BRIEFING BOOK FOR

WORKSHOP ON INDIRA GANDHI'S VISION ON WILDLIFE CONSERVATION-SCIENTIFIC ZOO MANAGEMENT AS ONE SUCH INSTRUMENT

AT
VIGYAN BHAVAN
29TH OCTOBER, 1994

CENTRAL ZOO AUTHORITY OF INDIA
NEW DELHI

The conservation of flora and fauna is neither a whim nor a luxury. It is essential for mankind's future survival.

—Indira Gandhi

CONTENTS

SECTION - I

GENERAL

SECTION - II

HEALTH CARE

SECTION - III

PLANNED BREEDING.

SECTION - IV

RE-INTRODUCTION

SECTION - V

EDUCATION

MISCELLANEOUS

SECTION - I

GENERAL

NATIONAL WILDLIFE ACTION PLAN

The statement of late Smt. Indira Gandhi to the XV meeting of the Indian Board for Wildlife, held on October 1, 1982, laid down the following list of aims on which a strategy and action programme for wildlife conservation in the country should be based:

1. The establishment of a network of protected areas such as national parks, sanctuaries and biosphere reserves, to cover representative samples of all major wildlife ecosystems and with adequate geographic distribution.

2. The restoration of degraded habitats to their natural state, within these protected areas.

3. The rehabilitation of endangered and threatened species and their restoration to protected portions of their former habitats, in a manner which provides some reflection of their original distribution.

4. The provision of adequate protection to wildlife in multiple use areas (such as production forests and pasture lands) so as to form "corridors" linking up the protected areas and providing for genetic continuity betweeen them.

5. Support for the management of botanical and zoological parks and gardens and undertaking captive breeding programmes for threatened species of plants and animals.

6. The development of appropriate management systems for protected areas, including a professional cadre of personnel fully trained in all aspects of wildlife and sanctuary management, as well as the provision of proper orientation to all officers concerned with wildlife.

7. The development of research and monitoring facilities which will provide a scientific understanding of wildlife populations and habitats essential to their proper management.

8. Support for wildlife education and interpretation aimed at a wider public appreciation of the importance of wildlife to human betterment.

9. The review and updating of statutory provisions providing protection to wildlife and regulating all forms of trade, so as to ensure their current effectiveness.

10. Assistance in the formulation and adoption of a National Conservation Strategy for all living natural resources on the lines of the World Conservation Strategy launched in 1980.

11. Participation in international conventions designed to prevent the depletion of the wildlife resources to provide protection to migratory species.

12. Long-term conservation of wildlife based on the scientific principles of evolution and genetics.

UNITED NATIONS CONVENTION ON BIODIVERSITY

Article 9. Ex-situ Conservation

Each Contracting Party shall, as far as possible and as appropriate, and predominantly for the purpose of complementing *in-situ* measures:

(a) Adopt measures for the *ex-situ* conservation of components of biological diversity, preferably in the country of origin of such components;

(b) Establish and maintain facilities for *ex-situ* conservation of and research on plants, animals and micro-organisms preferably in the country of origin of genetic resources;

(c) Adopt measures for the recovery and rehabilitation of threatened species and for their reintroduction into their natural habitats under appropriate conditions;

(d) Regulate and manage collection of biological resources from natural habitats for *ex-situ* conservation purposes so as not to threaten ecosystems and *in-situ* populations of species except where special temporary *ex-situ* measures are required under subparagraph (c) above; and

(e) Cooperate in providing financial and other support for *ex-situ* conservation outlined in subparagraphs (a) to (d) above and in the establishment and maintenance of *ex-situ* conservation facilities in developing countries.

Draft 1
15 June 1993

IUCN - Guide to the Convention on Biological Diversity

IUCN

The World Conservation Union | Environmental Law Centre

Union mondiale pour la nature | Centre du droit de l'environnement

Article 9. Ex-situ conservation

The Convention sees *ex-situ* (or off-site) conservation as predominantly to complement *in-situ* approaches. In other words, protection of habitats *in-situ* should be the highest priority, but where *ex-situ* conservation can contribute to that objective, it should be undertaken. The Convention thus rejects the argument made by some that the main approach to biodiversity conservation should be *ex-situ*, possibly through some form of global genebank, but does accept that *ex-situ* approaches have a role to play. This balance is important.

Ex-situ approaches can contribute most to *in-situ* conservation when habitats have become so degraded or population sizes have fallen so low that it is not possible to ensure survival of certain species (or of wild populations of genetic resources) in nature. This Article and the previous one, taken together, recognize the convincing case made for comprehensive programmes to species conservation that involve *in-situ* and *ex-situ* techniques in an integrated manner.

Ex-situ conservation is particularly important for domesticated and cultivated species, and has been the main conservation approach for agricultural land-races and other crop cultivars. The Convention implicitly recognizes this importance but, in the provisions of Article 8 and elsewhere, indicates a shift of emphasis towards *in-situ* approaches as well. Of course, for cultivated crops, *in-situ* conservation would have to be on farms and ranches, as the populations no longer would survive in nature. It is particularly important to conserve the wild relatives of domesticated animals and crop plants, both *in-situ* and *ex-situ*, because of their potential importance in breeding programmes. Current indications are that their conservation, at least of plant wild relatives, is very inadequate.

For wild animal species, the particular value of *ex-situ* approaches - essentially captive breeding - is to bulk up populations of endangered species for reintroduction back into the wild. As noted under Article 8(f), when a population is very low, it is vital to increase it as fast as possible, so as to minimize genetic loss; captive breeding can be very good at this. It is also vital, in particular for behavioural reasons, to reintroduce the animals back into the wild as soon as possible. Captive breeding has already saved some animals from extinction, notably the Arabian Oryx, which has been successfully reintroduced from captive-bred populations, and has the potential to contribute to the survival of many more. Also, some animals, like the Prewalski Horse, are only known in captivity; without captive breeding, this species would be extinct.

With wild plant species, the situation is somewhat different. Cultivation is just as important as with animals in bulking up populations of endangered species for reintroduction, and it can usually be done more quickly. Using techniques such as propagation by seed and micropropagation, one individual plant specimen can be turned into thousands of individuals in a year or so. Also, the behavioural difficulties in reintroduced animals do not occur in plants; the only necessity is to ensure the genetic constituency has not been modified during the time in cultivation. But the main difference between *ex-situ* conservation of plants and animals is that it is possible to store the seeds of the majority of the plant species of the world in seed banks, in which they will retain their viability for a hundred years or more. A small phial of seeds may contain the full genetic variability of a species. The fact that the seeds can usually be taken without reducing wild populations, and the ease of storage, means that for plants *ex-situ* conservation also has the wider role of providing an inexpensive insurance policy. This is valuable not just for species under immediate threat of extinction, but for a much broader set of species, in particular those that are naturally rare or those suffering from commercial collection in the wild. It is also easier to provide propagating material of plants for research, commerce and other purposes from *ex-situ* collections than from the wild.

The Global Biodiversity Strategy, the Botanic Gardens Conservation Strategy and the draft World Zoo Conservation Strategy, and the other references cited in the Bibliography, give States a clear rationale for *ex-situ* conservation, a precise outline of what is needed and an explanation of the various techniques involved. These strategies are all broadly in line with the objectives and approach of the Convention.

"Each Contracting Party shall, as far as possible and as appropriate, and predominantly for the purpose of complementing in-situ measures

(a) Adopt measures for the ex-situ conservation of components of biological diversity, preferably in the country of origin of such components;

This clause implies that States should establish and maintain *ex-situ* collections of:

- Representative samples of threatened species (there is little benefit to *in-situ* conservation in conserving non-threatened species), the samples being chosen to provide an adequate proportion of the genepool of the species;

- Samples of populations of genetic resources, selected so as to both provide adequate representation of the full genetic diversity of the resource and to include samples from the various populations containing the different characteristics of the genetic resource.

These collections should preferably be in the country of origin. This is significant, since historically most *ex-situ* conservation has been far away from the origin of the material. Yet for wild plants, at least, evidence is growing that *ex-situ* conservation in seed banks is much better done on a relatively small scale, in particular for the plants of an individual country or island, rather than in large international institutions.

Action implied Carry out a programme of ex-situ conservation for species and genetic resources as required.

"(b) Establish and maintain facilities for ex-situ conservation of and research on plants, animals and micro-organisms preferably in the country of origin of genetic resources;

To carry out the action in (a), States clearly have to provide the facilities needed, and this is the substance of this clause.

The phrasing in this clause, the previous clause and the beginning of the Article implies that every State should have *ex-situ* conservation facilities of its own. However, this may not be a realistic goal for small States, where facilities shared with neighbouring countries may be more appropriate. However, the intention of this phrasing seems to be to ensure a balance between action in developed and developing countries, since historically much *ex-situ* conservation has been in developed countries, for plants and animals far from their country of origin.

Most of the emphasis *ex-situ* facilities has been on seed banks for genetic resources of plants. The main institutions are the Crop Genetic Resource Centres, run under the aegis of the Consultative Group on Agricultural Research, and the growing number of national seed banks. For long-lived crops, such as cocoa, whose seeds cannot be stored in seed-banks, field genebanks are the next best option, but are vulnerable to disease epidemics and are expensive to maintain.

The main institutions for *ex-situ* of conservation of wild animal species are zoos and aquaria. For wild plant species, the main institutions are botanic gardens. However, for both plants and animals, some important collections of great value to biodiversity conservation are in private hands, and States need to make arrangements for these, to ensure that they reach the standards of protection and management required. For microorganisms, the main institutions are the 23 Microbiological Resources Centers (MIRCENS).

States are also obliged to provide facilities for research on plants, animals and micro-organisms. Research may be seen as a way of adding value to the collection. The research undertaken should include that necessary for *the ex-situ* conservation itself. This is needed, for plants, animals and microorganisms. In particular, the techniques for seed-banking were developed for a small number of well-known crop species and these techniques cannot always be applied successfully to other species without careful research and monitoring of viability.

Action implied:

> Provide facilities for ex-situ conservation and for research, preferably in the country of origin.

"(c) Adopt measures for the recovery and rehabilitation of threatened species and for their reintroduction into their natural habitats under appropriate conditions;

This essentially repeats Article 8(f). It may be interpreted on the one hand as reinforcing the view that effective recovery of many threatened species needs an integrated approach, involving both *in situ* and *ex situ* conservation. On the other hand, it may also be seen as providing one objective for the action taken under clauses 9(a) and (b): a reason for the *ex situ* facilities is to be able to ensure the recovery of the threatened species.

The clause does, however, introduce a further element, reintroduction. It implies that the ultimate purpose of *ex-situ* conservation for wild as opposed to domesticated and cultivated species is reintroduction into the wild. With large animals in captive breeding, the reintroduction should be in the short-term; with many plants, whose seeds can be stored in seed banks for as much as a hundred years without loss of viability, it is practical to see *ex-situ* also as a long-term insurance policy, used not only for species in need of immediate recovery but for a wider range of species which could conceivably suffer depredations and loss in future years.

Action implied: Covered under Article 8(f).

"(d) Regulate and manage collection of biological resources from natural habitats for ex-situ conservation purposes so as not to threaten ecosystems and in-situ populations of species except where special temporary ex-situ measures are required under subparagraph (c) above; and

This clause essentially means that in collecting samples of species and of genetic resources for *ex-situ* conservation, those species and genetic resources should not be further endangered, other species and genetic resources should not be harmed, and the ecosystem concerned should not be damaged.

This is a well-established conservation principle and guidelines have been prepared for collection of plants and animals. The problem is more acute with animals than with plants, since most plants can be propagated from seed or cuttings, and so usually the samples taken do not significantly reduce wild populations. It is not usually an issue with cultivated plants, such as crop varieties, since the samples taken are from fields and gardens, although of course it is essential to obtain permission from the farmer or grower first.

