

# Special challenges of maintaining wildlife in captivity in Europe and Asia

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*Summary:* In the second half of the 20th century, populations of many wild animal species have been established in captivity for various purposes (e.g. education, conservation, research, farming) and many are kept as companion animals. With continuing human pressure on the environment, captive or semi-captive management is likely to become a component in the conservation of an increasing range of species throughout Europe and Asia. The management of small and divided populations (some of which may be in zoos while some are free-ranging) requires careful control to minimise loss of genetic diversity. This, in turn, may require movements of animals or germplasm between sub-populations. A potentially serious hazard associated with these translocations is the accidental introduction of infectious agents into populations which have hitherto been geographically or ecologically isolated from these agents. When planning translocations, the state veterinary authorities of both importing and exporting countries should be contacted at an early stage for details of legal requirements in relation to animal health, welfare and conservation. Animal health legislation is mostly aimed at preventing disease in man and domestic animals, and further disease control measures may be required when translocating wild animals. In addition to the need for efforts in ensuring genetic diversity and disease control, good husbandry and welfare can often be challenging in species about which relatively little is known. A variety of organisations are involved in coordinating captive breeding programmes in Europe and Asia, and some of these organisations and the routes through which they can be identified are mentioned here.

**KEYWORDS:** Captive breeding – Conservation – Infectious diseases – Management – Translocation – Welfare – Wildlife species.

## INTRODUCTION

There is a long tradition of maintaining some wild animal species in captivity (e.g. for centuries, birds of prey have been kept for falconry). Until recently, however, few species were kept on a large scale. This has changed over the last half century, with breeding groups of a wide range of wild animals having been established. The reasons for this include commercial, scientific, conservation and welfare factors. Intensive management under captive or semi-captive conditions is likely to play an increasingly important role in the conservation of endangered species in the future, and this is the main focus of this paper.

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Before proceeding, it is worth emphasising that the word 'captivity' is used to describe a wide range of circumstances, from the close confinement of some pet or laboratory animals to the semi free-ranging state of, for example, park deer. As the natural habitats of many species have been altered, diminished or taken over by the growing human population, the fate of many species has become so closely dependent on human affairs that the distinction between captive and free-ranging states has become blurred, to some extent, in two ways. First, there is often relatively little difference in the degree to which the fate of captive and free-ranging populations is dependent on humans, and there is therefore little case for upholding a marked distinction in the degree of responsibility entailed by human stewardship of these different populations. Second, the conservation of an increasing range of species depends on the application of the same active management procedures, regardless of whether the populations are on reserves or are kept in a more closely confined and regulated environment (28).

## **REASONS FOR MAINTAINING WILD ANIMALS IN CAPTIVITY**

### **Maintenance in captivity for conservation**

The human population of the world doubled between 1950 and 1987. The current figure is 5.5 billion, but this is predicted to rise to 6.4 billion by the year 2000, and to 10 billion by 2050. The figure may stabilise at between 11 and 12 billion (23). Not only are humans very numerous, but we utilise energy and other resources and produce waste at biologically unprecedented rates; we have also introduced an array of novel, toxic and persistent chemical agents into the environment (29).

As a result of competition for resources, and the damage and disturbance caused to the environment by the human population, many species are seriously threatened. Over the last 400 years, approximately 490 species of animals are known to have become extinct (36), and recent estimates suggest that up to 1,350 species of birds (i.e. 12% of bird species) will be committed to extinction by the year 2015 unless recent trends can be reversed (19; see also 6). The scale of the threat is similar in other vertebrate taxa. For example, 647 (15%) of mammal species and 3,161 (7%) of all vertebrates are considered to be threatened or endangered (37, 52). Many species of invertebrates are also threatened. Techniques for assessment of the viability of populations vary, and objective description of the degree and immediacy of threats is difficult (9). These estimates will be continually revised, but there is no doubt that the situation is very serious.

The survival of many species is already dependent on the active management of populations, and this is likely to be true for an increasing range of species in the future (53). Captive breeding is already an important component of the conservation strategy for many species, and this practice may become relevant for an increasing range of species as pressures on the environment escalate. The captive propagation of wild animals presents many challenges. These populations are often small, and chance mishaps (such as epidemics or natural disasters), together with the possible deleterious consequences of gradual loss of genetic diversity, make long-term survival precarious (2, 40, 46).

