-5,000 in 1946 to the low level of 360 in 1967. There were some animals in Pakistan in the 1960s (Charco and Nagar Parker Tehsils of Tharparkar District, Sind), but the last was shot in 1969-1970 (Goyal in litt. 1991). Nonetheless, this subspecies must be considered Endangered as it is represented by one population only.

The information on the dziggetais (Table 8) indicates that they have been declining seriously in China (Gao and Gu 1989) and Mongolia. For the two kiang subspecies, eastern kiang and western kiang, we again cannot provide separate data, though numbers may still be high (Table 2, Gao and Gu 1989). It is possible that the major part of the remaining western kiangs are in central and eastern Ladakh, Jammu, and Kashmir. These subspecies are Indeterminate or Insufficiently Known (Gobi dziggetai).

Three onagers. Makhtesh Ramon, Israeli Negev (photo by Bill Clark).

Conservation actions

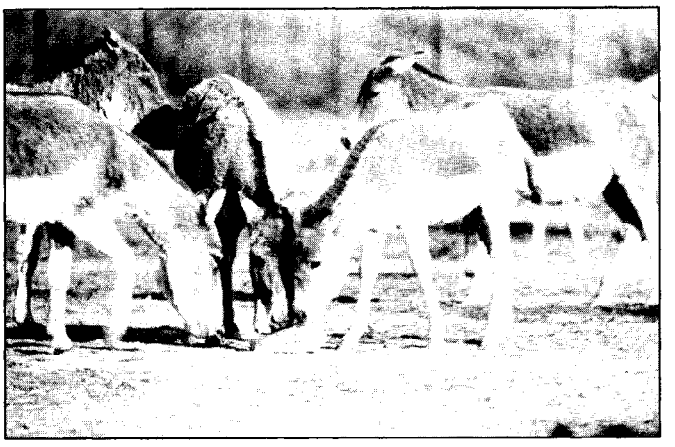
The extant subspecies are all legally protected in the countries where they occur, but adequate enforcement is a problem in some areas (Table 9).

CITES lists:
Appendix I
North Mongolian dziggetai (*E.h. hemionus*)
Indian wild ass (*E.h. khur*)
Appendix II
E. hemionus (kiang, *E. kiang*, and onager, *E.h. onager*).

The CITES lists should read:
Appendix I
Onager (*E.h. onager*)
Indian wild ass (*E.h. khur*)
Kulan (*E.h. kulan*)
Appendix II
All other Asian wild asses (*E. hemionus* and *E. kiang*).

As soon as accurate information is available on the status of the indeterminate subspecies (the north Mongolian dziggetai and the western and southern kiangs), the lists should be reviewed.

There are protected areas in the ranges of all the subspecies, and, for the subspecies where adequate data are available, significant numbers of animals use these protected areas. There is no doubt that they play a key role for kulans, onagers, and Indian asses, and that they could do so for the other subspecies.



Indian wild asses (photo by S.P. Goyal).

Threats

The specific threats for each subspecies are summarized in Table 10. The two of the most important are competition for grazing and water and small population sizes. The only subspecies which are currently not threatened are the eastern kiangs, which live in sparsely inhabited central Asian deserts. The other populations in Mongolia, China, and the Himalayas must be classified as indeterminate (I) or insufficiently known (K).

The IUCN (1990a) Red List of Threatened Animals lists one species and one subspecies: *E. hemionus*—Vulnerable and Indian wild ass (*E.h. khur*)—Endangered. On the basis of the information presented here this should be amended to:

- *E. hemionus*—Insufficiently Known
- Onager (*E.h. onager*)—Endangered
- Indian wild ass (*E.h. khur*)—Endangered
- Kulan (*E.h. kulan*)—Endangered
- Gobi dziggetai (*E.h. luteus*)—Insufficiently Known
- North Mongolian dziggetai (*E.h. hemionus*)—Indeterminate
- Southern kiang (*E.k. polyodon*)—Indeterminate
- Western kiang(*E.k. kiang*)—Indeterminate

Captive Populations

In the world's zoos there are captive populations of: Kulans—363 (128 males, 235 females) ISIS 1989; Onagers—141 (54 males, 87 females) ISIS 1989; and Eastern kiangs—52 (29 males, 23 females) ISIS 1989 (Chinese numbers unknown).

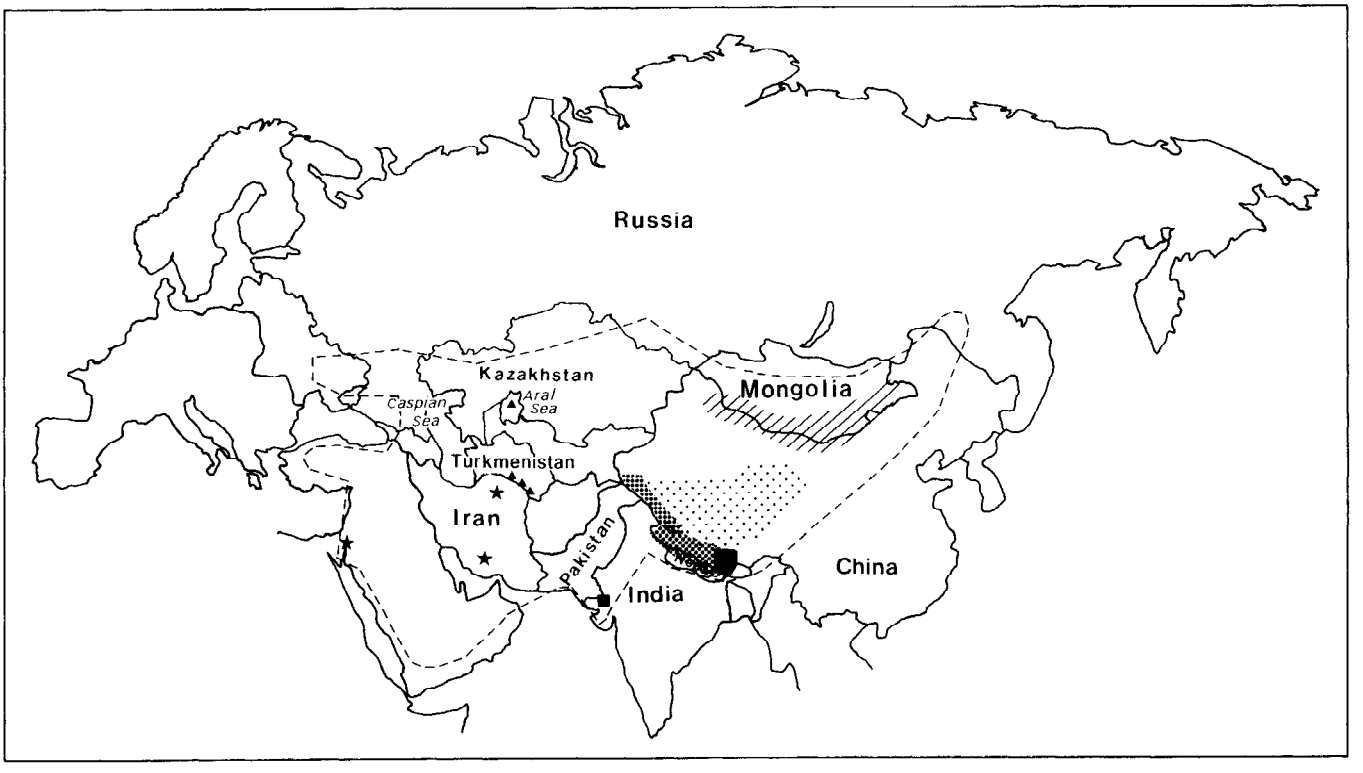


Figure 8. Past distribution of Asian wild asses (dotted line) and approximate present distribution of Kulans (triangles), Indian wild ass (open star), Western kiangs (dense dots), Southern kiangs (darkest shading), Onagers (filled stars), Dziggetais (hatched), and Eastern kiangs (sparse dots).