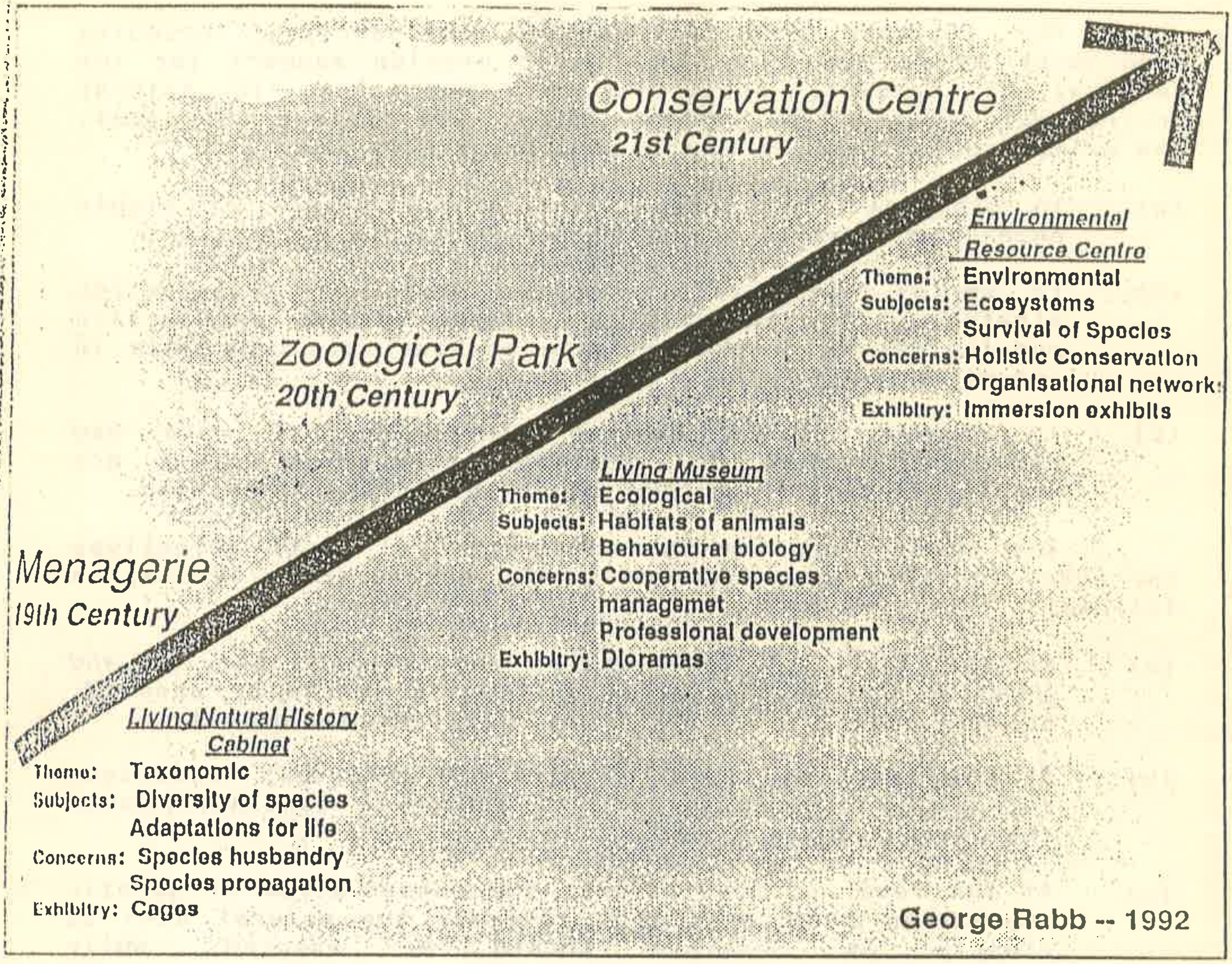
A good way of implementing this clause would be through requiring a permit for all collection of threatened species. This could be handled through the legislation required under Article 8(k). The permit issuing authority, which could be the nature conservation agency of the State, would be required to ensure the conditions of this clause, and any other other conditions deemed necessary, are adhered to. The question is probably only controversial in the case of large, critically endangered animals, where any removal of wild specimens will reduce the wild population significantly; a difficult judgment call is needed and this is best made by the nature conservation agency, rather than left to interested parties such as, perhaps, the zoo eager to captive breed the animal concerned or the park authority anxious to maintain its herds in the wild.

The IUCN Policy Statement on Captive Breeding makes the important point that the vulnerability of small animal populations has been consistently underestimated and so the removal of individuals for captive breeding has tended to be left to the last moment, when the removal of those animals reduces the wild population proportionately far more than it would have done earlier. Timely recognition of declining populations that may need captive breeding is needed.

Action implied: Regulate all collection of plants, animals and microorganisms for *ex-situ* conservation so as to comply with the conditions of this clause.

"(e) Cooperate in providing financial and other support for ex-situ conservation outlined in subparagraphs (a) to (d) above and in the establishment and maintenance of ex-situ conservation facilities in developing countries.

CHANGING ROLE OF ZOOS.



GOALS AND PREREQUISITES OF EX-SITU CONSERVATION

The ultimate goal of captive, or ex-situ, breeding programmes as we see them now, is to provide support for the survival of species, subspecies or pouplations in natural environments (Seal, 1986, Foose, 1986). To achieve this goal, the primary objectives of the ex-situ programmes are:

(a) to propagate and manage ex-situ populations of highly endangered taxa to prevent their immediate extinction;

(b) to employ these programmes as parts of conservation strategies that interactively manage ex-situ and in-situ populations to ensure ultimate survival of these taxa in the wild;

(c) to develop stable captive populations of rare and endangered taxa for education programmes which are beneficial to the survival of conspecifics in the wild.

The foundations for the achievement of these objectives for every breeding programme can be defined on three levels, as follows:

(a) At the level of individuals, sufficient longevity and physical and psychological well-being should be ensured. Animals should live long lives of acceptable quality.

(b) At the level of breeding pairs and colonies, sufficient reproduction should occur, to guarantee continuity over the generations.

(c) At the level of populations, the conservation of genetic population structures that resemble the natural ones as closely as possible should be assured, while demographically stable population structures should be established as well.

(Source: Development of coordinated genetic and demographic breeding programmes - L.E.M. de Boer.)

Biodiversity and Conservation 2, 426–437 (1993)

Captive breeding – a useful tool in the preservation of biodiversity?

CARSTEN RAHBEK*
Zoological Museum, University of Copenhagen, Universitetsparken 15, DK-2100 København Ø, Denmark

Received 6 September 1992; revised and accepted 8 February 1993

Within the next decades species extinction may eliminate between 20 and 50% of the Earth's species. Captive breeding has often been claimed to be a useful tool in preservation of biodiversity. The role of zoos in conservation work and the value of captive breeding are discussed; the latter exemplified by the Peregrine Falcon (*Falco peregrinus*) Programme and the Arabian oryx (*Oryx leucoryx*) Programme. Captive breeding programmes are very resource demanding and can only be afforded for a very small number of species, which limits their value significantly.

Zoos deal mainly with vertebrates, but these comprise less than 3% of the described species, and although the 878 zoos considered hold more than 20 000 specimens of 140 threatened mammal species, they probably only contribute to the conservation of 20 full species. The situation for birds, reptiles and amphibians is even worse. Zoos face serious problems with minimum viable population sizes and hybridization. However, zoos can make a major contribution to preservation of biodiversity through educating and informing the public. Today, where the crisis of extinction of species has reached such daunting dimensions, captive breeding and other *ex situ* conservation tools should be the last resort for preserving biodiversity, and captive breeding must not become an excuse to avoid dealing with preservation of habitats.

Keywords: captive breeding; *in situ* and *ex situ* conservation tools; the role of zoos in conservation

Introduction

Although the global biological diversity is close to its all-time high (Wilson, 1988a), the assumed extinction rate is now so high that it is no exaggeration to talk about a global crisis. Species extinction caused primarily by deforestation in the tropics may eliminate between 20 and 50% of the world's species within the next decades (Lugo, 1988). Financial, demographic and socio-economic reasons make it impossible to preserve all the remaining undisturbed areas and its biodiversity. Diamond and May (1988) succinctly express this in a paper headline in *Nature*. 'Conservation biology: a discipline with a time limit.' Tough decisions must be made on what to preserve and what to lose. The prevalent strategy on which these decisions are based is the concept of biodiversity (in the sense of Wilson, 1988b). It is obviously necessary to examine explicitly how the maximum number of species can be preserved using the limited funds that are available.

Many strategies have been proposed and several techniques have been developed to face this challenge. They can roughly be divided into two groups: the strategies primarily

*Present address: Department of Vertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560, USA.

focus on areas with huge diversity, while the techniques tend to focus on the species. Examples of the area and diversity approach are the megadiversity countries approach (e.g. Mittermeier, 1988; McNeely *et al.*, 1990; Mittermeier and Werner, 1990), the endemism or restricted-range species approach (e.g. Myers, 1988; Miller *et al.*, 1989; Myers, 1990; Fjeldså, 1991, 1993; Bibby *et al.*, 1992), the critical faunas analysis or complementarity approach (e.g. Ackery and Vane-Wright, 1984; Collins and Morris, 1985), the stepwise or network analysis approach (e.g. Kirkpatrick, 1983; Margules *et al.*, 1988; Margules, 1989; Pressey and Nicholls, 1989a, 1989b), the taxic diversity measurement approach (e.g. Humphries *et al.*, 1991; Vane-Wright *et al.*, 1991; Williams *et al.*, 1991, 1993), the phylogenetic diversity measurement approach (e.g. Faith, 1992, 1993), and the evolutionary approach (e.g. Erwin, 1991). Examples of the species approach are the field gene bank technique (e.g. Leadlay and Wyse, 1992), the seed bank technique (e.g. Plucknett *et al.*, 1987; Ashton, 1988; Levin, 1990; Leadlay and Wyse, 1992), the *in vitro* storage technique (e.g. Brush, 1991; Leadlay and Wyse 1992; Rubluo *et al.*, 1993), the transplantation and translocation technique (e.g. IUCN, 1987; Nielsen and Brown, 1988; Griffith *et al.*, 1989; Dodd and Siegel, 1991; Franklin and Steadman, 1991; Hearne and Swart, 1991; Maunder, 1992), and the captive breeding technique (e.g. Temple, 1977; Cade, 1988; Flesness and Foose, 1990; DeBlieu, 1991; Gilpin and Wills, 1991; Miller and Hedrick, 1991).

Captive breeding is one of the species maintenance techniques receiving most attention. It has often been claimed to be a very useful and indispensable tool in conservation work (Low, 1980; Cade, 1988). Today where the focus of conservation is biodiversity, it is relevant to discuss the value of captive breeding in regard to preservation of biodiversity, which is the aim of this paper. Two of the best known captive breeding programmes, the Peregrine Falcon (*Falco peregrinus*) Programme and the Arabian Oryx (*Oryx leucoryx*) Programme, will be used as examples to discuss the value of captive breeding as a conservation tool. These two programmes have been chosen because they are generally regarded as successes, and thus illustrate the captive breeding approach when it functions best.

In recent years, zoos have been strongly advocating that they can and will play an important and active role in international conservation work. The Arabian Oryx Programme could never have been carried out without the active commitment and interest from zoos. It is thus natural in this context also to discuss the importance of zoos as centres for captive breeding programmes.

Ex situ programmes for animals and plants have the same final goal, and the concept and philosophy behind them appear to be identical. Yet, they involve different methods and cost-benefit values. The discussion and arguments used in this paper concentrate solely on captive breeding programmes for animals. The conclusion reached cannot simply be transferred to botanic *ex situ* programmes, although the main conclusion might well be the same, if analyzed.

The peregrine falcon example

The background for the captive breeding of the peregrine falcon was the catastrophic situation in the 1950s and 1960s, where the effects of organochlorine pesticides such as DDT and dieldrin led to a dramatic population crash. This situation led to intensive measures to secure the dwindling population in most European countries and in the U.S.

We have now seen that the species is capable of recovery without our help (*sensu* captive breeding programmes) when living conditions are improved (Cade, 1982, 1988). Still, the captive breeding programmes continue, apparently with no consideration of whether other priorities may be more urgent.

The peregrine falcon is a cosmopolitan species, and is thus not the prototype of an extinction-prone species. An argument for this intensive 'production' in the Midwest would be that the captive breeding programme is the only way to save the gene-pool of the Midwest population of peregrines in order to maintain the genetic diversity within the species. However, this is not the case. The new Midwest population has been built up from a variety of individuals from all over the world (Cade, 1988). Much manpower and money have been and are being used to establish a population of peregrines representing gene-pools that were doing well in their areas of provenance.

It is thought-provoking that Sweden, despite its being the European country where most effort has been spent on captive breeding programmes, is probably also the country in Europe where the population of breeding peregrines is still at the lowest level compared with the situation before the population crash.

The Arabian oryx – a successful re-introduction

The Arabian oryx originally inhabited the entire Arabian Peninsula, but in the beginning of the 1960s the population had decreased to only 100 to 200 individuals (Fitter, 1982). An impressive programme was set up to secure the survival of the species. This programme, 30 years after it was started, is often regarded as one of the best examples of a successful restoration of a captive-bred large animal to the wild (Fitter, 1986).

The surviving 1960 population of the Arabian oryx was found in the great Rub al Khali desert on the border to what is today Oman and South Yemen. At that time, the animals were exposed to high hunting pressure from motorized parties of hunters (Henderson, 1974; Fitter, 1982), the species would probably have become extinct if a conservation plan had not been initiated. In 1962, an expedition was launched by the Fauna Preservation Society with the aim of securing a stock for captive breeding and eventual return to the wild. With additional contributions of animals from zoos, a breeding herd was established in Phoenix Zoo, Arizona (Fitter, 1986). What was probably the last wild oryx was shot in Oman in October 1972 (Henderson, 1974).

The captive breeding programme was a success and in the early 1980s the return of Arabian oryx from zoos to the Middle East began. In 1982 the first small flock was released in the Jiddat al Harassis desert (Fitter, 1984; Spalton, 1990). This was followed by other releases in 1984, 1988 and 1989 (Spalton, 1990). In 1990 the wild population of Arabian oryx numbered 109 individuals of which 80% were wild-born (Spalton, 1990). The captive breeding programme and restoration of the species were apparently a success. However, the recent years of drought have resulted in a high mortality, especially among newborns. Only 3 of 15 calves born in 1991 are today still in the wild; 10 others are dead and 2 have been captured (Jenkins, 1992). According to World Conservation Monitoring Centre (WCMC), new releases of captive bred oryx are being planned to ensure a better demographical distribution and genetic variation of the wild population (Jenkins, 1992).

