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Conservation breeding programmes: an important ingredient for species survival

JEREMY J.C. MALLINSON
Jersey Wildlife Preservation Trust, Les Augrès Manor, Trinity, Jersey, Channel Islands, British Isles

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Captive populations for the primary purpose of securing the survival of species through stable self-sustaining populations need to be founded and managed according to sound scientific principles. Given the current rate of habitat fragmentation and its effect on animal populations, species conservation over the long term increasingly will require management to reduce risk of extinction. This may include *ex situ* populations which can support and interact demographically and genetically with wild populations. This paper presents a review of what can be achieved through a multidisciplinary approach, involving science, interactive management, politics, environmental education, habitat preservation and habitat restoration. Examples of what conservation-oriented breeding programmes have contributed to date, what represents a viable population and what is meant by effective conservation are provided, and various scenarios for the future are discussed.

Keywords: captive propagation; conservation biology; species survival; animal welfare; genetic diversity; captive breeding.

Introduction

Tropical rainforests contain about half of the earth's estimated 5–10 million species on 7% of its land surface (Mahar, 1989). Due to ever-increasing human population growth, the present rate of habitat destruction and over-exploitation is greatly accelerating the loss of genetic diversity. The World Conservation Union (IUCN) identifies the number of threatened taxa at just over 5000, but these numbers represent only those taxa known by IUCN to be threatened. Many, many more taxa are threatened, many of them as yet undescribed by science. The number of taxa listed in the IUCN Red List of Threatened Species is therefore likely to be a large underestimate (Groombridge, 1993).

Now that we are in what Norman Myers refers to as the opening phase of a mass extinction, one with scope apparently to eliminate anywhere between one quarter and one half of all species within the foreseeable future, we need to devise conservation responses which have maximum capacity to stem the biotic holocaust, in so far as this is still possible. At the same time we should recognize that such a challenge places a premium on a thorough scientific understanding of all the major issues involved (Myers, 1993). The recent United Nations population conference in Cairo adopted an ambitious 20 year plan to limit the world's population, to promote the status of women and to preserve the environment (La Guardia, 1994). However, no matter how well such a global strategy may turn out in the long term, the catastrophic extinction waves are still before us, and current practices and the present devastating growth of the human population continue. The available evidence indicates that human activities are eroding biological resources and greatly reducing the planet's biodiversity (McNeely, 1994).

By far the most important conservation work to be carried out is concerned with the preservation of ecosystems, involving both animal species and associated habitat.

With species disappearing at rates never before witnessed, conservationists will have to utilize all of the resources at their disposal, if they are to achieve their objectives. One of these resources is the establishment of self-sustaining captive populations which, together with other supportive intervention, are needed to avoid the loss of many species, especially those at high risk in greatly reduced, highly fragmented and disturbed habitats. The recent progress zoos have made in breeding endangered species and establishing self-sustaining populations, indicates that captive breeding programmes can not only help prevent the loss of wild populations, but they can also provide a means of maintaining genetic diversity, thus saving populations which would otherwise have a continuously high expectation of random extinction (Mace and Foose, 1986).

Whilst the breeding of endangered species in captivity is likely to be crucial to the survival of many forms, it is important for demographically and genetically managed populations to be used as a method of preventing extinction alongside the maintenance of the wild stocks in their natural habitats. The development of scientifically managed breeding programmes is the primary conservation responsibility of zoos. However, zoos can and should also contribute to the efforts of governments and international conservation organizations for the preservation of critically endangered species within their natural habitat (Kleiman, 1984).

The World Conservation Union's development of a global network for species survival (IUCN, 1991; Rabb and Sullivan, this issue) identifies the threats that endangered species face from the growing human population and its increasing consumption of natural resources. At the same time, when a species is threatened by low numbers, severe habitat destruction or lack of protection in the natural range, the Species Survival Commission also recognizes the full significance of captive breeding programmes to reinforce conservation efforts in the wild.

The World Zoo Conservation Strategy defines the responsibilities of the world's zoos and aquaria for the conservation of global wildlife and the opportunities available to them. It sets out the conditions which individual zoos and aquaria and their cooperative networks must satisfy in order to realize their full potential for conservation (IUDZG/CBSG, 1993; Wheater, this Issue).

In order to keep species' survival options open, maintaining a genetically viable captive population in suitable environments is decidedly preferable to the irrevocable alternative of extinction.

So what has to be considered in the context of zoos aiding species survival? Why is there a requirement to develop viable captive populations of endangered species? What do we mean by effective conservation? Will species survival be by invitation only? In this paper these interdisciplinary issues are discussed and it is concluded that zoo breeding programmes represent an important ingredient for species survival.

Prevention of extinction

The passenger pigeon *Ectopistes migratorius* of North America was once so prolific that its migration in dense flocks darkened the clear skies like storm clouds. Some reports record that at roosting sites, limbs of trees crashed under the sheer weight of its numbers. By 1850,

due to the popularity of the pigeon's savoury flesh, several thousand people were employed solely in its capture and marketing. In 1855, a New York handler alone had a daily turnover of 18000 pigeons. In 1879, a billion birds were captured in the State of Michigan. The last nest was observed in 1894 and the last passenger pigeon died in Cincinnati Zoo in 1914 (Ziswiler, 1967). Such reckless exploitation of a species represents a classic example of how human greed and drive for profit can override the basic necessity to use nature's resources sustainably.