Table 10. Threats to the survival of the Asian wild asses (from the references cited in the text).

Dziggetais	China Mongolia	Exclusion from habitat due to human settlement; poaching. Competition with livestock, shooting for meat.
Kulans	Turkmenistan and Kazakhstan	Shooting for meat is probably occurring.
Onagers	Iran	Shooting for meat and medicine with vehicles; and competition for resources are probably all significant. Small populations.
Indian wild asses	India	Exclusion from habitat due to human settlement, cultivation, and salt extraction. Competition from livestock. Shortage of water in droughts. Military actions. Small number of animals in a single population.
Eastern kiangs	China	None reported.
Western kiangs	China and Nepal India	Small population. Increasing livestock numbers may lead to competition. Breakdown in law and order in Jammus Kashmir.
Southern kiangs	China and Sikkim	As above for western kiangs.

There are also captive populations of North Mongolian dziggetais in China, and of Gobi dziggetais in India (e.g. Sakkarbaug Zoo, Junagath, Gujarati), but the International Studbook has not been kept informed of their numbers. There is a breeding herd of about 50 onagers (perhaps with some kulans among their founders) in the desert Hai-Bar (Israel), which has been used to produce animals for reintroduction in Maktesh Ramon (central Negev) to replace the extinct Syrian wild ass. There are now 30 free-ranging animals in the Negev.

Of the Endangered and Indeterminate subspecies, the captive population of kulans approaches 500. For the other subspecies (onagers, Indian wild ass, southern kiang, western kiang) the numbers in captivity are inadequate to conserve their genetic diversity for a significant length of time (see page 5).

The actions proposed for the conservation of Asian wild asses are given on page 26.

Przewalski's horse

John Knowles and Simon Wakefield

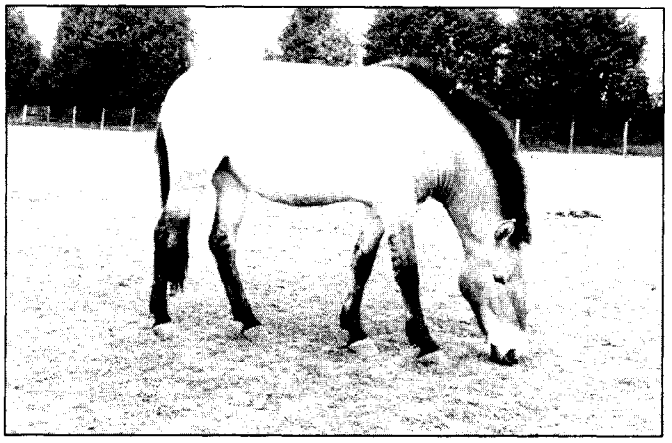
Przewalski's horse is closely related to the domestic horse (Table 1), but they show a number of consistent differences in their chromosomes and their appearance. The chromosome number of Przewalski's horse is 2n=66, domestic horses have 2n=64; nonetheless they differ only by a Robertsonian fusion (Benirschke et al. 1965), and the genetic material of the two species is so similar that their hybrids are fertile (Ryder et al. 1978, Trommerhausen-Smith et al. 1979). The manes of Przewalski's horses are erect, and the upper part of the tail has short guard hairs, unlike horses which have long, falling manes and long guard hairs all over the tail. Further, in their social behavior Przewalski's seem to be more aggressive than domestic horses (higher frequency of threats, attacks, etc., cf. Feh 1988). These differences show that Przewalski's are more than another breed of domestic horse.

Past distribution

Cave drawings in France, at Lascaux and Niaux, show horses which look like Przewalski's horse (Mohr 1971). In prehistoric times, the species probably roamed widely over the steppes of central Asia, China, and western Europe (Ryder 1990a). In literature of the Middle Ages references to wild horses are far fewer than to kulans (Bokonyi 1974). This may be because the horses were rarer, though they may also have been less approachable, because of expeditions to capture foals for domestication.

The first mention of Przewalski's horse in western literature was by John Bell, a Scottish doctor who travelled in the service of Tsar Peter the Great in 1719-1722 (Mohr 1971). Bell and subsequent observers all located horses within the area of 85°-97° E and 43°-50° N, Fig. 9. Small groups of horses were reported through the 1940s and 1950s in an area between the Baitak-Bogdo ridge and the ridge of the Takhin-Shara-Nuru (which translated from Mongolian means "the Mountain of the Yellow Horses", Fig. 9). The population declined markedly during this time due to hunting by Chinese and Mongolian border guards, and also because their access to grazing and water was restricted by pastoralists (Amos 1987).

The first specimens brought into captivity were collected in what is now China by the Polish geographer N.M. Przewalski at the end of the nineteenth century. He saw Asian asses in herds of hundreds but wild horses only twice, in Dzungaria (Fig. 9; Mohr 1971, Amos 1987). The last possible sighting was in 1966 on the Takhin-Shara-Nuru plateau (Fig. 9, Bokonyi 1974) when the Hungarian zoologist, Z. Kaszab counted a group of eight individuals which he believed to be one stallion and seven mares. Annual investigations by the Joint Mongolian-Soviet Expedition



Przewalski's horse (photo by A. Wakefield).

have since failed to find conclusive evidence for their survival in the wild (Ryder 1990a). Chinese biologists conducted a survey in northeastern Xinjiang from 1980 to 1982 (covering the area of 88°- 90° E and 41°31'-47°10' N) without finding any horses, but still believe that a remnant population survives in this area (Gao and Gu 1989). Nonetheless, Przewalski's horse has almost certainly disappeared from the wild (Ryder and Wedermeyer 1982).

Captive populations

Przewalski's horses have been saved from extinction by the dozen zoos which carefully preserved captive herds in the first half of the twentieth century. There is now a population of over 1,000 individuals which are descended largely from Przewalski's horse origins, but with a significant and incompletely documented contribution from domestic horse stock (Seal et al. 1990). Of the 70 animals recorded in the studbook as having been caught in the wild, only 12 contribute any genes to the current living population.