It seems as if the Arabian oryx has been re-established as an element of the desert ecosystem: the first example of an animal extinct in the wild being successfully reintroduced (Fitter, 1984, 1986). Yet, the cost has been tremendous. Primarily caused by the fear of the diseases blue tongue and of tuberculosis, a veterinary programme has been a necessary integrated part of the project in all stages (Jenkins, 1992). Released animals are monitored by rangers with four-wheel drive vehicles, and 40 selected individuals are monitored with radio-tracking equipment (Spalton, 1990; Jenkins 1992). As competition with domestic herds has increased, it has been necessary to negotiate with local tribesmen about the grazing problem. Thus, careful management of the project continually needs to be made, so although the Arabian oryx project has been a success as a reintroduction programme, it also serves to demonstrate that the success of a captive breeding programme largely depends on long-term commitment and a high level of resources and man-power (Jenkins, 1992). In the present situation we can only afford to do this for a limited number of species. Captive breeding and reintroduction programmes like the one for Arabian oryx, no matter how successful, only make a very limited contribution to the preservation of biodiversity. It is relevant to ask whether such limited, but expensive programmes should continue to be endorsed, supported and implemented by the international conservation community at the present level, or be given a lower priority.

The role of zoos in conservation

It is often claimed that captive populations of animals kept in zoos can function as significant demographic and genetic reservoirs from which wild populations can get vital infusions to secure a declining population or to found a new population. The Arabian Oryx Programme is an example that captive populations can be a last resort to rescue a wild population that otherwise probably would have become extinct. However, in an analysis by the WCMC of *ex situ* conservation of animals, it was concluded that zoos perhaps have the capacity to do this, 'but to date efforts have been relatively limited and the vast majority of captive specimens in the world's zoos have little importance for the conservation of species or even in maintaining genetic diversity amongst non-threatened species' (Jenkins, 1992). Though the 878 zoos and aquaria that WCMC considered in their analysis hold 20 628 specimens from 140 threatened mammal species the zoos make a significant contribution to the conservation of only 20 full species and perhaps approximately the same number of subspecies (Jenkins, 1992).

As Table 1 reveals, the situation is worse for other groups of organisms and on the genetic level it is undoubtedly even less promising. Only for species with very small populations, for example a species of fish restricted to one or a few small lakes, it is *perhaps* possible to create a captive stock that will be roughly equivalent to that in the wild population. Even then, in order to secure the full genetic range, so many individuals from the wild stock might have to be taken into captivity that the chances for the wild stock to survive might be impaired. Securing a captive 'replica' of the wild gene pool might thus be a chimaera. Much time and effort has been spent by the Captive Breeding Specialist Group of International Union for Conservation of Nature and Natural Resources' (IUCN) Species Survival Commission to develop strategies and computer programs that maximize the out-breeding of captive species. This will surely reduce the problem, but not eliminate it.

Of the more than 1000 bird species listed as threatened, less than 3% are found in zoos (Table 1). These figures do not include species kept in private or semi-private collections.

Table 1. The number of described and threatened vertebrate species in the world compared with the number and individuals of threatened vertebrate species in zoos and aquaria (n = 878), with indications of the total size of the captive population and numbers of species bred in captivity

Category	Mammals	Birds	Reptiles	Amphibians	Fish
Number of described species	4237[a]	9200[b]	6550[c]	4000[d]	21 700[e]
Percent of total number of species described[f]	0.25	0.54	0.39	0.24	1.28
Number of IUCN threatened species[g]	647	1161	207	65	1081
Number of IUCN threatened species in zoos and aquaria[h]	140	33	36	5	?
Number of IUCN threatened species bred in captivity[h]	121	29	32	1	?
Number of IUCN threatened individuals in zoos and aquaria[h]	20 770	2961	6187	206	?
Number of populations with > 500 specimens[h]	9	1	1	0	?
Number of populations with > 250 specimens[h]	23	4	4	0	?
Number of populations with > 100 specimens[h]	62	8	11	1	?

References: [a]Corbet and Hill (1991); [b]Howard and Moore (1991); [c]Halliday *et al.* (1986); [d]Frost (1983); [e]Nelson (1984); [f]using the 1.7 million figure given by Hammond (1992); [g]number of species listed as threatened or endangered by the IUCN (1990); [h]data compiled from Olney and Ellis (1991) in Jenkins (1992).

Although the latter collections would raise the number of threatened species held in captivity, many conservation organizations have experienced how hard it can be to cooperate with such private collections to carry out successful captive breeding programmes *including* the introduction of the captive raised individuals into the wild. A good case-history is the Spix's macaw (*Cyanopsitta spixii*); see Collar *et al.* (1992) for an excellent review.

The number of threatened species in groups of organisms other than mammals and birds is just as low. Jenkins (1992) lists 36 species of reptiles and only 5 species of amphibians held captive in zoos that are registered as threatened by the IUCN, whereas he points out that corresponding data for threatened fish or for invertebrates are not available (see Table 1).

Whether a species is present in a zoo or not is only the first requirement that zoos have to fulfill to be able to contribute to the preservation of biodiversity. Returning to mammals, which are the best represented group of threatened species held in zoos, two major problems in zoo capacity arise: (i) mammals as a group (and vertebrates in general) are poor representatives of the total global diversity. Mammals account only for approximately 0.25% of the known species (Table 1); (ii) there is the important question of minimum viable population (MVP) size. For only 9 threatened mammal species (Table 1) can the captive population be considered as viable if 500 individuals are regarded as the critical number for a MVP as suggested by Lande and Barrowclough (1987). (see also Lande, 1988; Simberloff, 1988 for a discussion of MVP sizes; Marker and O'Brien, 1989 for a case study on captive bred cheetahs (*Acinonyx jubatus*) in North American zoos). Even if the size of a viable population is less than the suggested 500 individuals, the situation is not much better (see Table 1).

Another serious problem zoos have to face is their mismanagement of the species and subspecies concepts in the past. Hybridization has been and perhaps still is a very common phenomenon. Hybrids account today for a major part of the captive stock for many species held in zoos (Cohn, 1992). For example, genetic analyses have shown that all 250 Indian tigers (*Panthera tigris tigris*) held in North American zoos are hybrids of Indian and Siberian tigers (*P.t.altaica*) (Cohn, 1992). Accidental hybridization among similar species has on several occasions led to the extinctions of zoo populations (Benirschke and Kumamoto, 1991). Hybridization in zoos has generated a severe problem that has to be taken seriously and solved before captive breeding programmes can be used in the work for preservation of endangered wild populations of species or subspecies.

With the seriousness with which most zoos today go into international work on the preservation of single species, it is likely that zoos will be able to tackle these problems for more and more species, but for the total global biodiversity it will still be on a minute scale. The question is whether we should use additional resources on captive breeding programmes to secure the preservation of, for example, more mammalian species, while thousands of other species (primarily invertebrates) might become extinct in the meantime.

However, zoos might be a valuable partner for transit-location in reintroduction programmes, where movement of individuals between wild populations is used as a conservation tool. The success of such programmes is still low for endangered or sensitive species. For such species Griffith *et al.* (1989) found the rate of success for mammals and birds to be 44% ($n = 198$), while Dodd and Siegle (1991; see Burke, 1991 and Reinert, 1991 for comments) in an analysis on reptiles and amphibians only found a success rate of 19% ($n = 26$). It is noteworthy that of the five successful projects, four involved crocodilians (Dodd and Siegle, 1991).

Zoos have an important role as informational and educational bodies in the struggle for preservation of biodiversity. They can be used to visualize the beauty and wonder of nature, especially for children (i.e. upcoming adults and decision-makers on all levels). Here children can learn for themselves that wild animals are not just something on television. Animals in all their different sizes, shapes and colours do in fact exist. They are real. The seed of respect and care for wildlife has been sown in many adults in their childhood through the opportunities that zoos offer a growing urban human population. This is an important point and it is one of the major tasks and contributions of zoos to the future preservation of biodiversity. Zoos are one of the most important educational and information tools we have, if used wisely, and captive breeding programmes can be an integrated part of their function.

The cost/benefit of captive breeding

There is a great gap between theory and practice of reintroduction of endangered species. Worldwide there are pitifully few examples of successful re-establishment of bird populations through release of captive-reared stocks (Imboden, 1987; Cade, 1988). In a paper discussing the value of captive breeding, the director of Bird Life International (formerly the International Council for Bird Preservation) concludes that captive breeding is a useful tool only under certain carefully controlled conditions and that it is often an illusion (Imboden, 1987).

The danger of using efforts and money on captive breeding is also that it provides a pretext for ignoring the key issue: the protection and restoration of the natural habitat of the threatened species (Meltofte, 1987).

Unintentionally, captive breeding programmes often give the wrong signals to the public and politicians. Authorities will probably feel less urgency to do something if they get the impression that disappearing species can be readily reintroduced from captivity. Today too much effort is being used to save a few endangered species, while an area of tropical forest larger than Costa Rica is being cut down each year (Wilson, 1988c), perhaps causing extinction of hundreds of species.

The Eastern Peregrine Recovery Programme in the USA has not preserved any genetic variation at all; the total cost up to 1988 has been between 3.0 and 3.5 million US dollars, perhaps more (Cade, 1988). More than 325 people, mostly temporary summer helpers, have worked directly for The Peregrine Fund, not to mention dozens of federal and state agency personnel who also helped (Cade, 1988). This is only one of four major regional recovery programmes for the peregrine in the USA, and there are other programmes in Canada, Europe and elsewhere. This is an immense amount of money to be used on one single cosmopolitan (not globally threatened) species.

Consider how much just a fraction of these resources would mean if used elsewhere for preservation of biodiversity. Podocarpus National Park in southern Ecuador could be used as an example. The 1462 km^2 national park is probably one of the 5 richest national parks in the world in terms of birds (Bloch *et al.*, 1991). Today more than 550 bird species are known from the area (own information), and it is estimated that this relatively small area may harbour as many as 800 of the approximately 9200 bird species in the world (Bloch *et al.*, 1991). The management and protection of this park depend on only 6–8 poorly paid wardens with no training at all and one administrator with a small budget. To date, most of the park is almost untouched by man, but it is now severely threatened by new and increasing human activity (roadbuilding, mining, settlements, etc.). Money and manpower cannot solve the problems alone but they are key factors in developing and implementing a sustainable management plan for the area.

Zoos have a great challenge in raising the awareness of people, especially the urban population, and it will require much money to do properly. From a cost-benefit point of view with respect to saving the biodiversity of tomorrow, the effect of education and information is probably much more valuable than massive and costly captive breeding programmes.

Resources used on captive breeding programmes *per se* in zoos might well be a misallocation of money. There is a disparity in the money spent on captive breeding efforts in comparison with money spent on similar *in situ* single species-oriented conservation programmes, especially when considering that captive breeding programmes are often less cost-effective than *in situ* programmes (Jenkins, 1992). Leader-Williams (1990) has provided a good example of this for African elephants (*Loxodonta africana*) and black rhinos (*Diceros bicornis*). He found that it costs 50 times as much to keep these two species in zoos than to manage the same number of individuals in the wild. Furthermore, keeping captive individuals of one species does not contribute to the benefits for other species, as an *in situ* programme focusing on habitat conservation would.

It is often argued that the money and effort spent on captive breeding programmes to save an exotic species would not be available to other and perhaps better measures of preservation of biodiversity. This is likely to be true in some cases, but on the other hand, these actions might also divert attention from the real problems, the destruction of natural habitats. Undoubtedly, captive breeding projects taking care of a single species have big public relations value, by which many people become aware of nature conservation problems. Nevertheless, a negative 'Panda-effect' is also created. People begin to believe that the problems are already taken care of, and they appreciate the fact that someone seems to do the job for them. Thus, the projects might unintentionally divert attention from the fact that the surrounding nature is disappearing while a few chosen species are being saved through species-specific captive breeding programmes.

Conclusions

Recent estimates show that we should maybe think in terms of 30 million, or perhaps 50 million species on Earth (Erwin, 1982, 1988; see May, 1988, 1990, 1992; Stork, 1988, 1991; Hammond, 1990; Hodkinson and Casson, 1991, for discussion and other estimates; and Hammond, 1992, for a review). Today only around 1.7 million living species of organisms have been described (Hammond, 1992). It is estimated that by the end of this century, our planet could lose 20 to 50% of its species (Lugo, 1988).

Well aware that captive breeding programmes and other kinds of species-manipulation 'tools' are only a part of the work in conservation of biological diversity, a strategy for conservation of biodiversity must be based on the realization that the crisis of extinction of species has now reached such daunting dimensions (Myers, 1993) that the focus of attention must be concentrated on the habitat approach. However, 'vogue' species can still be used to some extent in campaigns as 'flagships' to justify the preservation of specific habitats or specific areas that also hold species of lower conservation profile, e.g. using *in situ* (secondarily *ex situ*) work on the giant panda (*Ailuropoda melanoleuca*) in promotion campaigns for saving the threatened Chinese bamboo forests.

It is hard to imagine specific programmes for each of the immense number of species that are in danger of extinction within the next decades. Besides, raising funds for all these programmes or just a small fraction would be impossible alone due to the fact that most of the endangered species are tiny arthropods or other invertebrates with low 'appeal' and thus low public relations-effect and low public interest.