In South Africa, the Boer farmers came to regard the existing ungulate herds as troublesome competition for their cattle and they systematically set out to destroy them. Glover (1973) relates how little people were aware of the growing rarity of the once common zebra species, the quagga *Equus burchelli quagga*: in 1861 a London Zoo collector in South Africa published advertisements specifically for 'Zebras (not Quagga)'. Between the years 1865 and 1870 quagga disappeared from the Cape Colony and, although some reports state that it had also disappeared from the Orange Free State during 1873, others suggest that it survived until about 1878. The quagga, along with the blauwbok *Hippotragus leucophaeus* (extinct 1800) and the Cape lion *Panthera leo melanochaitus* (extinct ca. 1865), were among the first of the large African mammals to be exterminated by people (Fitter, 1986).

As with the passenger pigeon, the last known quagga died in a zoo. The mare that lived in the Amsterdam Zoo from 1867–1883 is now displayed as a mounted specimen in a glass show case in the Artis Museum, Amsterdam. In the mid-nineteenth century, the thirteenth Earl of Derby had a pair of quagga and had raised no fewer than 70 passenger pigeons in captivity at his famous Knowsley Menagerie. On the Earl's death, the great flock of pigeons were dispersed in pairs and small groups to many different locations (Gray, 1846). A colonial nester was never again afforded the opportunity to breed in a colony situation in captivity and, perhaps, consequently to reproduce successfully. A number of quaggas had also lived in various European zoos during the mid-nineteenth century (including Antwerp, Amsterdam, Berlin and London); but in spite of the opportunity to form a breeding population, the need for such a requirement had yet to dawn on people. A catalogue of lost opportunities has since been compiled.

Preserved in captivity following extinction in the wild

During the last 400 years, some 490 described species of animal are known to have become extinct (WCMC, 1992). Captive breeding, to preserve species at risk of extinction in the wild and to supply animals for reintroduction projects, is increasingly recognized and accepted as part of the repertoire available to conservationists. However, as yet, the number of species that has actually been saved by captive breeding programmes is small, with only 25 species having been preserved in captivity following extinction in the wild (Magin *et al.*, 1994).

The following examples record how species that have become extirpated have been saved by the establishment of captive populations and, in the majority of cases, have been successfully reintroduced into their former habitat.

The first example of a species being saved by breeding in a captive environment outside the wild state was the Père David's deer *Elapharus davidianus*. In 1865, the French missionary and naturalist, Père Armand David, described a large, handsome deer species that he saw inside the Chinese Emperor's Imperial Hunting Park just south of Beijing

(Peking). It has never been established how long this species had been extinct in the wild or how it came to be preserved in the 45 square miles walled-in park. It was fortunate that British and French diplomats manged to smuggle some live specimens out, for in 1895 a flood breached the park wall and all but a handful of the deer escaped, and were either drowned or poached. Five years later, the foreign troops quelling the Boxer rebellion killed off most of the remainder, and within a few years the deer became extinct in China. However, at this time, the eleventh Duke of Bedford pursuaded the zoos of Europe to let him collect together all the available animals to a total of 18, in his large park at Woburn Abbey and build the stock up again (Fitter, 1986). Despite many setbacks during the two world wars, in 1987 the world register for the Père David's deer recorded 1452 individuals. A breeding population has also been restored to the wild in a reserve in China.

The European bison, or wisant, *Bison bonasus*, was exterminated in the wild in 1921, but was bred in zoos starting from 12 animals in 1913. Zoo bred stock were successfully reintroduced in 1956 in the Bialoweiza forest, on the border of Poland and Russia, where these animals thrive today (Flesness and Foose, 1990).

Another important historical example is the Mongolian wild horse *Equus przewalskii* which represents a classic example of species conservation by zoological institutions. Although only first recorded for science in 1881, in less than a century it was presumed to be extinct in the wild. All present day animals are derived from individuals caught in three expeditions at the turn of the century and one wild-caught animal in 1948. From the founder population of 13 animals, by January 1960 the studbook listed 59 individuals, and by 1992 the world herd consisted of some 1000 animals. This herd is being closely managed by regional species management groups, together with the Global Management Plan Working Group (GMPWG) to maintain a demographically and genetically viable captive population; bearing in mind the limited carrying capacity of cooperating institutions, and the need for captive conservation programmes for other equid species (Knowles *et al.*, 1992; Ryder, 1993).

Although the GMPWG had a mandate to initiate programmes for the establishment of free-living populations in former range areas in China, Mongolia and parts of the former USSR, this has not yet been achieved due to a combination of political and economic factors. These led to misunderstandings as to how a scientific programme to establish this goal should be conducted and funded. Outside the formal structure, animals have been sent to China and Mongolia. However, details of the status of these animals, both as to breeding success and degree of containment, have yet to be published (J. Knowles, personal communication).