Eleven were brought into captivity in 1899-1901 and the last of them died in 1939. Only one wild horse, the mare 231 Orlica III captured as a foal in 1947, has been bred into the population since then. However, the living population has 13 founders, the additional animal being a domestic horse. A stallion, 56 Halle 1, was born in 1906 at Halle (Germany) to a wild caught stallion and a domestic Mongolian mare: she is therefore the 13th founder. Although the 12 other founders are officially recorded as being of truly wild origin, a mare (18 Bijsk 8) is suspected on the basis of phenotypic evidence as having domestic horse ancestry (Dolan 1982). Where genetic analyses have taken this into account (Geyer and Thompson 1988; Geyer, Thompson and Ryder 1989) the assumption made is that 18 Bijsk 8 is an F1-hybrid. Because Przewalski's and domestic horses are so close genetically, any of the founders may have had some domestic horse influence.

Genetic drift and bottlenecks in the history of the captive population have resulted in the loss of some of the genetic diversity represented by the original founders. This has been accentuated by variable and artificial selection, orientated largely towards the production of a phenotype that resembles the descriptions (e.g. Salensky 1907) and specimens of wild individuals.

Captive propagation has become progressively more organized. The International Studbook for the Przewalski's Horse (Volf 1961-) was one of the first for a wild species in captivity and the majority of the horses are now being managed within formal programs to retain the maximum amount of the remaining genetic variation of the species. The objective of these programs is to retain 95% of current average individual heterozygosity for at least 200 years (see Appendix 2 for further details). As a result of these pioneering efforts by responsible zoos, the species is secure from extinction for the foreseeable future.

Threats

The long term threat to the relatively small captive population is continued loss of genetic diversity. The numbers cannot be increased much further because the carrying capacity of zoos is limited, and Przewalski's horses compete with other large mammals for space (Seal et al. 1990).

Conservation measures

There is a strong will among owners of Przewalski's horses to respond to these threats by modern techniques of gene pool management and by the reintroduction of the species to its historic range (Ryder, 1990a). A Global Management Plan has been drafted to achieve these objectives (Seal et al. 1990). A Global Management Plan Working Group (GMPWG) was approved at the Fifth International Symposium on the Preservation of the Przewalski's Horse, held at Leipzig Zoo 19-23 May 1990, to act on behalf of the owners and breeders of Przewalski's horses in the preparation and implementation of the global plan. The GMPWG consists of Species Coordinators from the regional management programs, the Chairs of four SSC Specialist Groups (Equid Specialist Group, Captive Breeding Specialist Group, Reintroduction Specialist Group, and Veterinary Specialist Group) and the International Studbook keeper and specialists in different scientific fields.

Captive breeding

The programs have two main objectives, to maintain as much of the present genetic diversity as possible, and to produce animals for reintroduction into the wild. The number of animals required depends on the precise genetic and demographic aims of the program, the biological characteristics of the population and the kinds and levels of stochasticity operating. These issues are dealt with in detail in Seal et al. (1990) and Foose (1992).

The captive space required by Przewalski's horse in relation the needs of other mammalian taxa with similar requirements is now being addressed by Equid Taxon Advisory Groups, which have started in both Europe and North America. The growth rate of the population in European zoos needs to be reduced: this is being realized as far as possible through fertility control, by the use of immunocontraceptive vaccines which can reduce fertility in a simple and reversible way.

The reduction of genetic variation through past bottlenecks and artificial selection in captivity raised concerns that today's horses have reduced abilities, behaviorally and genetically, to survive in the wild. However, the use of "semi-reserves", enclosures large enough for a group to range freely in search of food and water (Bouman-Heinsdijk 1982), has shown that they can adjust successfully and develop a normal social structure.

To date semi-reserves have been established at Askania-Nova

(Ukraine), in Alberta (Canada), Xinjiang (China), the Netherlands, Germany, and the Cevennes National Park (France). At Askania Nova, the breeding stallion of a large herd in a 1500 ha enclosure was removed and two new stallions introduced, resulting in the formation of two separate breeding groups. Social factors will clearly need to be taken into account during the initial establishment of the reintroduced groups (Duncan 1992) and such semi-reserves enable us to learn about Przewalski's horses under more natural conditions for future reintroduction programs.

The Cevennes semi-reserve consists of an enclosure of 135 ha ranging in altitude from 850 m to 1,000 m, with a hot, dry summer and a cold, damp winter. Zoo-bred stallions were able to survive a hard winter, with temperatures of -10° C, in good condition with only occasional supplementary food. During snowy periods they cleared the snow by pawing in order to graze (Granier and Feh 1984). A breeding herd is to be established in a 500 ha steppe reserve in the Cevennes in the near future.

Reintroductions

The ultimate objective of the Global Management Plan is to reintroduce the species to secure wild habitat in sufficient numbers to allow the continued evolution of the species by natural selection (Seal et al. 1990). The sites chosen for reintroduction should satisfy three essential criteria:

- that there is no possibility of contact with feral or domestic horses, with which Przewalski's horses readily hybridize;
- that the habitat requirements of the horses are satisfied; and
- that the predator populations do not impose rates of predation which are too high.

In addition, the reintroduced populations must:

- be large enough to avoid extinction by predation or stochastic events, and
- contain representation from as much of the gene pool as possible.

There should be at least five self-sustaining populations of >500 individuals, ideally but not necessarily in the ancestral area (see above). Reintroductions will be organized along the lines of the Arabian oryx project (Stanley Price 1989). An essential aspect of these projects will be their integration economically and culturally into the local community's program of development. Without this, the inevitable constraints linked to the creation of new protected areas, and especially the prevention of hybridization with domestic horses, will not be accepted by the people in the long term.

Although the Przewalski's horse will be returning to its historic range, lack of adequate habitat may have been a significant contribution to its extinction in the wild, particularly if the animals were forced by human pressures to use sub-optimal habitat (Sheehy 1991). It is essential that the habitat in the proposed reintroduction areas within their historic range is of high enough quality to favor an expanding population of zoo-born Przewalski's horses. No direct information on the habitat requirements of Przewalski's horses (food, water, shelter etc.) is of course available, but we can provisionally assume that these are the same as the requirements of domestic horses, about which a considerable amount is known (Berger 1986, Duncan 1992).

Identification of individuals for acclimatization and release will be through the analysis of the pedigrees of the captive animals (Ryder 1990b). The offspring from a large number of relatively unrelated individuals located in many zoological institutions will be required to facilitate transfer of the gene pool resources from the captive population to the released populations; the GMPWG provides the organizational framework to achieve this.