The sad fact today is that the number of species in need of conservation action is so immense that it is hopeless to make specific actions for them all. The main goal must be to save as much as possible of the biodiversity of the Earth. This includes the hundreds of thousands of arthropods and other invertebrates as they are just as an important part of an ecosystem as a tiger or a giant panda; moreover arthropods alone account for more than half of the known species – just think of the insects! (See *Biodiv. Conserv.* 2, 189–282.) By contrast, the vertebrates that captive breeding focuses on only account for less than 3% of the described species, and much less in reality: 0.4% if using Hammond's (1992) conservative estimate of possibly-existing species.

Captive breeding programmes and maintaining artificial collections in zoos and other places are last resorts for preserving selections of already known taxa. Instead, resources should be used to save habitats and ecosystems and to provide information to raise public awareness; this is where zoos can play a vital role. The direct contribution to preservation of biodiversity through captive breeding programmes in zoos is unfortunately secondary to the informational and educational value of such programmes. The vast majority of captive specimens held in zoos are unimportant for preservation of biodiversity (Jenkins, 1992).

The question must also be raised whether such programmes as the Peregrine Falcon Programme and Noah's Ark programmes of zoos actually proceed because they have become good funding sources for the institutions, rather than because they represent a valuable tool for conservation. Captive breeding must not on any level result in misallocation of available resources *or*, more importantly, become an excuse to avoid dealing with preservation of habitats.

Acknowledgements

Jon Fjeldså and Nicolaj Scharff provided much inspiration through several discussions. They were also helpful with comments to an earlier draft of this paper, and so were Jon Lovett, Hans Meltofte and Mary E. Petersen. I thank them all, though they are not responsible for the opinions expressed in the paper.

References

Ackery, P.R. and Vane-Wright, R.I. (1984) *Milkweed butterflies*. London: British Museum, Natural History.

Ashton, P.S. (1988) Conservation of biological diversity in botanical gardens. In *Biodiversity* (E.O. Wilson, ed.) pp. 269–78. Washington D.C.: National Academy Press.

Benirschke, K. and Kumamoto, A.T. (1991) Mammalian cytogenetics and conservation of species. *J. Hered.* 82, 187–91.

Bibby, C.J., Crosby, M.J., Heath, M.F., Johnson, T.H., Long, A.J., Stattersfield, A.J. and Thirgood, S.J. (1992) *Putting biodiversity on the map: global priorities for conservation*. Cambridge: ICBP.

Bloch, H., Poulsen, M.K., Rahbek, C. and Rasmussen, J.F. (1991) *A survey of the montane forest avifauna of the Loja Province, Southern Ecuador*. ICBP study report No. 49. Cambridge: ICBP.

Brush, S. (1991) A farmer-based approach to conserving crop germplasm. *Econ. Bot.* 45, 153–65.

Burke, R. (1991) Relocations, repatriations, and translocation of amphibians and reptiles: taking a broader view. *Herpetol.* 47, 350–7.

Cade, T.J. (1982) *The falcons of the World*. London: Collins.

Cade, T.J. (1988) Using science and technology to reestablish species lost in nature. In *Biodiversity* (E.O. Wilson, ed.) pp. 279–88. Washington D.C.: National Academy Press.

Cohn, J.P. (1992) Decisions at the zoo. *BioSci.* 42, 654–9.

Collar, N.J., Gonzaga, L.P., Krabbe, N., Madroño Nieto, A., Naranjo, L.G., Parker III, T.A. and Wege, D.C. (1992) *Threatened Birds of the Americas: The ICBP/IUCN Red Data Book*, pp. 266–81. Cambridge: ICBP.

Collins, N.M. and Morris, M.G. (1985) *Threatened swallowtail butterflies of the world. The IUCN Red Data Book*. Cambridge and Gland: IUCN.

Corbet, G.B. and Hill, J.E. (1991) *A world list of mammalian species*. Oxford: Oxford University Press.

DeBlieu, J. (1991) *Meant to be wild: the struggle to save endangered species through captive breeding*. Colorado: Fulcrum Publishing, Golden.

Diamond, J.M. and May, R.M. (1988) Conservation biology: a discipline with a time limit. *Nature* 317, 111–2.

Dodd, C.K. and Siegel, R.A. (1991) Relocation, repatriation, and translocation of amphibians and reptiles: are they conservation strategies that work? *Herpetol.* 47, 336–50.

Erwin, T.L. (1982) Tropical forests: their richness in Coleoptera and other Arthropod species. *Coleopt. Bull.* 36, 74–5.

Erwin, T.L. (1988) The tropical forest canopy: the heart of biotic diversity. In *Biodiversity* (E.O. Wilson, ed.) pp. 123–9. Washington D.C.: National Academy Press.

Erwin, T.L. (1991) An evolutionary basis for conservation strategies. *Science* 253, 750–2.

Faith, D.P. (1992) Conservation evaluation and phylogenetics. *Biol. Conserv.* 61, 1–10.

Faith, D.P. (1993). Systematics and conservation: on predicting the feature diversity of subsets of taxa. *Cladistics* (in press).

Fitter, R. (1982) Arabian Oryx returns to the wild. *Oryx* 16, 406–10.

Fitter, R. (1984) Operaton Oryx: the success continues. *Oryx* 18, 136–7.

Fitter, R. (1986) *Wildlife for man: how and why we should conserve our species.* London: Williams Collins and Co Ltd.

Fjeldså, J. (1991) The conservation of biological diversity: using birds to set priorities. In *Environmental concerns – an inter-disciplinary exercise* (J. Aa. Hansen, ed.) pp. 157–75. London and New York: Elsevier Applied Science.

Fjeldså, J. (1993) The avifauna of the *Polylepis* woodlands of the Andean highlands: the efficiency of basing conservation priorities on the patterns of endemism. *Bird Conserv. Int.* (in press)

Flesness, N.R. and Foose, T.J. (1990) The role of captive breeding in the conservation of species. In *1990 IUCN Red List of Threatened Animals*. Gland: IUCN.

Franklin, J. and Steadman, D.W. (1991) The potential for conservation of Polynesian birds through habitat mapping and species translocation. *Conserv. Biol.* 5 506–21.

Frost, D.R. (1983) *Amphibian species of the world. A taxonomic and geographical reference.* Lawrence: Allen Press Inc. and the Association of Systematics Collections.

Gilpin, M. and Wills, C. (1991) MHC and captive breeding: a rebuttal. *Conserv. Biol.* 5, 554–5.

Griffith, B., Scott, J.M., Carpenter, J.W. and Reed, C. (1989) Translocation as a species conservation tool: status and strategy. *Science* 245, 477–80.

Halliday, T., Adler, K. and O'Tool, C., eds (1986) *The Encyclopedia of Reptiles and Insects.* London: Unwin.

Hammond, P.M. (1990) Insect abundance and diversity in the Dumoga-Bone National Park, N. Sulawesi, with special reference to the beetle fauna of lowland rain forest in the Toraut region. In *Insects and the Rain Forests of South East Asia* (W.J. Knight and J.D. Holloway, eds) pp. 197–254. London: Royal Entomological Society.

Hammond, P.M. (1992) Species Inventory. In *Global biodiversity: status of the Earth's living resources* (B. Groombridge, ed.) pp. 17–39. London: Chapman & Hall.

Hearne, J.W. and Swart, J. (1991) Optimal translocation strategies for saving the Black rhino. *Ecol. Mod.* 59, 47–63.

Henderson, D.S. (1974) Were they the last Arabian Oryx? *Oryx* 12, 347–50.

Hodkinson, I.D. and Casson, D. (1991) A lesser predilection for bugs: Hemiptera (Insecta) diversity in tropical rain forests. *Biol. J. Linn. Soc. Lond.* 43, 101–9.

Howard, R. and Moore, A. (1991) *A complete checklist of the birds of the world.* Second edition. San Diego: Academic Press Inc.

Humphries, C., Vane-Wright, R.I. and Williams, P. (1991) Biodiversity reserves: setting new priorities for the conservation of wildlife. *Parks* 2, 34–8.

Imboden, C. (1987) The captive breeding controversy. *World Birdwatch* 3, 6–7.

IUCN (1987) *The IUCN position statement on translocation of living organisms: introductions, re-introductions and restocking.* Gland: IUCN.

IUCN (1990) *1990 IUCN Red List of Threatened Animals.* Gland: IUCN.

Jenkins, M. (1992) *Ex situ* conservation of animals. In *Global biodiversity: status of the Earth's living resources* (B. Groombridge, ed.) pp. 563–75. London: Chapman & Hall.

Kirkpatrick, J.B. (1983) An iterative method for establishing priorities for the selection of nature reserves: an example from Tasmania. *Biol. Conserv.* 25, 127–34.

Lande, R. (1988) Genetics and demography in biological conservation. *Science* 241, 1455–60.

Lande, R. and Barrowclough, G.F. (1987). Effective population size, genetic variation, and their use in population management. In *Viable Populations for Conservation*. (M.E. Soulé, ed.) pp. 87–124. Cambridge: Cambridge University Press.

Leader-Williams, N. (1990) Black rhinos and Africa elephants: lessons for conservation funding. *Oryx* 24, 23–9.

Leadlay, E.A. and Wyse, P.S. (1992) Techniques for *ex situ* plant conservation. In *Global biodiversity: status of the Earth's living resources* (B. Groombridge, ed.) pp. 557–61. London: Chapman & Hall.

Levin, D.A. (1990) The seed bank as a source of genetic novelty in plants. *Am. Nat.* 135, 563–72.

Low, R. (1980) *Parrots: their care and breeding*. Poole: Blandford Press.

Lugo, A.E. (1988) Estimating reductions in the diversity of tropical forest species. In *Biodiversity* (E.O. Wilson, ed.) pp. 58–70. Washington D.C.: National Academy Press.

Margules, C.R. (1989) Introduction to some Australian developments in conservation evaluation. *Biol. Conserv.* 50, 1–11.

Margules, C.R., Nicholls, A.O. and Pressey, R.L. (1988) Selecting networks of reserves to maximize biological diversity. *Biol. Conserv.* 46, 63–76.

Marker, L. and O'Brien, S.J. (1989) Captive breeding of the cheetah (*Acinonyx jubatus*) in North American zoos. *Zoo Biol.* 8, 3–16.

Maunder, M. (1992) Plant reintroduction: an overview. *Biodiver. Conserv.* 1, 51–61.

May, R.M. (1988) How many species are there on earth? *Science* 241, 1441–9.

May, R.M. (1990) How many species: *Phil. Trans. R. Soc.* 330, 293–304.

May, R.M. (1992) How many species inhabit the Earth? *Sci. Am.* 267, 18–24.

McNeely, J.A., Miller, K.R., Reid, W.V., Mittermeier, R.A. and Werner, T.B. (1990) *Conserving the World's Biological Diversity*. Gland: IUCN, Gland.

Meltofte, H. (1987) What kind of bird fauna do we prefer? In *Proceedings of the Fifth Nordic Ornithological Congress, 1985* (M.G. Eriksson, ed.) pp. 176–81. Göteborg: Kungl. Vetenskaps- og Vittershets-Samhället.

Miller, P. and Hedrick, P. (1991) MHC polymorphism and the design of captive breeding programs: simple solutions are not the answer. *Conserv. Biol.* 5, 556–8.

Miller, R.I., Stuart, S.N. and Howell, K.M. (1989) A methodology for analyzing rare species distribution patterns utilizing GIS technology: The rare birds of Tanzania. *Land. Ecol.* 2, 173–89.

Mittermeier, R.A. (1988) Primate diversity and the tropical forest: case studies from Brazil and Madagascar and the importance of the megadiversity countries. In *Biodiversity* (E.O. Wilson, ed.) pp. 145–54. Washington, DC: National Academy Press.

Mittermeier, R.A. and Werner, T.B. (1990) Wealth of plants and animals unites 'megadiversity' countries. *Tropicus* 4, 4–5.

Myers, N. (1988) Threatened biotas: 'hot spots' in tropical forests. *The Environmentalist* 8, 187–208.

Myers N. (1990) The biodiversity challenge: expanded hot-spots analysis. *The Environmentalist* 10, 243–56.

Nelson, J.S. (1984) *Fishes of the world*. New York: John Wiley and Son.

Nielsen, L. and Brown, R.D., eds (1988) *Translocation of wild animals*. Milwaukee: Wisconsin, Human Society.

Olney, P.J.S. and Ellis, P., eds (1991) *1990 International Zoo Yearbook Volume 30*. London: Zoological Society of London.

Captive breeding

Plucknett, D.L., Smith, N.J.H., Williams, J.T. and Anishetty, N.M. (1987) *Gene banks and the worlds food.* Princeton: Princeton University Press.

Pressey, R.L. and Nicholls, A.O. (1989a) Efficiency in conservation evaluation: Scoring versus iterative approaches. *Biol. Conserv.* 50, 199–217.

Pressey, R.L. and Nicholls, A.O. (1989b) Application of a numerical algorithm to the selection of reserves in semi-arid New South Wales. *Biol. Conserv.* 50, 263–77.

Reinert, H.K. (1991) Translocation as a conservation strategy for amphibians and reptiles: some comments, concerns, and observations. *Herpetol.* 47, 357–63.

Rubluo, A., Chávez, V., Martínez, A.P. and Martínez-Vázquez, O. (1993) Strategies for the recovery of endangered orchids and cacti through *in vitro* culture. *Biol. Conserv.* 63, 163–9.

Simberloff, D. (1988) The contribution of population and community biology to conservation biology. *Ann. Rev. Ecol. Syst.* 19, 473–511.