Much of contemporary conservation biology is concerned with small populations of endangered species and has a multi-disciplinary and interventionist approach. Scientifically coordinated conservation breeding programmes have not only bought time for an increasing number of animals, but have made captive bred stock available for return to the wild. More recent examples of species becoming extinct in the wild yet preserved by successful zoo-based breeding programmes include the Arabian oryx *Oryx leucoryx* (extinct in wild, 1972), Moorea tree snail *Partula* spp. (extinct in wild, 1983), black-footed ferret *Mustela nigripes* (extinct in wild, 1985), and the California condor *Gymnogyps californianus* (extinct in wild, 1987). The reintroduction programme for the Arabian oryx in Oman is a classic example of how a soundly-planned, properly executed reintroduction has proved to be a successful form of wildlife management and conservation. Similarly serious scientific approaches are being taken in the reintroduction programmes for the

other species mentioned (Stanley Price, 1989; Miller *et al.*, 1994; Pearce-Kelly, 1994; Toone and Wallace, 1994).

Ex situ *populations greater than those in wild*

Zoo collections vary greatly in size, depending on their specializations and approach to exhibition. It is difficult to estimate the total number of individual animals and species in zoos, although 400 of the world's zoos register their collections in the International Species Information System (ISIS), and some 800 zoos include data on their collection in the International Zoo Yearbook (IZY) on an annual basis. The total number of living animals listed in the data base of ISIS at the end of 1992 was 180 000. Given the fact that less than 40% of the organized zoos send data to ISIS, the total number of animals in approximately 1000 organized zoos is assumed to be at least 5–6 times higher. This gives a rough estimate of the current capacity of the world's zoos to be about 1 000 000 animals (IUDZG/CBSG, 1993).

With the world's rapidly diminishing resources and increased pressure on remnant wild populations, an increasing number of exotic species held by zoos, the private sector and in scientific institutions have much larger *ex situ* populations than those remaining in the wild.

For example:

In scientific institutions: the cotton-top tamarin *Saguinus oedipus* although common in zoos is more numerous in scientific institutions, due to this species being the only one known to develop spontaneous colonic cancer in captivity (Snowdon, 1989). Endemic to Colombia, this species is among the most endangered of callitrichids, with a population of only a few hundred (Savage, 1990).

In private collections: the Edwards' pheasant *Lophura edwardsi* has not been seen in the wild since an intense 45 day battle took place in its restricted range in Vietnam close to the city of Hué, in 1966. Currently over 600 Edwards' pheasants are held in captive collections, mainly by private breeders in Europe and North America (K. Howman, personal communication).

In zoos: Zoo populations of a growing number of animals range from: Mammals – Siberian tiger *Panthera tigris altaica*, estimated wild population 170–220 (Jackson, 1994), zoo population 652 in 1991 (Olney and Ellis, 1993); Birds – Bali mynah *Leucopsar rothschildi*, estimated wild population 35–37 in October 1993 (R. Grimmett, personal communication), zoo population 800–900 (D. Jeggo, personal communication); Reptiles – Indian gharial *Gavialis gangeticus* with a total of 1287 specimens released in 1988 into the National Chambal Sanctuary which numbers far exceeded the remnant wild population (Rao, 1990); Amphibians – the Jersey agile frog *Rana dalmatina*, either in very low numbers or extirpated, but conservation breeding programmes, including the one at Jersey Zoo, hold an estimated 50 adult specimens and 200–300 captive bred young (Q. Bloxam, personal communication); Invertebrates – the British wart biter cricket *Delectus verrucivorous* at one time down to an estimated 100 individuals in wild state, whereas London Zoo frequently holds up to 2000 eggs, which results in the captive number well exceeding the wild population (P. Pearce-Kelly, personal communication).

Viable populations

Breeding and husbandry

The first life science discipline to make a certain impact on zoos was veterinary medicine. As Brambell (1993) summarized: In the early 1950s many animals in zoos were diseased: some arrived diseased, some contracted their diseases at the zoo. The illnesses could only be diagnosed and cured if the animals could be handled closely. The most satisfactory way of doing this was to sedate and tranquillize the animals; once this had been done, they could be examined more or less as domestic animals, albeit sleepy ones. Fortunately, at this time new tranquillizing and sedating drugs became available. The next science to make an impact on zoo management was that of nutrition, which has done more to revolutionize zoo animal management than anything else.

Thanks to the great progress made in zoo husbandry, many species once thought too difficult to sustain in zoos are now routinely maintained. More information on diet, social structure, environmental enrichment, physiology, veterinary concerns, and climatic influences is now available. Furthermore, modern technology can be used to optimize the conditions for each individual species. The World Zoo Conservation Strategy calls for zoos to continue and accelerate advances in animal care, and to facilitate the communication and free exchange of their research results and experience (IUDZG/CBSG, 1993).

Demographic and genetic mangement

Knowledge of population biology has greatly increased during the past decade. Population geneticists and demographers, many connected with zoos, have been studying the effects of small population size and fragmentation of populations. It was the analyses by Ralls *et al.* (1979), that did so much to alert the zoo and scientific world to the dangers of inbreeding and its implications for management of both wild and captive populations.

The deleterious effects of inbreeding are not restricted to particular groups or taxa and the potential dangers may vary in degree from species to species. However, as Lovejoy (1980) pointed out, too often in the past inbreeding aroused alarm only when it had gross manifestations such as funnel chest in the San Diego ruffed lemurs *Verecia v. variegata.* He concluded that 'it was natural and easy to take much heart from those few populations which had undergone the genetic roulette of a genetic bottleneck, or of inbreeding and in so doing had been divested of their deleterious genes – in fact, in the past, the effects of inbreeding were somewhat reduced and masked by acquiring fresh animals from the wild'. Boer (1994) highlights how preservation of a population's genetic structure is crucial to its survival. The preservation of genetic structure influences the probability of success when the *ex situ* population is used to re-establish or reinforce wild populations that will be exposed to natural selection at some stage in the future. The dominating animal science of the future will be genetics and the demands it makes on the demographic management of populations (Brambell, 1993). Flesness and Foose (1990) emphasized that captive propagation facilities must develop and sustain genetically and demographically sound captive-bred populations of hundreds, perhaps thousands, of wisely selected taxa.