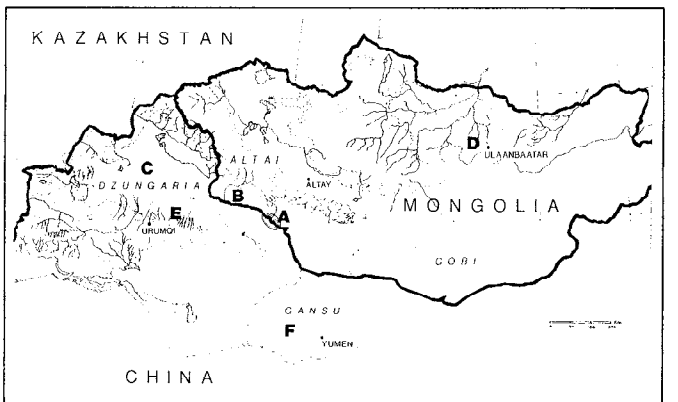
Several new initiatives are underway in Mongolia and China. Some of these are being developed through the GMPWG while others are independent projects, which is unfortunate as this reduces synergy and may confuse partners in the host country.

In Mongolia the GMPWG has started a new initiative with the National Takhi Commission. On April 22, 1991, a contract was signed between the Mongolian government and the GMPWG which provides a framework for a program of reintroduction of Przewalski's horses in the Gobi B National Park. Scientists from Europe and America, in collaboration with scientists from the State University and Academy of Sciences in Ulaanbataar, are visiting potential release sites. The oasis of Gun Tamga, adjacent to the eastern edge of the National Park has abundant water and grasses, and appears to provide the conditions required for a successful reintroduction. The boundary of the park has been extended to include the oasis during 1992. Horses will then be transferred from Western zoos and released progressively when funding of the project is secured.

Also in Mongolia, the Dutch Foundation for the Preservation and Protection of Przewalski's Horse is cooperating with the Academy of Sciences in Moscow, the Ukrainian Scientific Research Cattle Breeding Station "Askania Nova," and Mongolian bodies in a program at Hustain Nuruu, 100 km from Ulaanbataar (Bouman and Bouman 1990). The first horses arrived in 1992 (Zimmermann, pers. comm.).

In China, the Wild Horse Breeding Station in Jimsar County, Xinjiang began a breeding program in 1987, and in April 1990, nine horses were released from the Station into the adjoining steppe (Fig. 9; Jun et al. 1990). The Howletts and Port Lympne Foundation are also planning a reintroduction project in the Gansu province (Fig 9; Aspinall 1990).

The actions proposed for the conservation of Przewalski's horse are given on page 26.



A=The area between Takhin-Shara-Nuruu plateau and Baitak-Bogdo ridge (hatched)
B=The Gobi National Park
C=Dzungaria
D=Hustain Nuruu
E=The Wild Horse Breeding Station, China
F=Gansu Province

Figure 9. Area in which sightings of Przewalski's horse were recorded in the Middle Ages (85°-97° E, 43°-50° N) (Mohr 1971) and locations of current reintroduction projects.

3. Action Proposed to Conserve Wild Equids

The wide range of actions proposed covers policy, planning, research, *in situ* conservation projects and *ex situ* captive breeding. An absolutely crucial component of this Action Plan is the analysis of the genetic differentiation of the different populations in the genus (see pages 1 and 5). Until this has been completed, neither the determination of priorities for conservation actions nor the detailed planning of the genetic management of populations can be done satisfactorily. The species are placed in order of priority. Within species, actions are categorized as: ***crucial to prevent extinction; **very urgent; and *urgent.

African Wild Asses

Species coordinator: Patricia Moehlman

Action to conserve this species is required more urgently than for any other equid, though the tragic turmoil in the Horn of Africa makes this appear difficult, even trivial. Peace and stability are prerequisites for any successful, integrated conservation action.

Ordering priorities for action requires a better understanding of the genetics of the different populations, both wild and captive (see page 5).

1. Protecting and building up the wild populations***

The aim is a wild population of 2,500 (see page 5), or more if there prove to be wild asses in northern Ethiopia or in North Africa. Some wild equids, like mountain and Grevy's zebras, have long coexisted with people and livestock. Though this coexistence is more difficult for African asses because they interbreed freely with donkeys, and they live in a poor and politically unstable part of the world, experience with zebras suggests that populations of wild asses could be conserved if nuclei are maintained in protected areas, and asses outside these nuclei are tolerated by the people who use the grazing lands and there is no crossbreeding with domestic animals.

In Ethiopia, the declared reserves for wild asses (Yangudi-Rassa National Park and the associated reserves) protect an essential nucleus of the wild population. With better management, poaching and competition with wildlife could be further reduced and the numbers built up. This requires a Management Plan, and the Equid Specialist Group, together with the Ethiopian Wildlife Conservation Organization (EWCO), have initiated the process of identifying requirements in people and resources.

In Somalia, a multiple-use reserve has been proposed for the Nugaal Valley (Moehlman 1989). This involves protection of the asses and research on their ecological requirements, and pastoral management, including extension programs.

We recommend that this reserve be created and managed as soon as politically feasible.

2. Building up the captive population***

In view of the critical situation of this species in the wild, the captive population needs building up to 500. A first step needs to be the determination of genetic differences between existing zoo stocks, and a comparison with wild asses and donkeys (see page 27). This should be followed by the preparation of a Global Captive Action Plan (CAP).

In situ captive breeding in or near Yangudi-Rassa National Park would, in addition to increasing the captive population, serve as a management nucleus for this protected area (cf. the okapi captive breeding center in Zaire). The causes of successes and failures of captive breeding in other countries, with particular emphasis on the desert Hai-Bar (Israel), should be determined as part of the CAP process.

3. Monitoring numbers**

All known populations appear to have declined significantly in the last ten years. Information is urgently needed on the current size and distribution of populations in Ethiopia and Somalia as a basis for successful actions for the conservation of this species in the wild. Monitoring should ideally be done at two-year intervals, which is clearly impossible at the moment. We strongly endorse the annual monitoring of the captive population by the Tierpark, Berlin (Claus Pohle).

Grevy's Zebras

Species coordinator: Mary Rowen

1. Management of Buffalo Springs, Samburu, and Shaba National Reserves***

The Buffalo Springs, Samburu, and Shaba population is important both as a tourist attraction and as a breeding population. Management of this population is critical for the long-term survival of the species, and should take account of the following:

- *Administrative reform.* Buffalo Springs and Shaba Reserves are in Isiolo District, Eastern Province, while Samburu Reserve is in Samburu District, Rift Valley Province: this makes wildlife management difficult. Plans of the Wildlife Service (KWS 1990) to create a wildlife zone that would allow these reserves to come under a single management authority would go a long way to resolving these difficulties.
- *Corridors.* A narrow band divides the Samburu and Buffalo Springs Reserve from the Shaba Reserve. The Wildlife

Planning Unit of the Wildlife Service has studied various means of connecting these reserves, thereby creating a single protected area of some 600 km². We support plans to achieve this: such a connection would facilitate management and protection of the reserves and movement of animals through the area, thus greatly improving the value of the reserves for Grevy's zebras, and probably for all wildlife.