Spalton, A. (1990) Recent developments in the reintroduction of the Arabian Oryx (*Oryx leucoryx*) to Oman. *Species* 15, 27–9.

Stork, N.E. (1988) Insect diversity: facts, fiction and speculation. *Biol. J. Linn. Soc. Lond.* 35, 321–37.

Stork, N.E. (1991) The composition of the arthropod fauna of Bornean lowland rain forest trees. *J. Trop. Ecol.* 7, 161–80.

Temple, S.A., ed. (1977) *Endangered birds: Management techniques for preserving threatened species.* London: Croom Helm Ltd.

Vane-Wright, R.I., Humphries, C.J. and Williams, P.H. (1991) What to protect? – systematics and the agonies of choice. *Biol. Conserv.* 55, 235–54.

Williams, P.H., Humphries, C.J. and Vane-Wright, R.I. (1991) Measuring biodiversity: taxonomic relatedness for conservation priorities. *Aust. Syst. Bot.* 4, 665–79.

Williams, P.H., Vane-Wright, R.I. and Humphries, C.J. (1993) Measuring biodiversity for choosing conservation areas. In *Hymenoptera and biodiversity.* (J. LaSalle and I. Gauld, eds) Wallingford: CABI (in press).

Wilson, E.O. (1988a) The diversity of life. In *Earth '88: Changing geographic perspectives* (J. De Blij Harm, ed.) pp. 68–78. Washington, DC: National Geographic Society.

Wilson, E.O., ed. (1988b) *Biodiversity.* Washington D.C.: National Academy Press.

Wilson, E.O. (1988c) The current state of biological diversity. In *Biodiversity* (E.O. Wilson, ed.) pp. 3–18. Washington, DC: National Academy Press.

David Jones
Director of Zoos

The role of zoos and their management

Good zoos work constantly to improve the standards of husbandry, welfare and presentation of their animals. Such institutions recognise that they have a moral obligation to be more than just a family day out; they must fulfil educational and conservation roles as well. But good zoos will suffer as long as bad ones survive. Defining and working towards acceptable international standards in animal welfare and in exhibit presentation has to be the highest priority, closely followed by the need to change traditional perception of their function by zoo staff. The day has long gone when a collection plan can be based on the need for a wide taxonomic range. Living animals should be assembled largely as a means of illustrating specific and clearly defined messages about the problems confronting our planet; how these problems must be tackled and how each particular institution is contributing to those solutions. The cynics will say that this approach will not bring people through the gate, but they do not have the imagination to see that with proper planning, visitor interest and conservation awareness are not incompatible.

With ever larger numbers of people living in towns and cities, whether it be in the Developed or Developing World, a large proportion of the world's population are becoming more and more detached from the living organisms. In developing countries, zoological gardens as conservation-education centres can act as the focus of interest and awareness for the animal and other natural resources of that country. In the developed world, such institutions should act as a means of bringing people into close contact with live animals and at the same time showing them some of the reality of coping with species-specific survival problems. This approach is made even more important because of the apparent unwillingness of the media in many countries to present the realities of conservation in a way which will allow most people to understand the issues clearly.

It is vital that the future leadership for all zoos should be aware of the broader environmental picture. It is also important that all staff be made aware of the purposes of the institution and that all other activities be directed towards this end. It is probably inevitable, for different reasons in different countries, that most zoos will have to find the majority of their income from normal commercial sources, usually the main gate and supportive catering and retail outlets. Central support will usually be necessary but a degree of independence from government interference is also desirable, otherwise the zoo management and continued progress are all too often hampered by bureaucracy and politics.

The presentation will examine these concepts in more detail giving specific examples and will show ways in which changes can be effected in public perception of an institution and in the styles of management needed to achieve the right results.

BEYOND THE ZOO : THE BIOPARK

By
Michael H. Robinson
National Zoological Park, Smithsonian Institution, Washington D.C. 20008

Zoos are more popular than ever, new zoos are being built every year throughout the world, and in the United States more people visit zoos per year than attend all field sports combined. This is a remarkable reflection of man's interest in animals. It should be viewed alongside the burgeoning interest in natural history films and T.V. series and the continuing expansion of petkeeping. What of the future, have zoos progressed to the ultimate level of development as educational institutions and places for recreation and research? The answer is no, further change is both possible and necessary. However, in the process zoos will almost certainly cease to be zoos.

In the last hundred years zoos have progressed from animal freakshows to wonderful, state-of-the-art, naturalistic displays of exciting and interesting animals. Even twenty years ago most zoos were simply art galleries of exotic animals, in which the "collection" was of as many species as the Director could assemble. In such "galleries" the social grouping representing each species was almost always unnatural. The progress from this stage has been astonishing. The monumental style of zoo architecture, in which buildings dominated and diminished animals and public alike, has largely disappeared. It has been replaced by exhibit design based on artfully contrived simulations of habitats. To achieve this design teams have used every artifice of Hollywood to recreate exotic landscapes in the heart of cities throughout the world. In the middle of the Bronx, New York City, one can walk through a technically superb recreation of a South East Asian mangrove swamp, a magnificent rainforest, or a Siberian tundra. These exhibits involve complex concrete and fibreglass facsimiles of terrain and trees; the detail is immaculate and the effect totally convincing. Along with the advances in the design of animal living space (the word cage is now obsolete and inaccurate) there have been equally important changes in animal husbandry. The philosophy of zoo-animal care has also been radically revised. Animals are now kept in appropriate social groupings instead of in artificial assemblages or in isolation; this leads to healthier happier animals that now can indulge in a wide range of normal behavior to the delight of the visitor. Additionally there is an increasing tendency to produce multiple species displays, broadly simulating natural but simplified habitat groupings. The traditional zoo subdivisions of exhibits between mammals, birds and reptiles are disappearing as naturalism advances. The reasons for keeping birds in the Bird House, reptiles and amphibians in the Reptile House, and mammals separated into Cats, Small Mammals, Pachyderms and Hoofstock, the capitalised divisions of past fashion, are no longer paramount. All this is good, but zoos are still living with traditional divisions that are no longer philosophically valid or a necessary result of practical constraints. The ultimate obsolete tradition is the zoo itself. There is really no longer a good reason for separating animals from the rest of the living world. It is time to replace zoological parks with biological parks.

This may sound like a revolutionary statement but it is, at its most extreme, actually only a piece of hyperbole designed to focus attention on a problem. The problem is simply stated: why should collections of living animals be separated from collections of living plants, and why should either of these be separated from collections of the structures composing plants and animals and the fossils of their past history? In short, why should zoos, aquariums , botanic gardens and natural history museums be separate entities? Zoos are places where one can see, ideally, a wide variety of exciting animals in attractive settings. Botanic gardens are places where one can see beautiful and interesting plants from around the world. Aquariums are places where one can see aquatic animals, preponderantly fishes, in glorious profusion. Natural History Museums are places where one can learn a great deal about the structure, relationships, and fossil history of plants and animals. All of these institutions are a point of contact between urban mankind and the living world. Their separation is a continuing disaster for biological education. Why should plants and animals be separated, when in the real world they are inextricably interlinked and interdependent? The most basic lesson of biology is that if there were no plants there could be no animals. Why should terrestrial animals be at the zoo and fishes (usually) at the aquarium? Worst of all, at least to those of us interested in how things work, is the separation between living things and displays of their structural components. The place to see the skeleton of an African Elephant is in close proximity to a live one. One can see an elephant in all its majesty at the zoo but it is totally ridiculous that it is then necessary to take a trip to the nearest natural history museum to see its skeleton - the mechanical basis for its leg movements, or where its heart is, how it beats, or how its amazingly specialised nose works. Imagine an elephant exhibit where the visitor could compare a working model of an elephant's trunk with the real thing. The precise control that makes it possible for an elephant to pick up a peanut, with its trunk, is a fascinating triumph of anatomical evolution. It can only be fully appreciated, as such, if we combine the techniques and contents of zoos and museums.

Of course there are historical reasons why the disciplines and institutions of biology developed separately. There are also continuingly good reasons why some specialized institutions should continue to remain separate and unchanged. But there are overwhelmingly good reasons for creating a series of Bioparks to amalgamate and unify the themes and educational functions of the presently separate entities. History and expediency created separate institutions, and it is worth examining this history for the lessons it can teach us, but the first task is to define the scope, purpose and advantages of Bioparks.

Bioparks could present a holistic view of the living world by presenting plants and animals as integral parts of ecosystems. At present when zoos have plants in their habitat exhibits they are almost always used as a naturalistic backdrop against which the animals can be staged. To exhibit designers plants are now, most frequently, merely part of the decor. Plants can and should be presented as important and interesting in their own right and as part of an interactive matrix, that is the root of all biological systems. For instance, a direct comparison can be made between the airconditioner that adjusts the atmosphere of human habitations and the plant life of oceans, rivers and terrestrial ecosystems that provides, in effect, a global airconditioning system. The carbon dioxide produced by animals and the combustion of fossil and other fuels, is removed from the earth's atmosphere by the photosynthetic activities of plants. Unless there is a gross imbalance in carbon dioxide production compared to plant activity conditions favorable to animal life are maintained. Animals also depend on plants as the ultimate source of all food. These plant activities are illustrated in a striking fashion by the coral reef macrocosm ecosystem devised by Adey (1983). This makes a instructive aquatic exhibit but is also virtually self-contained. In it phytoplankton production, with the input of light, carbon dioxide and mineral salts supports zooplankton production which, in turn, support corals and a wide variety of other organisms. While the system is obviously complex its components clearly demonstrate the dependence of all animals on plants.

If a zoo were to be transformed into a biopark the plants on exhibit would have to be carefully chosen to illustrate interdependent relationships; this would be a profitable area for fundamental education. For instance, the whole rich area of pollination and the coevolution of flowers and insects is, if properly presented, of great potential interest. Very large numbers of people grow flowers in their houses and gardens and even more people buy flowers as decoration. Yet very few people are consciously aware that most flowers exist only because of insects. Color vision in insects, coupled with the plant's need to transport its sex cells are the essential components of an evolutionary equation. Not only is the color of flowers a product of this interaction, but so also is their shape and scent. What a powerful set of messages about life could be based on a really well-designed butterfly/plant exhibit. Better yet we should probably design a pollinatarium that includes the other important pollinators such as bees and hummingbirds. Hummingbirds could certainly coexist with butterflies but honeybees might be a problem to zoo visitors. On the other hand bumblebees are generally benign and good tempered and can be kept in artificial colonies. They are stronger than honeybees, and because they are long-tongued they can work for pollen and nectar on a different spectrum of flowers, and even when the weather is unsuitable for butterflies and honeybees. The opportunities for producing an exciting "Hall of Floral Sex" are endless, almost literally. Using suitable butterflies would also show that plants and animals are not just mutualistic, as in the pollination relationship, but are often antagonistic. Thus butterfly larvae - caterpillars - feed on leaves and the plants sometimes counterattack. A good example of this would be to grow passionflowers in the pollinatarium to show not only the evolution of a complex flower, but also the attack on the leaves by the larvae of butterflies and the plant's counterattack through the production of deceptive devices that mimick butterfly eggs. (The plant produces spherical outgrowths that look like butterfly eggs; these discourage female butterflies from laying eggs since the insects avoid leaves that already have eggs on them. Butterflies do this to avoid competition and the plant capitalizes on the insect's behavior pattern.)

Bringing plants into the picture, in an imaginative way, could strengthen the movement to regard the conservation of plants as a matter of urgency. The conservation of plants is certainly as important to our global ecology as is the conservation of animals. A rare orchid, or a tropical tree, is as irreplaceable as a giant panda or a siberian tiger. The whole history of civilization is intimately tied to the history of agriculture, this undoubted fact highlights the importance of plant species. The recent discovery of a perennial maize in Mexico could affect our history as much as did the discovery of the rubber tree in Brazil. We can illustrate much of the history of man in an exhibit on the plants and animals that we domesticated. What else could we do with plants in the zoo-to-become-biopark? Any exhibit that is climate-controlled to accommodate exotic animals could be adapted to house suitable exotic plants. Of course there would be restrictions imposed by the habits of the two kinds of exhibit components. Many of these restrictions and proscriptions are obvious, for instance, poisonous plants could not be introduced alongside rare animals that might eat them. Animals that have destructively great bulk, or steamroller patterns of movement could not coexist with delicate plants and so on. We would have to manage, manipulate and protect but we could surely advance far beyond where we now stand. We could promote beauty, excitement and fascination by applying existing knowledge and by adding the inventions of our ingenuity.

Of course adding plants to animals is not the only step we need to take in the development of the biopark. We need to integrate the aquatic and terrestrial worlds and, beyond that, to steal the techniques of museum exhibitry to link structure and function and, crucially important, we need to link the present to the past. Bringing the world of water into zoos is not such a revolutionary step. Many zoos have seals, sea lions, polar bears and penguins in semi-aquatic exhibits. In the United States some zoos have aquariums and this is more common in Europe. However, aquariums did arise independently of zoos and for technical reasons they continue to present an isolated image of the world of water, as though it were a separate entity unconnected to the terrestrial world. This is unfortunate since many aquatic systems, particularly in the tropics, are linked directly to terrestrial ecosystems, and all ecosystems are ultimately interconnected. The fish fauna of the Amazon is one of the richest and most diverse in the world (Roberts 1972) but it depends on the surrounding, and often enclosing forest for a major input of its food (Goulding 1985) . Many Amazonian fish species are specialized to feed on such terrestrially derived food as fruits and insects like ants, flies, beetles and grasshoppers. To set this incredibly diverse assemblage of fishes in its proper context the Amazonian freshwater tropical fish exhibit must be shown inside a forest.