Recognizing that time is short and zoos have limited resources, the importance of strategic collection planning on a global, regional and institutional level, is paramount to the success of the World Zoo Conservation Strategy, to integrating zoo conservation efforts with those of other conservation bodies, and to the interactive management of wild and captive breeding populations (Mallinson, 1994a).

Psychological and physical requirements

One of the putative aims of conservation breeding programmes is to preserve in capivity populations of animals as representatives of their wild ancestors for posterity, research and education. However, there is more to preserving an animal species than looking after its genes. Since behaviour is a consequence of interactions between both genetic and environmental factors, failure to reproduce an environment that is at least functionally equivalent to that of the wild will inevitably result in the loss of many forms and patterns of natural behaviour (Shepherdson, 1994).

Utilizing what is known about the biology and behaviour of a species under natural conditions is essential in improving the management of captive populations. With the design of new facilities and the improvements of old enclosures, observations from field studies should have a primary role in the creation of guidelines and principles for progressive housing and management. Much has recently been achieved by progressive zoos in altering old exhibits in ways that have greatly improved the mental and physical health of the animals. Re-perching or re-branching old cages, using bark litter on the floor, building more complex climbing apparatus, some of which moves, creating shelves and shelter high and low, as appropriate, are all changes easily arrived at (Mallinson and Redshaw, 1992). As an example, a significant proportion of the day for most wild primate species is spent in foraging and feeding activities; therefore, it is important not to underestimate the psychological value for captive primates of being provided with a foraging substrate like leaf or bark litter, in which they can search for scattered grains and seeds or live insects.

Although captive environments inevitably represent a compromise, it is the responsibility of zoos to maximize the 'quality of life' for the species being managed by them. Population structures should be healthy, and genetic degeneration and selection leading to domestication of these wild animals should be avoided. In the case of the majority of species, the importance of maximizing behavioural opportunities and increasing their chances of retaining and practising as many of their natural manipulatory and social skills as possible should not be underestimated (Redshaw and Mallinson, 1991; IUDZG/CBSG, 1993; Mallinson, 1994b).

Captive environments need not only to provide animals with opportunities to develop physiological tolerance and immune defences, but also to expose them, as much as possible, to the full range of environmental variability that they would find in their natural environment. Finally, it is of the utmost importance that captive animals be able to develop behavioural competence in all areas important for living in the wild (Snowdon, 1989).

Effective conservation

Education

During the past two decades, there has been a rapid implementation of formal education programmes in responsible zoos. These use the collection not only to teach good zoology, biology, botany and natural history, but perhaps more importantly to develop, particularly in young people, an awareness of our responsibility for species other than humans and of the global environment. If this awareness can be developed, then not only is the understanding of local conservation needs increased, but the step from local concern to one or more global proportions can be better achieved.

The development of topic related programmes can be most successfully achieved

through a consultation process with those responsible for formal education, education advisors and head teachers. In many zoological collections, the educational output is constantly under evaluation and review in order to maintain the highest possible standards. It is now recognized that the school class visit to the collection for educational purposes must not be in isolation from the rest of the pupil's education process, but part of it. Pre-visit preparation and post-visit development are essential and the visit under these circumstances should relate to science or other relevant subjects, or at a more junior level be part of the ongoing process of work during the school term (Mallinson, 1993).

Some institutions have developed programmes of visits involving a number of resource centres as part of an integrated programme of education. One such initiative known as 'interlink' was developed by the Royal Zoological Society of Scotland and now involves 14 different organizations developing programmes together. A typical example is the programme between the Zoo and the Botanic Garden. Pupils first visit the gardens and are introduced to the vegetation of tropical rainforests and are educated as to its development, utilization and, more recently, its exploitation. They then go to the zoo and look at some of the creatures which rely on this habitat; similar programmes have been developed with the museum and local nature and forestry reserves – thus the connections are made (Wheater and Mallinson, 1991).

In highlighting the role of zoos as significant education resources, it should be recognized that only a very small percentage of the world's population is fortunate enough to be in a position to be able to travel to places like Africa and to see for themselves the remnants of the continent's wildlife heritage. Therefore it should be appreciated that the opportunity to share knowledge of conservation, to sow seeds of awareness by exposing a person to live animals and the wonder of animal life, underlines one major aspect of zoos' contribution to conservation. In this context, it should also be appreciated that a six inch high gorilla or giraffe on a television screen does little to prepare a child or adult in any way to the majesty, scale, movement, scent and sound of the real animal (G. Durrell, personal communication).

Zoo education requires a professional approach. This means that wherever possible a well-staffed education department should be established. However, education is not only dependent on professional zoo educators; every person working in a zoo should be involved in education one way or another. Even casual, informal visitor contact can promote an educational agenda. If the entire zoo staff is indeed education-minded and time is made available, then even small zoos which cannot afford to set up an education department can still be excellent educational institutions. This is especially true if volunteer educators or docents can be recruited and trained (IUDZG/CBSG, 1993).