Many captive breeding programmes for endangered species are coordinated internationally through organisations such as the Species Survival Commission (SSC) of the International Union for the Conservation of Nature (IUCN) and the specialist groups of the SSC (these groups and their membership are listed in an SSC membership directory [22]). The IUCN Captive Breeding Specialist Group plays a coordinating role in captive breeding programmes for many species (52). In addition, various regional organisations coordinate captive breeding programmes, including the European Endangered Species Programmes and the Indonesian Zoological Parks Association. For many species, there is also coordination at the national level, e.g. by the Joint Management of Species Programme in the United Kingdom and Ireland. Valuable information about current programmes (by region and by taxa), as well as the names and addresses of persons and organisations coordinating these programmes, are available from current IUCN SSC membership directories (22) and in current regional yearbooks (4, 43, 44).

Many of the species maintained in captivity as part of conservation programmes in Europe and Asia are exotic to these continents. For example, many African and Australian species are present in European and Asian zoos (4, 43). Although it is difficult to generalise, the maintenance of wild animals in captivity is probably more problematic outside their normal geographical range than within this range. There are a variety of reasons for this, including possible exposure to stressful climatic conditions, possible exposure to novel hazardous flora and infectious agents, and disturbances to seasonal breeding patterns. As a general principle, therefore, it is preferable to site breeding programmes in the country of origin, if possible. *In situ* captive-breeding programmes are under way in many European and Asian countries for a wide and growing variety of vertebrate and invertebrate taxa, ranging from Asian elephants (*Elephas maximus*) to wart-biter crickets (*Decticus verrucivorus*).

### **Maintenance of wildlife casualties in captivity**

Interest in the rescue and rehabilitation of wildlife casualties has markedly increased in some countries of both Europe and Asia, and a large number of wild animals are brought into temporary or permanent captivity each year through these endeavours. These activities are performed by some welfare organisations, some zoos, and a growing number of private individuals. Facilities and standards of care vary greatly. Although treatment of casualties can be relevant to the conservation of small, free-ranging, endangered populations, most wildlife rehabilitation is motivated by concern for the welfare of the individual animals, and the bulk of cases involve relatively common species.

There is no doubt that human activities and alterations to the environment have a major negative effect on the welfare of large numbers of free-ranging wild animals (32, 49). Veterinary care of free-ranging wild animals is a controversial subject (26, 27), however, and steps taken to avoid harming wildlife are usually more appropriate than treatment and rehabilitation of casualties. Although policies differ, many organisations do not limit their attention to animals harmed as a result of human activities or environmental changes. Veterinary medicine of wild animals has developed to the stage where sick or injured wild animals can often be treated successfully and returned to the wild. The level of public interest and support seems likely to ensure that such efforts will continue to expand.

Regulation of wildlife rescue, treatment and rehabilitation varies considerably between countries. These activities are not permitted in some countries, while in others

a licence is required; in some countries there are few specific legal constraints, provided that the intention is to return the animal to the wild when it has recovered. In Great Britain, the British Wildlife Rehabilitation Council acts as a forum for the dissemination of information and provision of advice on the treatment and rehabilitation of wildlife casualties (18, 55). Similar organisations have been established in many countries.

### **Maintenance in captivity for research**

A variety of species of wild animals are maintained in captivity for research (46). Large-scale capture of free-ranging wild animals for biomedical research – such as occurred during the 1960s and 1970s – has mostly ceased, but some species are still taken from the wild for research purposes. The degree to which the use of animals in research is regulated by law varies between countries. This work is covered, in the United Kingdom, by the Animals (Scientific Procedures) Act 1986 and, in the European Union, by Council Directive 86/609/EEC.