The final component needed for the creation of the biopark is the component derived from the Natural History Museum. This does not mean that natural history museums should cease to exist. Like libraries the are great repositories for the raw materials of science and laboratories for studying the science of classification. (This science now demands research into ecology, behavior, biochemistry and evolution.) But their educational function, for which they use only a tiny fraction of their stored wealth of specimens, can certainly be shared by the Biopark. The value to general and popular biological education of fossil, skeletal and anatomical material can be greatly enhanced if it can be integrated with living plants and animals. Museums are increasingly adding live exhibits to their displays but there are almost always logistic restrictions on the extent of such zoos within the museum. Similarly zoos-to-be-bioparks have a finite space available for museological approaches, and no space for vast collections of taxonomic specimens. Ideally the biopark can select such materials as models, skeletons and fossils to illustrate broad sweeping principles. Such collections do not need to be synoptic. The biopark hould also include reference to the materials of anthropology and archeology. What better place, for instance, to illustrate some of the major factors in the life of North American indians than alongside some of the animals that played such a crucial role in their lives? No buffalo exhibit should ignore the role of the buffalo in the economy, ritual and magic of the plains indians. What a wonderful biopark exhibit could be created by reproducing the prehistoric line drawings of animals from the plains of Nazca in Peru!

These speculations could spread wider and wider. No exhibit about life can ignore evolution. Without evolution biology has no meaning. Currently evolution is a target of an antiscientism, and is being dismissed as a mere theory. To counteract this the biopark could simply exhibit, without strident comment, some of the major cases of "artificial selection". These are still among the most powerful arguments that Darwin marshalled in "The Origin of Species". Steps in the selection of wheat, corn or rice for cultivation could be shown in an evolution garden, while domestic varieties of rabbits or pigeons could show how selection by man has worked on animals. Here is a real possibility to enlighten by graphic example.

The biopark would draw together a diverse and varied audience and could be a powerful force for conservation and for engendering a humane attitude towards animals and a concern for plants. Only if the entire living world is set in context can an entirely holistic ethic be promoted. By setting things in a more realistic pattern, and avoiding the artificial fragmentation of knowledge, we can strongly promote concern, humanity and conservation. In this respect the biopark needs to establish an ambience that combats homocentric and dominionistic attitudes. One way to do this is to move beyond the present naturalistic style of exhibitry and apply our current state of knowledge of animal sensory physiology and ethology to exhibit design. This sounds alarmingly technical but we should remember that naturalism of present-day exhibitry is based on a human perception of the world, on our sensory view of reality. A primate's eye view is an uncommon one. Such exhibitry reinforces the kind of anthropocentrism that gives people an unreal view of the lives of animals. Such unrealism is frequently the basis of much emotional/sentimental misunderstanding about the lives of animals . While we desperately need a committment to animal welfare such attitudes are most soundly based when they derive from an appreciation of both our similarities with and differences from other animals. The view that animals are people too is seriously misguided and can lead to us making serious errors in animal husbandry.

We are separated from most mammals and many other animals by the sensory apparatus of the diurnal primate group to which we broadly belong. We have cone-rich eyes, excellent stereoscopic vision and good hearing. Our sense of smell is relatively poor. Since we walk erect we have a viewpoint that shows us a world that is scaled to a viewing height of around one and a half meters. All this separates us from the majority of other mammals. Many mammals have cone-poor eyes and bichromatic or monochromatic vision. They have highly developed audition, a superb sense of smell and a different scale and focus to our own. For instance a good dog exhibit (wolves, foxes, and so on) would consist of a largely black and white world, with close objects only in sharp focus and scent mark areas with a high subjective value. In addition to emphasizing sensory differences it is also necessary to emphasize differences in environmental relevances. Many animals are surrounded by environments which consist largely of background "noise". Like humans at a cocktail party who hear only a few personally important words out of the babble, other animals must ignore much of the input from their noisy sense organs in order to concentrate on survival. To a dog, the wood is monochrome and only the occasional tree, scent marked by conspecifics, is relevant to life. This is at great variance with much of our own way of viewing the world. The dog probably smells the world rather than views it. Similar comments could be made on deer, prairie dogs and even New World Primates. The latter have color vision but probably see the world like we see a badly adjusted T.V., their "color balance" is very different from our own. To avoid suggesting that animals see the worldthe same way that we do we should arrange at least some exhibits to reflect a particular animal's eye view of reality. This would help to correct our homocentric fallacies.

Finally we need to emphasize the point that life has a past. Man's history is absolutely emphemeral compared to that of life on earth. We need to show people not only the structure of elephants but also their ancestors. Everyone who has seen a mammoth is impressed, but a mammoth exhibited next to its largest living relative would make an indelible point. In the biopark's invertebrate exhibit, and we can no longer ignore ninetenths of the animal kingdom, we could illustrate the great proliferation of animals without backbones in the past. Trilobites, eurypterids, graptolites and many other groups blossomed and then totally disappeared. This knowledge might help us towards a proper humility.

Some knowledge of the past of biological institutions also helps. It can place their present state in perspective. Their origins are diverse and this diversity has molded their development. The following capsule histories are simplified and slightly simplistic, nonetheless they are instructive. Zoos started as royal or imperial menageries. As the name implies they were associated with households, with palaces. They were "oh my!" collections for entertainment, as well as status displays enhancing prestige. A collection of captive animals was as much a badge of power as a collection of 'captive' composers and musicians. The entertainment function had precedence when zoos moved out of the royal household. Botanic gardens grew out of primitive, herbal, medicine. Nearly all the early European botanic gardens were associated with those medieval universities that specialised in medicine. From the start, unlike zoos, they were associated with "science" and research. Later, as European powers became centers of great colonial empires, botanic gardens (and arboretums) became centers for the study and propagation of economically important exotic plants. The British converted Malayia into a vast rubber plantation by cultivating a Brazilian tree. Aquariums had something of the same origins as zoos. Although the Chinese and Japanese selectively bred fishes for aesthetic reasons, these were used in formal water gardens not aquariums. The aquarium had to await advanced glassmaking. For practical reasons most aquariums developed at the seaside because fresh seawater was necessary for maintaining the greater wealth and beauty of marine organisms. The harborside aquarium could not grow into an integrated zoo because it was space-restricted. Some aquariums had their origin in research needs. The growth of interest in freshwater organisms arose when the profusion of tropical fishes became available. Natural History Museums blossomed during the Enlightenment; their forerunners were royal curio collections. The Smithsonian Institution has been described as "the Nation's attic", natural history museums expanded as the attics of the explorer naturalists of the colonial period. Research was always a major function of these museums and they resembled libraries in that they were storehouses of specimens. These diverse origins directed institutions onto autonomous paths despite the high degree of programmatic overlap. Now there is the inertia that results from history to reinforce the separation and separateness.

From these projections of possible components of a biopark, and the history of the origins of bioexhibitry, a good case can be made for trying to create one. Today there is a broad general interest in the living world. In the United States zoos presently attract more visitors than attend all field sports combined. Millions of people keep plants and animals in their home, mostly for non-utilitarian reasons. Wildlife programs are extremely popular on television and together all these factors suggest that the living world has a lasting fascination for modern man. There can be little doubt that the biopark could capitalize on this fascination to enhance our concern for the conservation of our natural heritage. I strongly believe that biology is as important a subject for the continuance of human civilization as the classics and theology were once considered to be. Now is the time to be innovative.

Adey, W. 1983. The microcosm : a new tool for reef research. Coral Reefs I. 193-201.

Goulding,M. 1985. Forest fishes of the Amazon. In: Amazon, eds Prance, G.T., and T. Lovejoy. Pergamon Press pp 267-276.

Roberts, T.R.1976. Ecology of fishes in the Amazon and Congo Basins. Bulletin of the Museum of Comparative Zoology. 143: 117-147.

BIOLOGICAL PARKS IN INDIA -
MISSING LINK BETWEEN THE PURISTS AND THE PRACTITIONERS

Pushp Kumar *

INTRODUCTION:
The evolution of zoos as we know them today has been a long process. We realise that prehistoric man must have caught, kept and domesticated wild animals for his own use and eventual survival. In historical times wild animals were kept by kings and emperors for their own and the peoples edification and enjoyment. These endeavors in course of time evolved into present day zoos, institutions in their own right.

In India, the zoo movement as one may refer to it, followed the same pattern. Keeping of wild animals is traced back to Emperor Ashoka in the 3rd Century B.C. and to medieval times when Ashrams of Rishi always had deer and birds. The Moghul Emperors Akbar and Jahangir kept Cheetas. Throughout historical times big and small chieftans and kings kept collections of animals in their palaces.

However zoological parks as we know them today, came into existence in India in the 1800's many of them having been set up as adjuncts to parts of existing gardens or parks. To cite examples, the Hyderabad Zoo was set up as part of public garden, the Bombay Zoo as part of the Victoria Garden, etc.

This is also evident from the fact that they were managed by the horticulture or garden departments of the Municipality or public works department of the Government in some cases, which had the responsibility of maintaining public parks in the city. In a few cases they were run by trusts and boards, again dependent on public funds.

MODERN TRENDS:
The fifties form a divide between the old and the modern zoos. Alarmed at the decline of wildlife in the wild and recognising the role zoos could play, the Indian Board for Wildlife recommended in 1952 the setting up of zoological parks on modern lines for educating people. In 1956 a zoological park extending over 182 acres was set up at Delhi followed by large parks at Hyderabad (320 acres), Nandankanan (250 acres), Gauhati (300 acres), Patna etc.

These parks besides being set up on modern lines with large and barless enclosures, were also extensive in area.
In 1972 the Indian Wildlife Protection Act was enacted by Parliament which sought among other things to regulate trade in wild animals. The act recognised the beneficial role public zoos were capable of playing. The Act also listed about 140 species requiring full protection and many more as threatened and requiring some protection. The lists have since been revised and enlarged and in fact the Wildlife Act itself now includes a portion devoted strictly to zoos in the Amendments, the Recognition of Zoos Act, 1991.

After enactment of the Wildlife (Protection) Act, the Government of India set up an Experts Committee on Zoos in 1973 to look into the setting up and management of zoos in India. The Committee in its report among many others, made three significant observations and recommendations.

1. It defined the role that zoos should play in conservation, education and research as opposed to the objective of entertainment and recreation.

2. It classfied and categorised the 48 (mostly public) zoos that existed till then on the basis of extent, types of enclosures, landscape, level of management, popularity etc.

3. It suggested a central organisation for setting up and management of zoos, a corollary of this being the need for bringing public zoos under one agency. Now the Zoo Authority is set up through an Act of parliament, 18 years later. During the seventies with the shift in the objective and roles of zoos, two important developments took place.

I. Coming up of some large zoos, area wise :
Visakapatnam (625 acres)
Vandalur (Madras) (550 acres)
Chhatbir (Pubjab) (500 acres)
Van Vihar (Bhopal) (1000 acres)
and now Tirupati (1200 acres)

II. Expansion, shifting or modernisation of some of the old zoos like Mysore, Madras, Trivandrum, Junagadh etc.

The most significant development perhaps was the inclusion of "Captive Breeding and Development of Zoological Parks" in the National Wildlife Action Plan, taking cognisance of the wildlife situation i.e., loss of habitat and increase in inscription of species on the endangered list. Thus zoos were integrated into Wildlife Conservation in India.

THE PRESENT POSITION:
At this stage it may be relevant to take a look at the existing controlled wildlife institutions in India. A list prepared by the Wildlife Institute of India in January, 1991 listed totally 205 institutions of which 107 were zoos, 49 deer parks, 13 Safari parks and others 36 . More recently the Central Zoo Authority called for all zoos to register for evaluation upon which recognition (e.g. being allowed to continue as zoos) is dependent. This brought many zoos which were not known out in the open and now the list totals almost 350.

The break up of types of zoos is given in Annexure I. An analysis of the information sent by the zoos indicates that most of the zoos in India are managed by the department of Forests & Wildlife.

---

* Retd. P.C.C.F., Andhra Pradesh; Member, Central Zoo Authority; Chairman, Inspection Committee.
This paper was presented at the meeting of the International Union of Directors of Zoological Gardens at Singapore in 1991

The facilities set up have various designations. At least 24 different designations can be discerned (Annexure-II). This has come about due to lack of a proper standard defintion or description as to what consitutes zoos, zoological gardens, zoological parks or biological parks etc. Even in the Indian Wildlife Protection Act of 1972, though public zoos is mentioned, a definition of 'Zoo' is not assayed. In the absence of a definition, the dictionary meaning is used. This description does not appear appropriate to describe different types of facilities now set up in the country whose nomenclature reflects the attitude of people, setting it up, and vying with each other to make it sound as exotic as possible.

It may be appropriate to mention here that international bodies also do not appear to have laid down defintions of the various terms in use which may give rise to confusion and controversies. It may also be appropriate to suggest that such an exercise may be attempted in order to bring all zoological parks in line with a common terminology and identity.