Training

Applied ecology, zoo biology and zoo animal management, as scientific disciplines, are insufficiently recognized and understood. It was in the early 1970s that Gerald Durrell conceived the idea of bringing selected students to the Jersey Wildlife Preservation Trust (JWPT) to undergo an extensive training course. On their return home, they would then be in a position to assist their governments, or the relevant conservation organizations, to form breeding centres for the endangered species of their own country (Durrell, 1976).

The importance of the international zoo community to assist in developing training programmes in which zoo staff could teach essentials to counterparts from the developing countries was stressed by Mittermeier (1986). The Wildlife Preservation Trusts,

International Training Centre (ITC) for Conservation and Captive Breeding of Endangered Species, in Jersey has been in existence since 1978. It has been designed to cater for the requirements of people working directly with captive animals, the extent of practical involvement in their work places largely being dictated by employment position. From the outset, the programme has not been confined to the training of zoo personnel only, and the title alludes to the need to train staff from government departments such as forestry, wildlife and national parks, as well as from conservation NGOs. The principal aim of the WPTs/ITC programme is to give training in the captive breeding of endangered species to individuals with differing needs, in order for them to advance the cause of endangered species work and conservation in their own countries (Waugh, 1983, 1988). The University of Kent at Canterbury has validated the ITC programme, giving participants the option of preparing a dissertation, with the entire course leading to a university Diploma in Endangered Species Management.

The Smithsonian Institution's National Zoological Park (NZP) Zoo Biology Training Programme was initiated in 1987. The course was developed in response to increasing requests for zoo-related information received during the Wildlife Conservation and Management Training Course, which since 1981 has been presented annually at the National Zoo's Conservation and Research Center at Front Royal, Virginia. While the Wildlife Conservation Course is designed almost exclusively for *in situ* wildlife and conservation managers from developing countries, it became clear from numerous queries about capture and restraint, transport, captive propagation, and husbandry that there was a need for specific curricula on broad issues of zoo biology (Wemmer, 1990).

The WPTs and NZP training programmes demonstrate their essentially counterpart nature in trying to achieve the common goal of helping zoos in the tropics to improve and to have a conservation impact. Both programmes can demonstrate heartening examples of improvements in captive animal management through the efforts of people given the knowledge and stimulus from a period of training (Waugh and Wemmer, 1994).

Research

In the criteria for successful captive propagation of endangered species, Snowdon (1989) stated that it is not sufficient to create an 'Ark' in which a few remaining animals of a species can live in peace and safety, we must learn from these species as well. He also felt that there is a moral imperative that anyone undertaking to breed endangered species in captivity should develop an active research programme for that species.

Research is an integral part of zoo biology and the wider science of conservation biology, yet relatively few zoos have active research programmes, and zoological institutions are under-used as a resource for research. However, research need not be expensive and all zoological institutions, regardless of size, can contribute to research given trained personnel and a modest budget. Combatting escalating habitat destruction and decreasing biodiversity presents an urgent requirement for knowledge. Despite this increasing need for research, resources, such as time and money, are inevitably limited, and decisions on where to focus research effort must be made by every institution (Feistner, 1992).

The World Zoo Conservation Strategy (WZCS) stresses how much of the information acquired through zoo research is of direct relevance to conservation generally, and to the conservation of species and habitats in particular. However, the WZCS highlights the importance of increasing zoo research and of creating funds for zoo research and of making data easily accessible and available to the zoo conservation community. *Ex situ* and *in situ*

research programmes should be linked for the benefit of nature conservation (IUDZG/CBSG, 1993).

Reintroduction

Zoos increasingly claim a major conservation role mediated through breeding animals in captivity for reintroduction. This exercise contributes to the science of conservation biology in several aspects of small population biology and management. In response to growing interest in reintroductions, and the increasing number of properly planned and documented releases, the World Conservation Union Species Survival Commission's Reintroduction Specialist Group (IUCN/SSC/RSG) was formed in 1988. The stated objectives of the RSG are: to document, collate and analyse past reintroduction efforts, whether failures or successes; to provide information on past reintroductions to those planning or involved in other projects; to provide technical advice and evaluation for reintroduction planning design, monitoring, the definition of objectives and chances of success; to keep members and others informed on reintroduction activities through a newsletter; to promote soundly-planned, properly executed reintroductions as a modern, multidisciplinary management tool; to identify which species, in which areas, are most suitable candidates for re-establishment; to promote site visits by specialists where possible; to assess the ecological, scientific and educational value in conservation of each reintroduction; to promote communication and collaboration between the various disciplines involved; and to promote incorporation of simulations and predictions into field management of reintroductions where relevant (Stanley Price, 1991).

Despite evidence that reintroduction programmes of captive-bred animals are less likely to succeed than wild-to-wild translocations, captive-breeding is playing an important role in the reintroduction of some globally and locally endangered vulnerable and rare species (Rahbek, 1993; Wilson and Stanley Price, 1994). In the recent assemblage of a database of reintroduction projects involving captive-bred animals, Beck *et al.* (1994) record that in only 13 projects (10%) is there clear evidence that the reintroductions have resulted in the establishment of self-sustaining populations. Although the reintroduction of captive-bred wildlife is clearly a common recovery tool and one in which zoos are participating, it is also a comparatively new science and techniques require improvement if it is to have significant conservation impact.