### **Maintenance in captivity as pet or companion animals**

The number and range of wild animals kept as pets has increased greatly in many countries over the last twenty years. Part of the demand is met from captive breeding, but large numbers of birds, reptiles and mammals are still captured from the wild for this trade. Some species breed readily in captivity and some hobbyists maintain large groups. In many European and Asian countries, taking animals from the wild is illegal; not all taxa or regions are fully protected, however, and large-scale capture threatens species survival in some cases. For example, several species of amphibians and reptiles are currently under threat in the former Soviet Union as a result of commercial collection for the pet trade (35). International movements of wild animals (wild-caught or captive-bred) are controlled by the Convention on International Trade in Endangered Species (CITES) (37) and a range of animal health legislation (see below).

Disposal of animals which are intercepted during illegal importation or confiscated due to illegal ownership, or for other reasons, is a problem encountered in many countries. In general, it is inappropriate to return these animals to their country of origin, both on welfare grounds and also because they may have acquired exotic infections while in contact with other species in transit, or in the country in which they have arrived. Furthermore, unless the precise origin of the animal is known, there is a danger that they may be released into the range of a different subspecies and cause genetic 'pollution'. Euthanasia is often not considered to be an acceptable option, and attempts are frequently made by customs authorities to find homes for such animals in zoos or animal rescue centres.

### **Maintenance in captivity for commercial production**

Some wild animals are farmed for meat, fur or other commodities. In Europe, examples include the farming of mink and foxes for their fur, and the farming of ratites, deer and bovids for meat, hides and/or antlers. Similarly, wild animals are kept for meat and fur production in Asia, and in China bears are farmed to supply a local demand for bear bile (38).

## PROBLEMS OF MAINTAINING WILD ANIMALS IN CAPTIVITY

As described above, wild animals are maintained in captivity in Europe and Asia for a variety of reasons. Each case presents its own particular problems. For example, if animals are being maintained as part of a species conservation programme, measures to preserve genetic diversity are crucial and, if animals are to be released into the wild, prevention of simultaneous accidental introduction of infectious disease is essential. Particular challenges of maintaining genetic diversity, controlling infectious diseases, and other aspects of good husbandry are described below, but first a few general comments are pertinent.

Considerable debate surrounds the ethics of maintaining wild animals in captivity (41). There is some consensus, however, that this practice is acceptable as an important component of a conservation programme (either directly or through education), to promote the welfare of the animal itself or, more controversially in some cases, for various fields of research. Whatever the reason for keeping wild animals, it is most important that detailed consideration be given to welfare requirements.

All the disciplines of animal husbandry and medicine are relevant to the management of wild animal populations at all points on the spectrum from captive to free-ranging. In the second half of the 20th century, great advances have been made in the medicine and husbandry of wild animals. Nevertheless, the level of knowledge in these disciplines for even the best-studied wild animals is, in general, considerably lower than for domestic species. Literature on the veterinary science of wild animals is extensive and rapidly-growing; valuable overviews of progress in some areas are provided, for example, by Fowler (10, 11), Ritchie *et al.* (48) and Frye (13). Recent editions of the *Journal of Zoo and Wildlife Medicine*, the *Journal of Wildlife Diseases* and *Erkrankungen der Zootiere* (Proceedings of the International Symposia on Diseases of Zoo and Wild Animals, *Akademie der Wissenschaften*, Berlin, in which many articles are published in English) are also very useful sources of information.

### **Maintenance of genetic diversity**

One of the major challenges in the conservation of small, endangered populations is the maintenance of genetic diversity. Genetic diversity may be lost through 'founder' effects (when populations are derived from relatively few founders which, in any case, may have been related), genetic drift, inbreeding (some degree of which is inevitable in small populations) and chance demographic events (e.g. loss of genetically valuable individuals before breeding).

For conservation, the division of a population into a number of separate or semi-independent (free-ranging and/or captive) sub-populations has several advantages (7). In this way, genetic diversity can be maintained at higher levels, and extinctions – either through chance demographic events (e.g. chance skewing of the sex ratio) or accidents (e.g. epidemics or natural disasters) – are unlikely to affect all sub-populations simultaneously. Also, reservoirs of cryo-preserved semen, ova and embryos may be used in the genetic management of populations (20).