- *Water management.* We urge the Kenyan Wildlife Service to monitor and control the offtake of water from Buffalo Springs, in Buffalo Springs National Reserve, to ensure permanent and sufficient water at the Springs for use by wildlife. In addition NWS should monitor upstream use of water in the Ngara Mara and Isiolo rivers.
- *Park management.* While tourism is a critical justification for the long-term survival of these game reserves, better management of key areas is required if such use of wildlife is to be sustainable. The best long-term answer to over-use, off-road driving, and consequent habitat degradation is better enforcement of rules governing reserve use and the expansion of the protected area system to alleviate the load placed on existing reserves. Within the Buffalo Springs Reserve, however, greater protection must be afforded to the Buffalo Springs themselves. We urge a ban on all new development within five kilometers of the Springs. Furthermore, we suggest that the Springs be closed for bathing, as this kind of activity inhibits wildlife from using the Springs; and that the area surrounding the lower portion of the Springs be closed to vehicles. Therefore, the road system should be modified so that only the part of the Springs which is already fenced can be visited.
- *Conservation of the Laikipia Grevy's zebras.* This part of the population has been increasing: the fact that it is on private, fenced land poses special problems (e.g. maintaining interchange with the rest of the population) which require special attention as part of the program of the Wildlife Planning Unit.

2. Promoting economic value**

The Grevy's zebra, if not endemic to Kenya, is certainly best protected and most easily viewed there. We recommend that it be used as a magnet to attract tourists to various areas in northern Kenya. With a more intensive tourist use of the Buffalo Springs, Shaba, and Samburu Reserve complex, other areas on private land and group ranches in the north could be opened up to tourism, especially if Grevy's and other arid land species (reticulated giraffe, gerenuk, oryx) were marketed as tourist attractions more aggressively.

3. Monitoring the numbers*

In the field. Data on the status and distribution of the Grevy's zebra suggest that the species has suffered a 70% decline in numbers in the last decade, and that this decline follows significant declines in the 1970s (Klingel 1980). These data are based on aerial and ground surveys, that are subject to error. Actions, outlined above, are urgently required to determine and reverse the causes of decline; these must be accompanied by monitoring which is sufficiently precise to determine their success.

The most promising approach is to coordinate aerial surveys with ground censuses. As all Grevy's zebra can be individually identified using stripe patters, ground surveys can use modified "mark-recapture" techniques to assess numbers accurately. These censuses can also use historical data on known individuals (Klingel, Ginsberg, Rowen pers. recs.) to assess population trends and movements. Census areas should definitely include Laikipia Plateau, Shaba, Samburu and Buffalo Springs Reserves, Marsabit/Losai region, and the Sibiloi National Park. Their precise boundaries should be determined in consultation with the Kenyan Wildlife Service, so that they correspond with the boundaries of future aerial survey strata, and can thus be used to calibrate them.

In captivity. The captive population of this endangered species is of critical importance: maintenance of its numbers and genetic diversity should be a priority for the Captive Breeding Specialist Group. The studbook, currently maintained by the Marwell Zoological Park, is an essential part of this program.

Mountain Zebras

Species coordinator: Peter Novellie

1. Development of an overall species management plan**

Mountain zebras, and particularly the Cape mountain zebra, are conserved by careful management by the many organizations and people concerned: the National Parks Board (South Africa), the Chief Directorate of Nature and Environmental Conservation (CDNEC) of the Cape Province, and the Ministry of Wildlife, Conservation, and Tourism (Namibia), as well as various regional services, councils, municipalities, and private landowners. The management objectives and techniques need to be made easily available to new staff, and the activities of the different organizations involved need to be coordinated. This task would be facilitated by a Species Management Plan. Preparation of this plan will be coordinated by the South African National Parks Board (P. Novellie). The process will be launched with a Population and Habitat Viability Analysis Workshop jointly convened by the National Parks Board, the Equid Specialist Group, and the Captive Breeding Specialist Group. The key questions which need to be addressed are listed below.

2. Conserving genetic diversity**

The CDNEC has taken action to conserve the genotype of Cape mountain zebras by (a) defining geographically separate regions for each subspecies and making it illegal to introduce one subspecies into the region reserved for the other, and (b) by making it possible for landowners who already have extralimital Hartmann's zebras to exchange them for the Cape subspecies. Such exchanges are made at no cost to the landowner. We endorse this program, and propose a detailed study of the differences between the two subspecies (page 27) to provide a solid basis for evaluating the opportunity of costly efforts to conserve the subspecies separately in the future.

3. Building up the numbers**

Hartmann's zebras should be allowed to increase naturally. In particular: the government's plans for a protected area in Kaokoland are strongly supported—we encourage the Ministry of Wildlife, Conservation, and Tourism to take all possible actions to promote the welfare of mountain zebras in this area; the policies leading to the establishment of new herds on public and private land are

strongly supported, and should be continued and the CITES classification of the two subspecies should be reviewed.

The impact of large numbers of zebras on semi-arid ecosystems requires evaluation to allow objective decisions to be made on the necessity of limiting some of the populations.

The 600+ remaining Cape mountain zebras occur only in South Africa. Consideration should be given to building up herds outside their ancestral area, in free-ranging conditions, or in zoos if adequate numbers cannot be maintained in free-ranging conditions. This should be done where there is no risk of interbreeding with other subspecies or species. This would also allow research to determine the cause (nutrition, interbreeding) of the low breeding success of the animals in the Mountain Zebra National Park (32 foals/100 females/year).

4. Promoting economic value*

Namibia conserves Hartmann's mountain zebra as part of the world's heritage: the Ministry of Wildlife, Conservation, and Tourism could use this more widely in advertising for tourism.

5. Monitoring the populations*

In view of the relatively low level of numbers to which Hartmann's mountain zebras has fallen, and especially if they are moved from CITES Appendix II, we strongly recommend that the Ministry of Wildlife, Conservation, and Tourism reinforce procedures for monitoring the populations. In particular, aerial counts of the protected areas should be conducted at two-year intervals, and similar quantitative methods should be applied to private and communal lands.

The monitoring of Cape mountain zebras by the National Parks Board, the CDNEC, and Marwell Zoological Park is strongly endorsed. It should be restarted for the Mountain Zebra National Park. These actions are essential for the successful management of these small populations.

Asian Wild Asses

Coordinator: Patrick Duncan

Hemiones (*Equus hemionus*)

1. Preserve the remaining populations of onagers in Iran and establish new ones***

The onagers (*E.h. onager*) urgently need action to save them from extinction. The Bahram-e-Gour and Touran Protected Areas require support for their anti-poaching efforts. Competition with pastoral peoples, particularly for water, needs to be reduced by integrating onager conservation with rural development. A field project is urgently needed to provide the support and impetus needed to get actions underway. Contact has been made with the Iranian Department of the Environment. Sites where other herds could be safely set up within the ancestral range, or even in ecologically similar areas near it, need to be identified and reintroduction projects developed.

2. Building up the numbers of Indian wild asses**

Virtually all the Indian wild asses (*E.h. khur*) in the world (about 2,000) live in the Wild Ass Sanctuary in the Little Rann of Kutch. Numbers of this subspecies need to be built up, and new herds started elsewhere. The goal is a population of at least 2,500 animals (see page 5), managed and monitored under a species management plan coordinated by the Wildlife Institute of India.