The specific goals for a conservation-oriented reintroduction and the criteria by which success is evaluated depend both on the species' status in the wild and in captivity, and on the political and social conditions in the region surrounding the release site. Thus, success cannot always be measured by counting the number of surviving animals. For example, if a species' survival depends on habitat preservation and reintroduction results in a broader conservation programme, including greater habitat protection, then the reintroduction could be judged a success. However, reintroduction is one of several ways to manage an endangered species and can be an important conservation strategy if guidelines are followed; reintroduction should never override other approaches to conservation, but should work in tandem with them. It should also be recognized that while reintroduction of captive-bred animals is fast becoming a tool for the conservation of endangered species, it is not necessarily an appropriate approach for the majority of species held in zoos (Kleiman *et al.*, 1994).

Reintroduction as a conservation tool has the following objectives: to enhance the long-term survival of the species; to establish a keystone species (in the ecological or

cultured sense); to increase or maintain biodiversity; to provide long-term benefits to local people; and to achieve a combination of all the aforementioned factors (Kleiman *et al.*, 1994).

The Golden Lion Tamarin Conservation Programme (GLTCP) provides a fine model of adhering to such reintroduction criteria. Thanks to the sound demographic management of the golden lion tamarin *Leontopithecus rosalia*, from a captive population of approximately 70 individuals in 1972 to over 500 animals in the 1980s, surplus captive bred stock were made available for reintroduction (Kleiman *et al.*, 1986).

This significant reintroduction programme for primates has demonstrated continued success in meeting the six original objectives of the programme by: increasing the size of the wild population; increasing the genetic diversity of the wild population; expanding the geographic distribution of the wild population; protecting additional tracts of Atlantic coastal rainforest, and contributing to the science of reintroduction and enhanced programmes of public education. On the tenth anniversary of the programme (31 May 1994) Dr Benjamin Beck, Reintroduction Coordinator of the GLTCP, reported that since the programme's inception the size of the known wild populations has increased by 20%, with about 17% (126 animals) of the golden lion tamarins living in the Atlantic coastal forest being reintroduced captive borns and their descendants, and that the area of protected forest had increased by about 38% (Beck, personal communication, 1993; Beck *et al.*, 1994).

Two critically endangered species of Mauritius birds also very much owe their viability to captive breeding and reintroduction. In 1972, the Mauritius kestrel *Falco punctatus* was known to have a population of only four individuals. During the 1993/1994 breeding season, there were between 65 and 80 territorial pairs and the post-breeding season estimate, including individual young, was between 250 and 300 individuals. Releases have now been stopped and the population will be intensively monitored for at least five years. Similarly, the population of Mauritius pink pigeon *Nesoenas mayeri* fell as low as 20–25 birds in 1976. However, thanks to the success of the captive breeding programmes, both in Mauritius and overseas, leading to the reintroduction of captive-bred birds, there are now approximately 160 free-living pink pigeons in the wild. This is estimated to be the first time for over a century that this number has been recorded (Jones and Hartley, 1995; personal communication, 1994).

'Flagship' species

Common use of the term 'flagship' species often implies a vague relationship between an animal, usually a larger vertebrate, and the need for its conservation; more precisely, 'flagship' species are those that can be used to effect the conservation of a significant number and diversity of additional plants and animal species and their habitat (Dietz *et al.*, 1994). The appropriate selection and use of 'flagship' species can increase the impact of the single-species conservation efforts often sponsored by zoological parks to include additional components of biological diversity *in situ*, as well as the natural areas where the species is found. Three criteria may be used to predict the effectiveness of a potential 'flagship species' in achieving this objective. First, the species should be native to a region with high levels of species richness and endemism, and preferably with habitats still reasonably intact. Second, an effective 'flagship' species should possess behavioural and physical traits that endear it to the public whose support for conservation action is desired. Third, the species should possess ecological characteristics that link its conservation with

that of its habitat and additional species. To achieve the broader objective of conservation of biodiversity, projects designed around 'flagship' species must be multidisciplinary, involving at least community education and studies of the animal's biology, as well as habitat restoration and genetic management (Dietz *et al.*, 1994).

It is easier to generate the general public's interest and pride in a spectacular animal like a giant panda *Ailuropoda melanolevea*, than it is to communicate the complicated ecology of a rain forest habitat. As Macklin (1990) records: People can associate with something attractive, cuddly and charismatic, if you blind the uninitiated with pure science, most people can't cope. However, it should also be appreciated that through good communication, even 'low visibility' projects with diminutive endemic species have a potential for mobilizing local and national governments, as well as the public, to preserve endangered species and to conserve threatened habitats (Durrell and Mallinson, 1987).

By promoting the golden lion tamarin, Mauritius kestrel and Mauritius pink pigeon as 'flagship' species, and thereby attracting considerable public attention and support for their reintroduction programmes, the preservation and conservation of both endangered animals and associated habitat has been significantly aided.

Facing the facts

Balancing conservation and animal welfare

By focusing their attentions on the predicament and general welfare of individual(s), some animal welfare organizations ignore the multidisciplinary approach required for successful species conservation.