Movements of animals, or gametes or embryos, between sub-populations (e.g. between zoos or other collections) are necessary to avoid inbreeding and to preserve genetic diversity. Therefore, in addition to the need for sophisticated genetic management of populations (coordinated through the programmes mentioned above),

it is also necessary to deal with the practical, logistic and legal problems of moving animals or their genetic material within and often between countries (see below).

### **Controlling infectious diseases**

Infectious diseases can present serious threats to captive-breeding programmes, both directly (by causing disease or mortality) and indirectly (by restricting international and other animal movements) (56). Key elements in the control of infectious diseases are knowledge of the disease status of the populations into and out of which any translocations may be made, and appropriate quarantine and screening of the animals to be translocated. There are, however, serious difficulties in disease screening. For some diseases (e.g. spongiform encephalopathies), no reliable test may be available for the detection of affected animals or carriers; alternatively, where diagnostic tests are available, their use in non-domesticated species may not have been evaluated or may be unreliable (e.g. tuberculin tests) (14). Furthermore, it is likely that many species of wild animals may carry infectious agents which have not yet been recorded in these species.

Not surprisingly, as the veterinary science of wild animals is still in its infancy, many diseases of wild animals are poorly understood, and previously-undocumented infectious diseases are being recognised with increasing frequency. The many diseases recognised in recent years include the following: morbillivirus diseases of seals and cetaceans (25, 8), and lions (1); hepatitis caused by lymphocytic choriomeningitis virus in Callitrichidae fed on neonate mice (50); spongiform encephalopathies of various species of Bovidae and Felidae (31); infection with immunodeficiency virus of Felidae (5); European brown hare syndrome (16); polyomavirus infection in budgerigars and other psittacine birds (15); and various virus infections of reptiles (24, 51).

Many more infectious diseases await discovery. One of the most important hazards associated with animal translocations – whether between sites in the wild, between captive populations, or from the wild to captivity (or vice versa) – is exposure of animals to pathogens which they have not previously encountered. Some infectious agents cause little or no clinical effect in ‘usual’ host species but cause severe disease in other species (12). This is the case, for example, for several herpesviruses (e.g. *Herpesvirus simiae*, *Herpesvirus hominis*, alcelaphine herpesvirus 1 and some avian herpesviruses) which cause fatal disease in species closely related to, but geographically or ecologically separated from, their ‘usual’ host species. Similarly, marked differences may be observed between usual and new host species in the epidemiology of bacterial, parasitic and other infectious diseases. These differences may arise when animals become infected with agents not encountered by the species in recent evolution. The effects of such diseases on populations may be unpredictable, and control measures appropriate for the disease in the usual host may not be appropriate with a new host.

The severity of legislation covering intra- and international movement of animals or animal tissues varies greatly between countries and with time, and detailed consideration of this topic is beyond the scope of this review. The best strategy when planning to move animals, or animal tissues or germplasm, is to contact the state veterinary authorities of both the importing and exporting countries well in advance of transportation, to find out what measures will be needed to meet the requirements

of animal health, conservation (i.e. CITES) and welfare legislation. The process of arranging such translocations is often prolonged.

It is important to be aware that animal health legislation in this field has been developed largely or exclusively with the aim of protecting the health of production animals and humans. Existing legislation tends to be rather blind to the possibility of accidental introduction of diseases which may affect captive or free-ranging wildlife, and may not provide protection against this. Statutory quarantine, screening and prophylactic measures should not therefore be assumed to be all that is required when moving non-domesticated species. Detailed consideration should be given to the possible infectious agents which an animal or group might carry, in the light of knowledge of the species and of the areas from which and (if relevant) through which it is to be transported. The risks should be assessed (2) and appropriate measures should be taken. The translocation should be reviewed if there are any potentially serious risks which cannot be satisfactorily addressed.

In general, the risk of disease transmission associated with artificial insemination and embryo transfer techniques is lower than that which is associated with animal translocations (57), although many infectious diseases can be transmitted in semen. It has been found that transferring seven-day-old blastocysts, using the protocols approved by the International Embryo Transfer Society, presents relatively little risk of transmitting many viral and bacterial diseases of domestic animals (45), although some important diseases may be transmitted in this way. Useful reviews of the disease transmission risks associated with artificial insemination and embryo transfer have been provided by Philpott (45), Hare (17) and Singh (54). Codes for the hygienic collection and handling of semen, ova and embryos for domestic animals are published by the Office International des Epizooties (42).