Thus controlled wild animal facilities in India as in the world cover the entire spectrum from mini-zoos and menageries to zoological parks and biological parks. The differences in the lower end of the spectrum and the upper as they have evolved -- or should have evolved -- over the decades can be summarised mainly in the following approaches.

1. **Housing:** Small barred cages gave way in course of time to large open (moated) enclosures, though some still persist.

2. **Display:** From "naked cages" to large nature stimulating enclosure with vegetation and other 'props'

3. **Layouts:** From gardens with occasional exotic flora and display of flowers, to parks with landscaped areas, to virtual forests with exiting vegetation *in situ.*

4. **Breeding:** From single animals in large taxonomic based, postage stamp collections to fewer species in large breeding groups. Though a few centres for breeding endangered species were set up in India, e.g.:- Musk deer, White winged wood duck, Crocodiles etc., by and large breeding husbandry of wild animals in zoos continues to be on "Captive" lines rather than "Controlled" ones.

5. **Education:** From very basic cage labels giving the name of the animal to innovative educational displays focusing on the relationship of the animal to its habitat. Such signage and attempts made for sustained efforts at education of the visiting public in this country are limited to a few zoos only.

RECENT TRENDS:

Two important developments compel attention in the recent trends. Most parks set up were those under control of Government or quasi Government aegis. The significant fact that emerges is the land that was comparatively easily available. As a consequence two further corrolaries arise which are

1. It made possible the setting up of large parks at Van Vihar, Bhopal (1000 acres); Indira Gandhi Zoological Park, Vishakapatnam (625 acres), Arignar Anna Zoological Park, Madras (550 acres); M.C. Zoological Park at Chhatbir, Chandigarh (500 acres); S.V. Zoological Park, Tirupati (1200 acres) etc. It is not possible to get such large areas outside the forests reasonably close to population.

2. Such large areas brought with them large chunks of existing natural vegetation endemic to the area. Thus an already existing biological system became available. Planning and designing in such circumstances posed its problems not to mention their management. Animals had to be kept and displayed in local vegetation as well as landscapes. This has resulted to a great extent in the display of local animals in more or less nature simulating habitats i.e., the tropical vegetation and landscapes.

The new breed of zoos could now be truly termed "biological parks" wherin not only the local or native fauna is displayed but also the local vegetation, both in the enclosures as well as over the entire grounds. This is also applicable to fauna of the Tropical regions, since the vegetation, though not the same, would be nearer to the natural habitat than if they were displayed in temperate situations. In the temperate countries this drawback is now being overcome with the help of technology, eg:- Tropical Worlds, World of Birds, Indoor exhibits etc. which would prove too restrictive and costly for most parks in the tropics.

Some notable exampes of such biological parks (though they may not have been specifically designated so but as zoological parks) that could be cited are.

1. **M.C. Zoological Park**, Chhatbir, Punjab where the park has been set in a *Dalbergia sissoo* forest plantation in 550 acres.

2. **Van Vihar National Park** set amidst dry deciduous forest habitat on the outskirts of Bhopal city, extending over 1000 acres of picturseque and hilly country.

3. **Indira Gandhi Zoological Park** near Vishakapatnam city (over 625 acres) has been set up amidst thorny facies of the moist deciduous forest along the coast of the Bay of Bengal. However, the first Marineland of India is coming up along the seashore amidst casuarina and tidal mangroves. In the zoo, the 2 acres tiger enclosure and the 6 acres lions enclosures have been integrated in a continuum with the hilly landscape of secondary thorn forest of *Capparis, Carissa, Maba sps, Acacia, Leucophloa, Albizzia amara* etc. This also contains, small plantation of *Eucalyptus* and *Acacia aurkculiformis.*

4. **A.A. Zoological Park**, Madras extending over 550 acres of tropical dry evergreen forest occurs along the Coromandal coast. However small plantations of eucalyptus and cashew had been raised earlier in this area.

5. **Kanpur Zoological Park**, which was set up in the Allen Forest containing plantation of Sissoo and other sps, extending over 74 ha.

6. **Assam State Zoological Park**, Guwahati extending over 129 hectares of hilly patches of moist deciduous sal forest.

7.Nandankannan Biological Park, Bhubaneshwar, located in impressive, moist deciduous sal forest area, extending over 300 acres approximately. However, this was termed a biological park not because of its location but due to the fact that two sections one zoological and another botanical (horticultural) were set up seperately adjacent to each other in the same area.

8.Sanjay Gandhi Biological Park, Patna extending over (200 acres) was also so termed due to the same reasons.

Another category of facilities that were set up are deer parks. Those initially were intended to be small (about 5 to 10 acres) enclosure in the centre of tourist gatherings and were thought of as a facility providing an added attraction. However the one set up at Pakhal in A.P. extending over 15 acres was more a breeding centre where animals like spotted Deer *(Axis axis)* Sambar *(Cervus unicolor)* and Nilgai *(Boselaphus tragocamelus)* were bred and released into a protected area viz., Pakhal Wildlife Sanctuary. This enclosure was set up *in situ* admist dry deciduous forest, the habitat of the species which were kept, bred, and released.

In 1975 near Hyderabad the Mahaveer Harin Vanasthali was set up in a completely degraded area where just 70 to 80 years back the Nizam's of Hyderabad state chased and hunted Blackbuck *(Antelope cervicapra)* on horseback and also with Cheetah *(Acinonyx jubatus)*. However the forest and the herds of Blackbuck and Cheetal *(Axix axis)* were decimated. It was decided to protect part of the Nehru Zoological park. The intital groups (2.5) not only established and multiplied in the absense of any predation, but after a hesitant start, began multiplying so much so that a population of over 200 Blackbuck and 100 Cheetal are now to be found in the park. The forest eco-system recovered rapidly 10 species of mammals, 160 species of birds, and 20 species of reptiles have been recorded from this area to date. people are taken inside the are at fixed timings in mini- buses. An education centre conveys park values to visitors.

Another examples of the Biological parks are the Safari parks. The first one was set up in 1974 in the Nehru Zoological Park, Hyderabad. The 38 acres multi-habitat area was fenced in with a 16 feet hign fence. A very thick vegetation of marshy as well as Dry Deciduous species of vegetation has come up in the area wherein a small pride of Asiatic Lion *(Panthera leo persica)* has been released. There are features built into this park which makes it different from those in the western countries. A narrow winding dirt road takes a mini bus of 10 to 12 persons through a replica of the local forest. This bus makes trips at fixed timings. Thus only a limited number of persons are taken in under controlled conditions. The lions are viewed in thick vegetation simillar to their habitat.

The first safari park for lion was followed by one for tigers and now for sloth Bears *(Melursus ursinus)*. In these parks private cars are not allowed. 6 lion safari parks have to date been set up as adjuncts to existing facilities elsewhere.

CONCLUSION:

The progress of zoos in India has been quite interesting. They have evolved from small establishments attached to gardens and parks into an entity of their own in the form of modern biological parks extending over large areas. A commonality of approach is as yet lacking due to absence of a professional cadre of managers. As a result the momentum gained after their recognition as having a role to play in conservation especially after 1952 and then again after 1973, dissipated. Present trends tend to give an impression that momentum would again up with the coming up of new biological parks, eg:- Coimbatore Zoological Park in the south and Sepahijala in the east. The former set in the rainforests of the Western ghats and the latter in the moist deciduous forest of the North-Eastern Hills.

In the management aspects the zoological parks have yet to shed their policies of "captive" husbandry and resolved to take up "controlled" husbandry and breeding.

It is also essential that a sustained policy of education be adopted so that the estimated total of 30 million visitors annually, could be eduated about our biota and a significant contribution made to the conservation effort.

It is also necessary for zoos to move towards the biological part of the spectrum. This will have a dual effect.

1. It will demonstrate to the people that these institutions have a scientific base, and at the same time mitigate the opprobrium that the term "zoo" has come to acquire in the peoples mind.

2. The tern "Biological Park" may also have a better connotation in keeping with the present conservation atmosphere.

It could well be the "Missing Link" between the purists and the practitioners of different forms of conservation.

REFERENCES

1. Kapoor A.K. *et. al.* Management of Zoos in India, 1973, Government of India, Ministry of F & A Department of Forestry.

2. Olney, P.J.S.: International Zoo Year Book, Vol,20, 1980.

3. Temple, S.A. Endangered Birds, 1977

4. Martin, R.D. Breeding of Endangered Species in Captivity, 1975

5. Ministry of Environment and Forests, Government of India: The National Wildlife Action Plan.

6. Walker, S. , Zoo's Print, January, 1991

7. Kumar P, Conservation of Wild Animals, under controlled conditions, Zoo's Print, Jaunary, 1990.

ANNEXURE - I

ZOOS AND CONTROLLED BREEDING CENTRES IN INDIA

Presented at CBSG Annual Meeting, Antwerp, 1993, Report by S. C. Sharma
Excerpted from ZOOS' PRINT October 1993

TABLE : LISTING OF ZOOS IN INDIA BY MANAGING AUTHORITY

	State	Central	Municipal	Society/ Trust	Educational Trust	Public Sector	Private Sector	Individuals	Total
Large and Medium Zoos	18	1	3	3	-	1	-	-	26
Small & Mini Zoos & Deer Parks	159	6	23	6	7	11	24	6	242
Crocodile farms	9	-	-	-	-	-	-	3	12
Bird breeding farms	3	-	-	-	-	-	-	-	3
Snake Park	1*	-	-	1	-	-	-	5	7
Safari	3	-	-	-	-	-	-	-	3
Total	193	7	26	10	7	12	24	14	293

ANNEXURE - II

Various designations used for Wild Animals facilities in India.

1. Zoo
2. Mini zoo
3. Zoological park
4. Deer park
5. Bird and animal park
6. Breeding centre / farm
7. Biological park
8. Garden zoo
9. Aviary
10. Wildlife complex
11. Nature discovery centre
12. Aquarium
13. Nature park / centre
14. Safari Park / safari
15. Open park
16. Pheasantry
17. National park
18. Zoological gardens
19. Children park / zoo
20. Snake park
21. Prani sangrahalaya
22. Udhyan
23. Animal orphanage
24. Crocodile bank/ centre.

SECTION - II

HEALTH CARE

SSP NUTRITION ADVISERS: ROLES AND RESPONSIBILITIES

Ellen S. Dierenfeld, PhD
NYZS/The Wildlife Conservation Society, Bronx, NY 10460 USA

When we bring animals into captivity for any reason, we assume ultimate responsibility and indeed, moral obligation, for their health and well-being. The field of animal nutrition is one of many specialties which must be applied in order to successfully meet the future challenges of wildlife conservation, education, and science. Due to shortages of time, human, monetary, and animal resources, and with increasing emphasis on Species Survival Plans (SSPs), the need for detailed knowledge and management protocols, including dietary information, is imperative. Asking proper questions and disseminating proper information have become critical factors in species survival.

As with all specialty advisers, SSPs should establish minimal professional standards from Nutrition Advisers including: 1) knowledge of the literature, 2) efficient utilization of finite resources, and 3) awareness of limitations.

Roles of the Nutrition Adviser

To advise means simply to recommend or guide a course of action, and implies that the giver of the advice or opinion has knowledge and/or experience underlying those recommendations. While diet preparation, presentation, feeding ecology, and feed management are also important aspects of a comprehensive nutrition program, Nutrition Advisers should have some specific training in the underlying principles and tenets of the nutritional sciences.

Three separate, yet integrated functions of Nutrition Advisers include those of **Consultant**, Coach, and **Counselor.** As a **Consultant**, the Nutrition Adviser may be sought regarding diet, ingredient, or nutritional supplement composition or utilization, or be referred to for technical information. The adviser should be regarded as an expert, and should be expected to answer queries in these areas, or locate people who can. The Nutrition Adviser as a Coach should be considered an instructor, mentor, guide, or manager, and as such must be thoroughly prepared with background information as well as willing to share that information. This role might realistically be best applied with students or other collaborators. The evaluation of research plans or protocols, which are often focussed on small, finite projects, can most effectively be accomplished with the adviser overseeing a more comprehensive strategy. Thirdly, in the **Counselor** role, the Nutrition Adviser recommends a specific course of action based on serious deliberation and mutual exchange of ideas and opinions, often affecting the very survival of a species.

Responsibilities of the Nutrition Adviser

Literature Review - First and foremost, the Nutrition Adviser should be thoroughly familiar with, evaluate, and summarize available published information pertaining to diet and nutrition of the species of concern. In the field of wildlife nutrition, comprehensive literature review entails browsing not only nutrition specialty journals, but also human and animal medical publications, as well as those dealing with ecology, wildlife and zoo management, biology, physiology, behavior, and numerous peripheral topics. This must include, and in some instances should particularly target, foreign periodicals. While conference proceedings and newsletters are important forms of communication, they should not be considered primary references. Management protocols for individual species should include a bibliography of pertinent nutrition, diet, and feeding behavior literature, properly cited, for general dissemination.

A written summary which describes feeding behaviors (including meal patterns, ingredient selectivity, palatability factors) and any information on nutrient composition of diets, describing both free-ranging and captive diets, must be a starting point. If data do not exist; this fact should be identified as a possible conservation priority.

The Nutrition Adviser should be familiar with anatomical (i.e. beak architecture, dentition, gastrointestinal tract) and physiological (basal metabolism, enzyme systems) specializations of a given species, and understand how these features relate to diet processing. Knowledge of these basic biological attributes provides a solid foundation for the development of suitable feeding and nutrition recommendations.