For example, it is regrettable that newsletter editorials of The World Society for the Protection of Animals (WSPA) consistently promote an anti-zoo agenda by highlighting the plight of certain individuals and species held in inadequate accommodation, and take no account of the very positive work being carried out by an increasing number of zoos world-wide. In a recent editorial of Animals International, Dickson (1994) refers to the claims of the World Zoo Conservation Strategy (WZCS) document that modern zoos are now the 'champions' of conservation of endangered species by recording 'It is WSPA's contention that zoos, in fact, do little for conservation and that they are merely the providers of an outdated and cruel method of entertainment.'

As the Chairman of the Federation of Zoos of Great Britain and Ireland has subsequently pointed out, the recent Zoo Inquiry Report carried out by WSPA and the Born Free Foundation, which attacks the WZCS document, has not been subjected to any peer review and indeed the authorship of the document is unclear. That is in contrast to the WZCS document that has a named writer, editorial board, international editorial advisory board, individual contributors and support team from The World Conservation Union and the World Wide Fund for Nature.

In contributing to an increased global awareness of the importance of the relationship between conservation and animal welfare, it is important to avoid sweeping generalizations and anthropomorphic preconceptions. Although animal welfare and conservation organizations will, no doubt, continue to 'beg to differ' on a number of fundamental issues, it is now of the utmost importance for all those concerned with welfare and effective conservation to build on common ground. As Pinchin (1994) recently recorded: the relevance of research in animal welfare to zoos, highlights the integrated approach which must now be adopted by the conservation movement at large. In this

context, it is worth mentioning that a great deal of research on the welfare of exotic animals is carried out by the zoo community.

In the process of balancing conservation and animal welfare, it should be recognized that as traditional zoos evolve from zoological parks into conservation centres, it is important not just to review what the global zoo community has, or has not, achieved to date, but also to assess what the real potentials are.

The territorial imperative

More often than not, scientists and conservationists have overtly gone about their business with 'blinkers' on, ignoring each other as well as the people affected by their decisions – therefore conservation either will have to contribute to solving the problems of the rural poor who live day by day with live animals, or those animals will disappear (Adams and McShane, 1992). With the need to preserve as much as possible of the biological richness of the earth within the context of sustainable development, it is of the greatest importance to strike a balance between the conservation of the animal kingdom and the survival of the human race in order to arrive at a satisfactory consensus between disciplines, and thereby avoid the labyrinth of territorialism and the major and disturbing divergence between words and actions.

In order to overcome many of the current misunderstandings and insensitivities to what in reality is happening on the ground, and, in some cases, the dangers involved, conservationists will have to strive for the cooperation, understanding and participation of all those involved. For example:

Lack of collaboration: We have to recognize that there are many instances of animal conservation and welfare organizations working in a given geographical region, who are unwilling to divulge or pass on knowledge that would ultimately aid species survival. Instead of electing to work together to attain a specific conservation goal, they have preferred to work in isolation, and through such short-sightedness, some erosions of animal populations have been recorded; as well as some important conservation projects being unnecessarily handicapped (Mallinson, 1986).

Learning from an opposite viewpoint: By not having kept up to date with the significant progress made by an increasing number of zoos, with their conservation programmes representing an important ingredient for species survival, a former patron, and a former consultant, of 'Zoo Check' (re-named: Born Free Foundation) – which has as one of its chief aims 'to phase out all zoos in their present form', changed their apparent anti-zoo attitudes quite dramatically after being taken around a modern zoo and breeding centre in 1989 and 1991, respectively (R. Adams, personal communication; C. Lever, personal communication).

Symbols of conservation: As remarked upon at the time of the 19th IUCN General Assembly in Buenos Aires (1994), a major decision was taken by an international NGO in Switzerland about elephant culling in Zimbabwe, when only one of the 11 committee members had ever set foot in Africa. This degree of insensitivity and imperialistic treatment of the complexities concerning the sustainable use of mega-vertebrates was well addressed when Dr David Cumming recorded: If people outside Africa make elephants and rhinos into symbols of conservation and human rights, for which there is no value other

than the aesthetic value, they are in a sense condemning these animals to death in Africa (cited in Adams and McShane, 1992).

Procedural niceties: During the evolution of many NGOs, and connected with various degrees of territorialism between member(s) of a governing body, voting procedures, precedents, elections, appointment methods, privileges, definitions, are regularly put forward which in turn either impede or, on some occasions, severely handicap the progress of the conservation NGO concerned. Procedural niceties and personal agendas are frequently permitted to take priority over the protection and welfare of endangered species.

Dangers: In an increasing number of cases, field researchers have been viewed by land-owners, by local people or by squatters, as spies. A recent expedition into the Sierra Madre mountains of Mexico found that the habitat for the thick-billed parrot *Rhynchopsitta pachyrhyncha* proved to be a very dangerous territory to work in due to the activities of drug dealers (M. Pearl, personal communication, 1994). In the Brazilian States of Paraná and São Paulo, in the fragmented coastal forest distribution of the recently described black-headed lion tamarin *Leontopithecus caissara*, one of the field workers had threats to her life by illegal collectors of the valuable 'palm hearts' who considered that she was in league with the police – the researcher survived the attack, but her assistant was killed. Also, when a landowner learned that *L. caissara* occurred on his property, he immediately started cutting down his forested land prior to any legislation being made to protect either species or habitat (IRMC, 1994).