## **Husbandry**

Impediments to the long-term propagation and genetic conservation of small populations vary between species. Diseases, especially those related to animal management systems, have been very important in this context. For example, vitamin D3 deficiency was a major factor limiting captive populations of marmosets and tamarins (*Callitrichidae*) prior to 1967, when the importance of dietary D3 was discovered (21). Nutritional diseases, especially nutritional bone disease, remain a common problem in some taxa. The main constraints to successful long-term propagation may be fairly easily resolved in some cases but not in others. The problems may be complex and multifactorial, and thus difficult to diagnose and subsequently treat or prevent.

Full understanding of a disease often depends on a thorough knowledge of the normal form and functioning of an animal, and basic information which may be readily available for domestic species is often scant or unavailable for wild species. Thus, for example, metabolic rates have been measured in only approximately 17% of mammal species and 5% of birds (30), the pattern of post-natal weight gain has been described for only about 10% of mammal species (33), and data on normal haematology are available for approximately 10% of mammal and bird species (3).

A large body of literature exists concerning or relevant to the captive husbandry of a wide range of taxa. Due to the scale of the subject, however, few attempts have been made to produce comprehensive reviews and compendia (34, 47). Such information

must therefore be obtained via library search facilities, where available, or through contact with appropriate specialist groups (e.g. of the IUCN or within the international zoo community: see 'Maintenance in captivity for conservation' above).

### **Welfare**

Even when major problems which may have limited the viability of captive populations in the early stages of developing appropriate husbandry techniques have been overcome, additional problems often remain. Although these problems may be of minor relevance in sustaining the population, they can seriously compromise welfare and therefore demand attention. Problems in this category often account for significant resources in the veterinary care and husbandry of small populations in captivity. Such problems include minor diseases associated with nutrition, husbandry, infections and/or stress (e.g. due to boredom or social conflicts). In recent years, awareness has increased regarding the need to provide animals with environments which allow the expression of a full range of normal behaviours (39). Standards vary considerably between countries, however, and are influenced by cultural and economic factors.

Laws or codes which set forth standards for husbandry of captive wild animals vary both between countries and depending on the purpose for which wild animals are maintained. For example, in the United Kingdom, standards of husbandry for wild animals are covered by the Animals (Scientific Procedures) Act 1986 if the animals are kept for research, and by the Zoo Licensing Act 1981 if they are kept in zoos. There is no specific legislation concerning the husbandry of the same species in captivity, as wildlife casualties or as pets.

In some cases, where no legislation exists, voluntary codes of practice have been developed as a step in the process of raising standards of husbandry. For example, the membership of the European Association of Zoos and Aquaria has adopted a set of standards on the management of animals in zoos.

## **CONCLUSION**

Due to growing human pressures on the environment, it is likely that increasingly active management will be needed for the conservation of many species of wild animals. It is envisaged that the conservation of some species will require the integrated management of captive and free-ranging sub-populations, involving the translocation of animals or germplasm between these sub-populations to maintain genetic diversity. As these populations are often spread across several countries, such conservation programmes require a high degree of international co-operation. The accidental introduction of infectious disease into naive populations is one of the greatest risks associated with the transportation of animals or animal products. A considerable body of legislation has been enacted to protect the health of domestic animals and humans against these risks, and the impact of this and other legislation on planned translocations needs to be considered well in advance. The implications of the potential transmission of infectious disease to captive and free-ranging wildlife populations need to be carefully considered before any translocation, and it should not be assumed that animal health legislation covers these risks adequately.

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## LES PROBLÈMES SPÉCIFIQUES AU MAINTIEN EN CAPTIVITÉ DE LA FAUNE SAUVAGE EN EUROPE ET EN ASIE. – J.K. Kirkwood.