The status and management of the sanctuary should be raised to that of a National Park; its carrying capacity could be increased by appropriate habitat management—by stopping the expansion of salt-pans inside the sanctuary; and the high grazing pressure by livestock on its fringes should be reduced. This would require appropriate projects in the fringing areas which integrate conservation of the wild asses with local development.

The feasibility of reintroduction projects elsewhere is currently being evaluated by the WII, in the Ranns of Rajasthan states (Great Indian Tahr Desert). Free-living animals elsewhere in the sub-continent (or zoo herds) could also be advantageous.

3. Set up conservation areas for wild equids in China and Mongolia*

A survey of the two subspecies of dziggetais (*E. hemionus*) and also the three kiangs (*E. kiang*) is proposed by the Xinjiang Institute of Biology. This is strongly endorsed: it should be linked to the preparation of a project proposal for the creation of conservation areas for the remnant populations of dziggetai in China along the Mongolian border and perhaps in the Lop Nor region. A twin project should be developed in Mongolia, and linked to the actions for the reintroduction of Przewalski's horses.

Kiangs (*Equus kiang*)

4. Status and conservation proposals for western and southern kiang***

These subspecies of kiang (*E.k. kiang* and *E.k. polyodon*) live along the border areas of China, India, and Sikkim. It is not certain that the southern kiang still exists. The Wildlife Institute of India is willing to conduct a survey to establish the status of this subspecies and to make proposals for conserving it. Particular attention would be paid to creating protected areas, e.g. establishing national parks at Ruspshu and Chang-Chang-Chenmo and a wildlife sanctuary at Daulat Beg; captive herds in high altitude zoos in India and elsewhere; and launching an in-depth study of the ecology of this species.

5. Monitoring the populations of Asian wild asses*

The status of all the populations, especially the small and threatened ones in Iran, India, Soviet Union, and China need accurate and regular monitoring. The personnel to do this need to be trained to harmonize their techniques, and need to be provided with the funds and equipment necessary to do the counts. These will be promoted as part of projects Hemiones 1, 2, 3 and kiangs above.

Przewalski's Horse

Species coordinator: John Knowles

1. Maintenance of the captive population and its genetic diversity***

The Regional Programs, coordinated by the Global Management Plan Working Group are encouraged to maintain the captive population of Przewalski's horses at the highest level possible, without excluding taxa with more urgent needs from the space available in zoos. We also strongly support the management programs aimed at reducing the loss of existing genetic diversity,

and breeding animals for reintroduction, with low levels of inbreeding and as much experience as possible in fending for themselves, e.g. in semi-reserves.

2. Reintroduction to the wild***
At least five herds of <500 individuals need to be established (page 5) to allow wild-type characteristics to be maintained by natural selection. The current reintroduction programs should be pursued using the best techniques of animal management; developing strong links with the local pastoralists; and creating a cooperative and synergistic interaction between the different projects.

Plains Zebras

Species coordinator: Patrick Duncan

1. Documenting the economic importance of zebras outside protected areas*
Zebras on farmed land generally compete with livestock for water and forage, and may damage fences and crops. However, their main product, the hide, is complementary to the products of livestock, so mixed farming has economic potential. This economic potential is realized on both communally and privately owned land (Zimbabwe, Botswana, Namibia, South Africa) in some countries but not in others. Generalization of this practice would contribute to maintaining the populations outside protected areas. A study is required to document and diffuse information on the economic benefits of zebras on farmed land, on the current level of trade in zebra hides and meat, and on efficient farming and marketing practices. Particular attention should be paid to mechanisms which allow benefits to be channelled to users of communal lands.

2. The genetic management of the metapopulation*
Many of the small populations in protected as well as in farmed areas will lose genetic diversity unless animals are exchanged to allow gene flow. Such exchanges should be made, but only within subspecies. The need for a thorough genetic analysis of the plains zebra population was presented (page 1 and below). This work should be coupled with a survey of the numbers and trends of zebras in Zaire, Zambia, Angola, Namibia, Mozambique, and Swaziland. When, on the basis of the results of this study the genetic structure of the metapopulation is understood, a management plan should be prepared to coordinate exchanges of animals within the subspecies' populations.

3. Monitoring the numbers*
The numbers of wild plains zebras will be monitored by representatives of the Equid Specialist Group (ESG) in each country, and compiled by the ESG Plains Zebra Coordinator. The numbers of the captive herds will be monitored by ISIS. Information on the geographical origin of the animals is needed to document the whereabouts of captive representatives of endangered and vulnerable subspecies. A special meeting of the ESG is required to launch a continent-wide field survey, and to coordinate monitoring of the wild and captive populations.

For the Genus as a Whole

Uncertainties about the genetic differentiation of the surviving equid populations make it impossible to determine priorities for conservation action in a satisfactory way (see page 1). This urgent problem can be resolved only through a thorough comparative study of all the populations. The project will be carried out by the Center for Reproduction of Endangered Species, San Diego, United States. They will include the application of the most modern techniques, chromosomal and protein electrophoretic as well as molecular biological (e.g. mt-DNA mapping).

1. Genetic differentiation among equid populations**
Coordinator: Oliver Ryder

African wild asses and donkeys
The genetic differentiation of Nubian and Somali wild asses, feral populations in Algeria and the Nubian desert, and donkeys will be tested by screening as large samples as possible, using captive and free-living animals.

Mountain zebras
Genetic differences between the Namibian and South African populations need to be determined in order to evaluate the need for separate management.

Asian wild asses
Additional field material is required for study of the genetic differentiation from all of the populations, particularly the kiangs.

Plains zebras
A study of genetic differentiation in the plains zebra, the last abundant equid, would provide a useful model for the genetic structure of a large and widely ranging equid population. Such an understanding is urgently needed for planning the conservation of the genetic diversity of this and other fragmented equid populations, especially where genetic diversity is threatened by small population effects.

Feral horses
Genetic information is urgently needed in order to objectively identify populations of (national and international) importance for the conservation of genetic diversity.

2. Management of overabundant populations*
Coordinator: Patrick Duncan

A technical manual on management methods for free-living equids is urgently required to disseminate safe, efficient, and humane methods of managing the size of feral and wild equid populations.

3. Understanding the regulation of equid populations*
Coordinator: Patrick Duncan

Protected areas will continue to underpin the conservation of wild equids. In most of these areas the populations maintain themselves, but in some the numbers are declining (e.g. Etosha National Park), and in others the numbers have declined and then increased (Kruger National Park). Very little is known of the relative importance of the food supply, predation, and disease in the regulation of their numbers. An ecological research project is required to address this question. The plains zebra is obviously the best model; if possible, a parallel project should be conducted on a territorial species—Grevy's zebra and/or one of the Asian wild asses.