Partnerships and a multi-disciplinary approach

In the development of scenarios for the future, it is important to recognize that ultimately effective conservation depends on the activities of people who live in the regions where animal species are endemic, and on the adoption of a multi-disciplinary approach. The value of a policy of maintaining constant dialogue with governments and relevant conservation organizations, as well as of developing person-to-person relationships based on trust, mutual respect and friendship, and getting the human balance right, should not be underestimated (Mallinson, 1991).

As Mittermeier (1991) pointed out, by focusing on a particular region or group of organisms, solutions to conservation problems can be found by partnership between local communities, and governmental or non-governmental, national or international organizations.

With an estimated 80–85% of data on species/regions yet to be published, conferences/workshops form a mechanism of getting different disciplines and nationalities together to publish their data. The significance of an international or regional meeting is that it draws in, harmonizes, synthesizes and produces the type of results that are the creation of all the interactions that take place.

Scenarios for the future

Global strategies

The Species Survival Plan (SSP) of the American Zoo Association (AZA) makes it clear that cooperation without coordination is insufficient to preserve wild animals in captivity

over long periods of time and that captive populations, fragmented among many collections, can be preserved only if they are managed as a whole (Conway, 1982).

Therefore, the recent formal integration of the coordinated breeding programmes between zoos in Continental Europe and the British Isles, and the formation of the European Association of Zoos and Aquaria (EAZA) represents an important step forward to achieve the conservation goals of long-term species survival plans (Mallinson, 1993, 1995). Regional coordinators now fully recognize the importance of integrating with other regional programmes world-wide, as well as participating through SSC's Conservation Breeding Specialist Group in the development of Population and Habitat Viability Assessment Plans (PHVAs), and Conservation Assessment and Management Plans (CAMPs) to Global Conservation Action Plans (GCAPs) (Seal *et al.*, 1994; Ellis and Seal, this Issue).

The Specialist Groups of IUCN's Species Survival Commission represent the source of the most current and expert information on the conservation status and priorities for action for species in the wild and, as such, provide an invaluable resource in setting priorities for captive propagation and in linking *ex situ* programmes with *in situ* actions (Rabb and Sullivan, this Issue). With the development of criteria for assessing extinction threats and a re-evaluation of IUCN Threatened Species categories (Mace and Lande, 1991), and with the development of management plans involving multi-disciplinary committees of managers and scientists, so much now can be achieved through the expertise of both the zoo community and field conservationists to improve the interface between conservation breeding programmes, and the management of wild populations.

Survival by invitation only

In surveying modern methods of conserving animals and how mass extinction can be stopped, Tudge (1991) recently recorded that at one extreme is the intensive breeding centre in a good zoo – where animals live in a protected state, and at the other is the wilderness itself. In between, is every kind of compromise: fenced reserves ('sanctuaries') for just one species; tightly managed reserves, with a selected list of species and natural vegetation; and national parks, which resemble the wilderness, but must none the less be managed to maintain their diversity and prevent local extinctions. Whereas wilderness remains the 'ideal' dream, zoos can play an increasingly important role in sustaining genetically viable populations of animals in fragmented habitats.

The current environmental degradation crisis and the problems involved when trying to manage small populations of animals in fragmented habitats, like 'sanctuaries', was recently highlighted when 50 starving elephants had to flee from a bush fire in their sanctuary in West Bengal, India, wrecking a village and trampling six people to death (*Daily Telegraph*, 1994).

It is easy therefore to postulate that if there is to be a viable future for an increasing number of separate sub-populations of endangered species in fragmented habitats, they will have to be managed as a metapopulation; which may well include reintroduction of zoo-bred animals, the involvement of specialist zoo personnel in translocation and/or the managed dispersal of individuals among sub-populations.

This paper has attempted to put into perspective breeding programmes as an important ingredient for species survival, and to highlight the role of zoos in programming effective conservation scenarios for the future through a multidisciplinary approach. It has also addressed how essential it is that appropriate international NGOs, including zoos and

conservation bodies (e.g., SSC/CBSG and IUDZG), continue to develop their lead role in prioritizing conservation programmes and interactive management of *in situ* and *ex situ* populations of endangered species, thereby aiding the conservation of the world's biodiversity.

Zoos have much to do to improve their contribution to conservation breeding programmes, environmental understanding and scientific study. It is also acknowledged that we cannot save all the species, not even all the vertebrates, which, in a sense, means a place in tomorrow's biota, or in the ark which zoos can provide, will be by invitation only (Lovejoy, 1980).

As global zoos have evolved from menageries to zoological parks, and in turn evolve from zoological parks to conservation centres, it is pertinent to recall the prophetic words of Gerald Durrell:

> 'The World is as delicate and complicated as a spiders web. If you touch one thread you send shudders running through all the other threads. We are not just touching the web, we are tearing holes in it. Now think of the web as a safety net. The thin strands of survival. Help us tend it, repair it, hold it together' (Durrell, 1990).

In this latter context, the role of a modern zoo aiding global conservation has never been as important as it is today, for by developing reservoirs of endangered species as a hedge against extinction, by providing time to keep the survival options open, and by linking the international zoo community with *in situ* conservation zoos can increasingly help to prevent more species joining the irredeemable fate of the Dodo.

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