*Résumé : Depuis 1950, des populations appartenant à de nombreuses espèces animales sauvages ont été réduites à la captivité pour diverses raisons (éducation, conservation, recherche, élevage) ; plusieurs de ces espèces font maintenant partie de la catégorie des animaux de compagnie. En raison de la pression constante que l'homme exerce sur l'environnement, les systèmes de gestion en captivité ou en semi-captivité seront certainement appelés à contribuer à la conservation d'un nombre croissant d'espèces dans toute l'Europe et l'Asie. La gestion de populations réduites et isolées (certaines étant maintenues dans des parcs zoologiques tandis que d'autres vivent en liberté) demande un contrôle rigoureux afin de minimiser les risques d'appauvrissement génétique au sein de ces populations. Ceci peut exiger que l'on déplace des animaux (ou leurs semences) entre sous-populations. Un risque potentiellement élevé lié à ces déplacements concerne l'introduction accidentelle d'agents pathogènes au sein de populations jusqu'alors protégées par leur situation géographique ou écologique. Lorsque de tels déplacements sont planifiés, il convient de demander préalablement aux autorités des Services vétérinaires des pays importateur et exportateur toutes les informations nécessaires concernant les dispositions prévues par la loi en matière de santé animale, de protection et de conservation des espèces. La législation en matière de santé animale porte essentiellement sur la prévention des maladies chez l'homme et les espèces domestiques ; des mesures supplémentaires de contrôle peuvent donc s'avérer nécessaires lors des déplacements d'animaux sauvages. Outre les efforts requis par la sauvegarde de la diversité génétique et le contrôle sanitaire, les systèmes d'élevage et la protection de ces espèces relativement peu connues soulèvent souvent des problèmes. Différentes organisations s'occupent de la coordination des programmes de reproduction en captivité, en Europe et en Asie ; l'auteur en identifie certaines, ainsi que les moyens d'entrer en communication avec elles.*

MOTS-CLÉS : Conservation – Déplacements – Espèces sauvages – Gestion – Maladies infectieuses – Protection animale – Reproduction en captivité.

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## DIFICULTADES ESPECIALES DEL MANTENIMIENTO DE LA FAUNA SALVAJE EN CAUTIVIDAD EN EUROPA Y ASIA. – J.K. Kirkwood.

*Resumen: A lo largo de esta segunda mitad de siglo, poblaciones de muchas especies salvajes han sido reducidas a la cautividad con fines diversos (por ejemplo: educación, preservación, investigación, cría), y no pocas de ellas se utilizan hoy como animales de compañía. Dada la continua presión humana sobre el medio ambiente, es muy probable que el manejo de animales cautivos o en semilibertad se convierta en un parámetro importante de la preservación de un número creciente de especies en toda Europa y Asia. El manejo de poblaciones pequeñas y divididas (algunas de las cuales pueden hallarse en zoológicos y otras en libertad) exige un cuidadoso control, a fin de minimizar la pérdida de diversidad genética. Ello, a su vez, puede requerir el desplazamiento*

*de animales o la transferencia de esperma entre subpoblaciones. Un riesgo potencialmente grave asociado a estos traslados reside en la introducción accidental de agentes infecciosos en el seno de una población hasta entonces geográfica o ecológicamente protegida. Al empezar a planificar estos traslados, es necesario haber obtenido previamente por parte de las autoridades veterinarias tanto del país importador como del país exportador, todos los detalles relativos a las exigencias legales en materia de salud, bienestar y conservación de los animales. La legislación sobre sanidad animal tiene por objetivo básico la prevención de enfermedades en el hombre y los animales domésticos, y por esta razón pueden requerirse medidas adicionales de control sanitario para el traslado de animales salvajes. Además de la necesidad de esforzarse por mantener una diversidad genética y por prevenir las enfermedades, se plantean otros desafíos relativos a las buenas prácticas de cría y al bienestar de especies sobre las cuales se sabe relativamente poco. Diversas organizaciones trabajan en la coordinación de programas de cría en cautividad en Europa y Asia. El autor menciona algunas de estas organizaciones, así como el procedimiento que se ha de seguir para identificarlas.*

**PALABRAS CLAVE:** Bienestar – Conservación – Cría en cautividad – Enfermedades infecciosas – Especies salvajes – Manejo – Traslado.

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