Appendix 1: Numbers of Plains Zebras

The abbreviations of the protected areas (e.g. NP) can be found in IUCN/UNEP (1987).
***=range principally within a Protected Area.**

Area	Year	Number	Status	Reference
Grant's zebras (*Equus burchelli boehmi*)				
Ethiopia				
Yabello WS* + area	1990	1290±180	? stable	P. Syvertsen in litt. 2/92
Nechisar NP*	1988-1989	hundreds	? decreasing	Ato Tadesse Gebre-Michael & Ato Fekadu Kassaye in litt. 1/90
Mago NP*	1986	tens	? decreasing	
Omo NP*	1990	few	decreasing	J.C. Hillman in litt. 1/91
Total		**perhaps 2,000**	**decreasing**	
Number in protected areas		**majority**		
Sudan	**?**			
Somalia		**perhaps 1,000**	**decreasing**	J.B. Sale in litt. 11/91
Number in protected areas		none		
Kenya				
Total	**1987-1988**	**141,000**	**?**	**P. Wargute pers. comm. 7/92**
Number in protected areas		**>50 %**		
Uganda				
Lake Mburo NP*	1991	>3,000	increasing	M. Infield in litt. 7/91
Kidepo Valley NP*	1991	few	decreasing	M. Infield in litt. 7/91
Total	**1991**	**3,000**	**increasing**	
Number in protected areas		**virtually all**		
Rwanda				
Akagera NP & Mutara*	1990	3,800±650	? stable	R. Beudels in litt. 11/90
Surrounding areas		present ?	? stable	R. Beudels in litt. 11/90
Total	**1990**	**4,000**	**? stable**	
Number in protected areas		**virtually all**		
Burundi		**extinct 1961**		Klingel 1980
Tanzania				
Burigi-Biharamulo	1990	5,160	?	TWCMD in litt. 2/92
Katavi-Rukwa area*	1991	20,865	increasing	TWCMD in litt. 2/92
Lake Manyara*	1980	225	?	TWCMD in litt. 2/92
Mkomasi*	1991	1,826	?	TWCMD in litt. 2/92
Moyowosi-Kigosi	1990	1,525	?	TWCMD in litt. 2/92
Ngorongoro Crater*	1990	4,330	stable	TWCMD in litt. 2/92
Ruaha ecosystem*	1990	32,200	increasing	TWCMD in litt. 2/92
Saadani GR* and area	1991	34	?	TWCMD in litt. 2/92
Serengeti ecosystem*	1989	256,562	stable	TWCMD in litt. 2/92
Selous ecosystem*	1991	32,880	stable	TWCMD in litt. 2/92
Tarangire ecosystem*	1990	34,500	stable	TWCMD in litt. 2/92
Ugalla River G.R.*	1977	247	?	TWCMD in litt. 2/92
Total		**390,000**	**stable**	**TWCM 1991**
Number in protected area		**majority**		
Upper Zambezi zebras (*E. b. zambesiensis*)				
Zaire				
Kundelungu NP*		?	extinct in 1980s	C. Aveling in litt. 9/91

Area	Year	Number	Status	Reference
Upemba NP*		present	?	C. Aveling in litt. 9/91
Total		**?**		
Number in protected areas		**virtually all**		
Angola				
Bikuar NP*	1970	present		JCM Cabral in litt. 5/91
Iona NP*	1982	>100	?	Horsten 1982
Mupa NP*	1982	present		?
Chimalavera RNP*	1970s	present	?	Horsten 1982
Mavinga PR*	1970s	present	?	Horsten 1982
Moçamedes PR*	1970	present	?	
Luiana*	1970s	present	?	Horsten 1982
Total		**?**		
Number in protected areas		**?**		
Zambia (W)				
Kafue NP* & flats	1989	7,700	?	Jeffrey et al. 1989
Liuwa Plain NP*	1969	present	?	Benson 1969
Sioma Ngwezi NP*	1969	present	?	Benson 1969
Elsewhere		?		
Total		**>8,000**		
Number in protected areas		**majority**		
Crawshay's zebras (*E. b. crawshayi*)				
Mozambique (N)				
Rovuma PR/Niassa PR	1985	present	?	IUCN 1987
Total		**?**		
Number in protected areas		**?**		
Malawi				
Nyika NP*	1989	250	?	Simons et al. 1991
Vwasa marsh GR*	1989	68	decreasing	Simons et al. 1991
Kasungu NP*	1989	300	decreasing	Simons et al. 1991
Nkhotakota GR*	1989	100	?	Simons et al. 1991
Majete GR*	1989	0	extinct	Simons et al. 1991
Total		**perhaps 1,000**		
Number in protected areas		**virtually all**		
Zambia (E)				
Luangwa Valley NP*	1979	15,300	?	D-Hamilton et al. 1979
Chapman's zebra (*E.b. chapmanni*)				
Mozambique (S)				
Gorongosa NP*	1979	3,000	?	Tello 1986
Elsewhere		?		
Crawshay's/Chapman's zebra hybrids				
Zimbabwe				
Total	**1989**	**6,000**	**increasing**	**Dept. National Parks in litt. 1/90**
Number in protected areas		**majority**		

Area	Year	Number	Status	Reference
Chapman's/Damara zebra hybrids				
Namibia				
Kaudon GR* (W Caprivi)	1989	50	decreasing	M. Lindegue in litt 1/90
Eastern Caprivi GR*	1989	250	decreasing	M. Lindegue in litt 1/90
Total		**300**	**decreasing**	
Number in protected areas		**100%**		
Botswana				
Chobe/Savuti/Ngamiland pops.	1991	28,000	? decreasing	Bonifica SPA 1992
Makgadigadi pop.	1991	19,000	decreasing	Bonifica SPA 1992
Total		**47,000±17,000**	**decreasing**	
Number in protected areas		**60%**		
Damara zebras (*E. b. antiquorum*)				
Namibia				
Etosha NP*	1989	6,300	decreasing	W. Gasaway in litt. 5/91
Farms & communal land	1989	< 2,000	decreasing	W. Gasaway in litt. 5/91
Total		**9,000**	**decreasing**	
Number in protected areas		**majority**		
South Africa				
Kruger NP*	1989	33,000	stable	Nat. Parks Board in litt. 5/91
Transvaal 21 Reserves*	1989	1,500	stable	Nat. Parks Board in litt. 5/91
Tansvaal farms	1989	?	stable	Nat. Parks Board in litt. 5/91
Free State farms	1989	2,500	stable	Nat. Parks Board in litt. 5/91
Natal 12 Reserves*	1989	3,500	stable	Nat. Parks Board in litt. 5/91
Cape Prov. Reserves*	1989	150	stable	Nat. Parks Board in litt. 5/91
Cape Prov. farms	1989	1,120	stable	Nat. Parks Board in litt. 5/91
Total		**42,000**		
Number in protected areas		**90%**		

The 13 founders fall into six main groups, which were very closely inbred in the early generations (Geyer and Thompson 1988). The different lines are often known by the location of the collections where they were held:

Group 1	1Kobd1	
	5 Kobdo 5	Old Askania Nova line
	52 Kobdo C	
Group 2	11 Bijsk 1	
	12 Bijsk 2	Prague line
	Domestic (DOM)	
Group 3	17 Bijsk 7	
	18 Bijsk 8	Munich (U.S.) line
Group 4	39 Bijsk A	
	40 Bijsk B	
Group 5	211 Woburn 6	Woburn line
	212 Woburn 7	
Group 6	231 Orlica III	New Askania Nova line

The global Przewalski's horse population is divided between regional cooperative management programs that are already in place or are under development. These are in North America (through the Species Survival Plans or SSPs of the American Association of Zoological Parks and Aquariums), the United Kingdom and continental Europe (through the Europaisches Erhaltungszuchtprogramm, known as the EEP), in the Soviet Union (through the All-Union Federation of Zoological Parks) and Australia (under the Australasian Species Management Scheme). All regional efforts are coordinated by the International Studbookkeeper of the Przewalski's Horse (Prague Zoo, Czechoslovakia, Ryder 1990a).

As of August, 1990 there were 173 horses in the SSP (Ryder 1990c) and in February 1991 the EEP comprised 516 horses (W. Zimmermann, pers. comm.). With 44 in the Australian program as well (as of September 1990), approximately three-quarters of the captive population are in a formally managed program.

A genetic analysis of the captive population through its history to the present day, provides a revealing picture of the rate of loss of genetic variation in relation to captive management (Geyer et al. 1989). The genetic diversity of a species enables it to survive and reproduce under existing conditions and to adapt to changed environmental conditions in the future (Seal et al. 1990). Small populations lose genetic diversity at both the population level, due to genetic drift, and at the individual level, due to inbreeding.

The genetic diversity of the current captive population is measured relative to that of the founders. Each of the 13 founders is considered to have carried two distinct alleles at each locus, giving a total of 26 distinct alleles. Today, the average number of distinct alleles at autosomal loci is 10.476 (Geyer and Thompson 1988).

Figure 10 shows the mean number of surviving alleles per locus from each of six groups of founders plotted through the captive history of the species. The groups are arranged from bottom to top in order of increasing amounts of gene loss. It shows that there was a rapid and steady loss of alleles from the beginning of the captive population to 1970, since which time the population has been well managed and the loss of diversity has been negligible. Figure 11 shows the mean number of surviving genes plotted against population size. Rapid loss of allelic diversity continued while the population remained small; it was not until 1963 that the population reached 100 individuals, and since then the population has doubled about once every nine years. This has led to a corresponding slowing down of gene loss. The regional programs aim to preserve 90% or more of the genetic diversity present in the living population today. The theoretical population size required to achieve this is 800 (Seal et al. 1990).

Genetic analysis has also been used to reveal the extent of the domestic influence on the pedigree and guide breeding program design. Of the 10.476 distinct alleles that survive on average at each

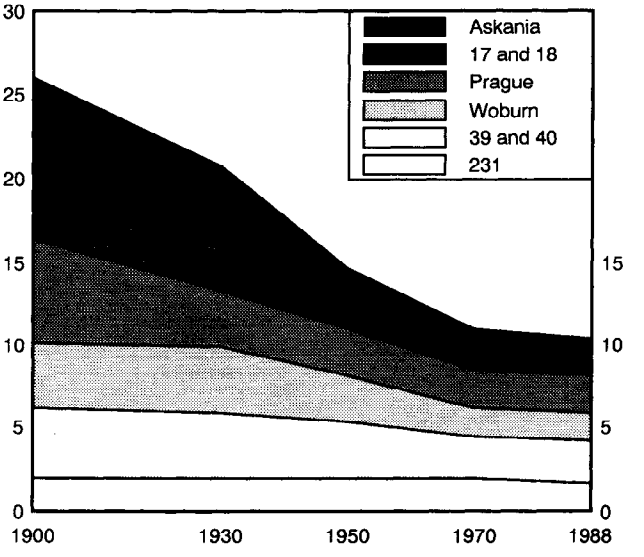


Figure 10. Number of surviving Genes from Founder Groups through History. The founder groups are Askania (Old Askania Nova line, 1, 5 and 52), 17 and 18, Prague (Old Prague line 11, 12 and DOM), Woburn (Woburn line 211 and 212), 39 and 40 and 231 (New Askania Nova line; from Geyer et al. 1989, with permission from Zoo Biology).

locus, 0.568 come from the domestic founder (DOM); however, of the 1516 horses in the pedigree analyzed by Geyer et al. (1989), 978 were DOM and her descendants, all through 56 Halle 1. A further 0.270 would come from one parent of 18 Bijsk 8 if it was an F1-hybrid. Thus, 9.638 wild-type genes per locus definitely remain.

Until mid-1988, the breeding program for the Przewalski's horse in the U.S. divided the population into two groups: those with and those without descent from DOM. In the group with descent from DOM only the mares were bred, to stallions without descent from DOM. The stallions with descent from DOM were never bred. This strategy was designed to reduce the frequency of the domestic genes in the group with descent from DOM while maintaining the growth rate of the total

population. However Geyeret al. (1989) highlighted that this would also exclude all genes from the two wild founders 11 Bijsk 1 and 12 Bijsk 2, because all of their descendents are also descended from DOM and vice versa. There are also other genes from the wild founders present in the horses descended from DOM but not in the non-DOM line, those genes that by chance were transmitted to the DOM horses and not the "pure" horses.

In order that these genes should not in fact be bred out of the North American subgroup descended from DOM, the breeding policy was changed in 1988 (Ryder et al. 1988). Both mares and stallions with descent from DOM are bred but gene flow is always one-way, from the non-DOM horses to those descended from DOM. Mares with no descent from DOM are never bred to stallions of the DOM subgroup. Thus two groups are still maintained, but the DOM group is now being managed to retain the genetic diversity that it represents.

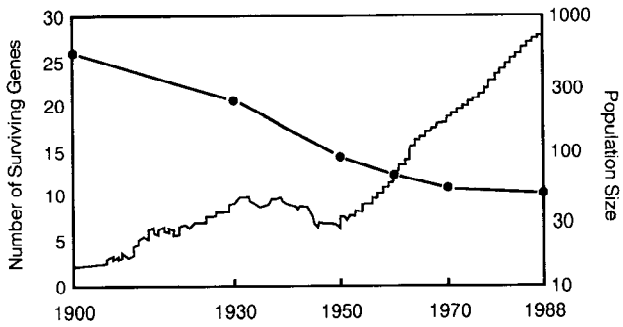


Figure 11. Gene Survival versus Population Size. The declining line is number of surviving genes (axis on left), and the increasing line is population size (axis on right). Note the log scale for population size (from Geyer et al. 1989, with permission from Zoo Biology).

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2. *Action Plan for Asian Primate Conservation: 1987-1991.* Compiled by A.A. Eudey and the IUCN/SSC Primate Specialist Group, 1987, 65 pp. (out of print).
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