A review of identified nutritionally-related disorders should also be addressed in the summarization.

Diet Recommendations/Reviews - Husbandry manuals are only beginning to incorporate systematically documented sections covering topics of Nutrition and Hand-Rearing. Based upon the literature summary, recommendations by a nutrition specialist should include: 1) the most appropriate comparative model species (domestic, laboratory, or livestock) for evaluating nutrient adequacy, 2) target range(s) for gross chemical composition of diets, and amounts of feedstuffs, and 3) appropriate methods of diet presentation, with physiological and psychological optimality of the animal the ultimate goals. Exceptions to generalities or coherent arguments that no suitable data exist should be clearly documented. While unique aspects of any given species may be identified, the basic biology underlying the science of nutrition must be the primary focus.

Diet recommendations should not imply specific ingredient or product endorsement, but rather, focus on nutrients. Ingredients from diets of free-ranging animals can rarely be duplicated in managed feeding programs, but nutrients can. Thus we must identify the nutrient levels, feedstuffs, and relationships underlying successful diets and/or feeding programs which allow management flexibility within geographic, environmental, or economic constraints. Participation in SSP groups should entitle zoological institutions access to current, updated nutrition information and recommendations for various species -- this service may be particularly valuable to facilities without staff nutritionists.

Minimal information necessary for proper diet review includes documentation of all diet ingredients (with nutrient composition), amounts offered and/or consumed, supplementation products and regimens (including some medical treatments), and occasionally housing conditions. Sometimes these data can be compiled through well-designed surveys and result in broad diet recommendations for meeting at least minimal nutrient requirements. More often, however, data acquisition requires one-on-one communication with involved personnel. The Nutrition Adviser should be prepared to ask detailed questions designed to gather the necessary information, and provide timely follow-up. Acknowledgement of samples, diet surveys, or information requests used in such reviews is not only professional courtesy, but a responsibility of the Nutrition Advisor.

Research Priorities - Nutrition Advisers should be able to identify relevant questions for nutritional research based, again, upon the foundation literature. If essential data don't exist, state the facts such that interested collaborators can be encouraged. Studies of vitamin E interactions with zoo herbivores, for example, have shown a clear lack of data relating dietary types and amounts of fat to status of this nutrient. The basic biochemistry underlying these relationships needs to be examined under controlled, laboratory conditions better suited to university and/or industry programs than zoos. Investigations that can appropriately be conducted in zoological facilities should be coordinated through species Nutrition Advisors when necessary to provide adequate numbers of animals and/or treatments for statistical design. In either case, appointed Nutrition Advisors should be consulted and considered the main communications conduit. Redundant, poorly designed, or extraneous investigations with limited animals, personnel, money, and time resources should be considered irresponsible and discouraged.

Information Updates - Data on diet composition, digestive physiology, feeding ecology, nutrition research, or health parameters should be regularly disseminated by the Nutrition Adviser through national and international species coordinators, publication (scientific journals, newsletters, popular press), and regular meetings of interest groups. The current system of SSP program reports through the AAZPA is an excellent step in this direction; compliance should be a requirement for all species advisers.

Specific Future Needs

A system of computerized zoo diet records, perhaps linked in some way with the International Species Inventory System (ISIS), remains the most pressing communications issue for current focus. Conservation is a matter of global concern, and should encompass institutions worldwide. The computerized module should therefore be developed in a standardized, compatible format that will encourage acceptance and use. SSP species, particularly those also managed by an EEP (European Endangered Breeding Program) could be targeted as the "prototype" groups for development of the broader system, to facilitate acceptance of the format in Europe.

Collaborative laboratory networks should be established within the zoo, academic, and private industry communities to support zoo animal nutrition research and development. Routine analytical assays and techniques utilized by commercial laboratories are often not applicable to the specialized samples or species we consider daily. Furthermore, interpretation of data, even if obtained, can be limited by experts not familiar with extensive comparative nutrition. Information databases needed to advance the field of wildlife nutrition, preferably in computer-accessible formats, include feedstuff chemical composition, clinical chemistry, and biochemical data.

The ISIS Physiological Normals database represents an initiation of such a compilation, but much more detail gleaned from research reports, published literature, and unpublished records is necessary. One example of data awaiting a proper outlet includes the fat-soluble vitamin database from the Wildlife Nutrition Laboratory of NYZS/The Wildlife Conservation Society. While published summaries of data do exist, the computerized files are constantly updated. Plasma values alone currently consist of data from blood samples comprising >8000 individuals of >300 species -- the largest comparative compilation of these data in the world.

We envision systems whereby these data could be readily accessible to the entire zoo/scientific community, and encourage others to contribute to and utilize such information. Clearly the field of wildlife nutrition, as with other wildlife specialties, must be one of collaboration and communication.

ACKNOWLEDGEMENTS

Many of the ideas presented here have been developed through discussion with others including J. Doherty, D. Wharton, and particularly, J. Nijboer and A. Melisson. Thanks.

NUTRITION AND DIET OF CAPTIVE ANIMALS, DIETARY REQUIREMENTS OF DIFFERENT SPECIES, QUALITY, QUANTITY AND NUTRITIONAL ASPECTS OF ZOO DIET. ROLE OF VIAMINS, MINERAL SUPPLEMENTS AND OTHER ADDITIVES. SPECIAL DIETS, MAINTENANCE OF DIET CHARTS.

L.N. Acharjyo

Nutrition means the process involved in taking in nutrients and assimilating and utilising them for the use of the animal. Nutrition has been defined by Ensminger and Olentine as "The Science of interaction of a nutrient with some part of a living organism". A nutrient is a substance that promotes the growth, maintenance, function and reproduction of a cell or an organism. There are over forty (including oxygen) nutrient chemicals that can be liberated through the action of digestion upon feedstuffs. These nutrients can then be subsequently utilised by various organs, tissues and cells of the body. Adequate good nutrition is vital for any living organism for the following main reasons:

i) for the survival of the species
ii) for the good health of the species
iii) for maximum resistance of environmental changes and diseases specially infectious and parasitic.
iv) for maximal reproduction
v) for maximal infant survival rate
vi) for longer span of life.

The food chemical which are essential both for domestic and wild animals can broadly be classified as follows:

Food Chemicals

- ORGANIC
  - -PROTEINS
  - -CARBOHYDRATES
  - -FATS AND OILS
  - -VITAMINS
- INORGANIC
  - -WATER
  - -MINERALS

PROTEINS

Protein is essential for life and it can not be replaced by other nutrients. The main functions of protein are:

i) Forms one of the ingredients of the internal frame work of cells and the interstitial cells like osteoid, dentine, connective tissue etc.

ii) Form the amino acids of protein, the hormones, enzymes, plasma protein and hoemoglobin are synthesized.

iii) The epidermis, lysozyme, mucous membrane, lencocytes and antibodies which help in the defecne of the body are made from protein.

iv) Protein are components of skin, hair, wool, feathers, nails, horns, hooves, eggs etc.

v) The primary function of protein is body building (building of new tissue) and its maintenance (maintenance of tissue that is already developed).

Proteins are composed of about 24 amino acids out of which 8 amino acids are very important for all animals. Some of the amino acids are manufactured by animals and therefore they are known as non-essential amino acids. Otters, the essential amino acids can not be manufactured by the animals and must be supplied in the food. The requirement of amino acids vary according to age and speceis of the animal. Animals can build protein from amino acids gained from digested plant protein as well as from proteins of animals they feed on. Inrvinants, the micro-organism commonly preseтn in the rumen can utilise any kind of nitrogenous substance present in the animal ration and converts them into different essential and non-essential amino acids required by the body. But in non-ruminants, animals must be supplied with many kinds of amino acids in feed to combine these into their own protein. Fats and carbohydrates are stored by the body as energy reserves but proteins are not stored to any appreciable extent.

High protein level only occur during the rapid growth stages of grass which the animals get during grazing. Legume forages are a good source of protein. Protein deprivation during pregnancy results in small, weak or aborted foetuses. In birds protein provide the major energy source for young growing birds and its definciency results in poor feathearing, stunted growth, high moratality rate of hatchings, emaciation and intertility in adult birds.

CARBOHYDRATES

Carbohydrates are the main and most readily available source of energy. Plants store most of their energy in the form of carbohydrates primarily as starch. The main function of the carbohydrates are:

i) Chief source of energy required by the body
ii) Chief source of heat of the body
iii) Necessary for oxidation of proteins and fats.

The carbohydrates forms about three fourths of all dry matter in plants. They include the sugars which are relatively simple organic compounds and also starch, cellulose and other compounds which are very complex in nature. Ruminant animals make good use of complex carbohydrates on account of the bacterial action in the ruman. Such a process in some animals like ass, horse, elephants takes place in the large intestine. It is found in high proportions in cereals, grains, roots, tubers and fruits. Meat has also quite a high carbohydrate content. Glycogen n manufactured from simple carbohydrates and stored mainly in the liver for use at short notice by the body.

The requirement of energy increases during last trimester of pregnancy, lactation; growth and stability of body heat during severe weather conditions. Deficiency of carbohydrate will cause negative energy balance and the animal will be forced to draw on its fat store. Pregnancy ketos is anoremia, central depression acidosis unconsciousness, ketone bodies in the urine occur in wild sheep that have been fed poor quality grasses.

FATS AND OILS

At normal temperature the fats are solids and the oils are liquid. Fats and oils consist of organic acids called fatty acids. Fats are the most concentrated forms of stored energy in animal kingdom. These main functions are:

i) Fats provide 2.25 times as much energy and heat per pound on oxidation as do carbohydrates.

ii) They help to maintain the health of the skin and plumage.

iii) It provides insulation for the vital organs protecting them from mechanical shock and maintaining optimum body temperature.

iv) During winter, body fats act as an excellent insulator.

v) They improve the taste of the food.

vi) Many natural fats contain fat soluble vitamins like vitamin A,D,E and K and so their intake is essential to provide these vitamins.

Dietary fat is not required by wild ruminants. Volatile fatty acids are among the major byproducts of ruman fermentation and they are the sources of immediate energy. Excessive feeding of fat may result in diarrhoea and excess fatness in some animals and birds may lead to intertility. When food is in short supply, the body fats are utilised as ready source of energy.

VITAMINS

The vitamins are required in minute quantity by the body and they are mostly absorbed from the food canal, roady for use. There are about 15 vitamins known but the vitamins-A, B-Complex, C,D,E, and K are usually of importance for the animals and man. They are important because of the following reasons:

i) For maintaining sound health and to develop resistance to diseases.

ii) For satisfactory growth and reproduction.

ii) For shining body coat, hairs and feather.

iv) They do not yield energy but are required to act as catalysts for the biocheical reaction taking place for the metabolism of energy yielding substances like cabrohydrates, fats and protein. so their deficiency interferes with the biochemical activities of cells.

v) Deficiency of vitamins cause various diseases e.g. infertility, night blindness, retarded growth, fall in egg production and hatchability in birds, rickets etc.

The vitamin A,D,E and K are fat slouble and the vitamin B-Complex and C are water soluble. In general all green forage crops are rich in nearly all the vitamins except vitamin D which the animals get by the effect of ultra-violet rays in sunlight when they are exposed to sunlight. The B-Complex vitamins are normally synthesized by the rumen flora. Vitamin A is very important for the animals and it is present in the form of carotene in green leaved plants and certain other feeds of plant origin.

Feeding of a wide variety of fresh feed usually meets the vitamin requirements of an animal. But when feeds are fed after long storage sepecially in damp containers without a variety of diet relative deficiency of one or more vitamins may occur. During diseased conditions there is increased demand for vitamins and there may be difficulty for absorption and utilisation of vitamins.

WATER

It is the largest single constituent of all living plant or animal tissues. The plants and animals contain 70% or more of water. The green succulent growing plants usually have 70 to 80 per cent of water. Even thorughly cured grain contain 8 to 10 per cent of water. There is an interdependency between water and dry matter intakes. Whenever the intake of one is reduced the voluntary intake of the other is affected. The water performs the vital functions of the body as given below.

i) Carries the nutrients from one part of the body to another part of the body e.g. blood.

ii) Minerals are dissolved in water and then it is absorbed by the plant roots and the animals get minerals through plants.

iii) For control of body temperature.

iv) For helping breaking apart of complex food substances into much simpler ones for absorption into the body (metabolism).

v) For structural support of the body. Cells are filled with water to give firm shape. During dehydration tissues collapes.

vi It helps to carry off body wastes.

vii) Water acts as a lubricant to prevent friction and drying in organs like conjunctiva, joints etc.

Water is obtained by drinking from feed and from metabolic water formed from oxidation of nutrients. Water is lost from the body throgh faeces, urine, expired air and from skin (sweat).

MINERALS

The mineral nutrients are essential for health and even life of the animal. Animal body tissues contain about 3 per cent minerals. There are about 30 to 40 mineral elements which occure in various parts of the body of the animal. Calcium is about 49%, phospherous is about 27% and the rest minerals are about 24%. Major part of the mineral material is available in the skeltal tissue of the animal. Calcium is about 49%, phosphorous is about 27% and the rest minerals are about 24%. Major part of the mineral material is available in the skeletal tissue of the animal. The main functions are:

i) They regulate the osmotic pressure of body fluids, e.g. sodium, potassium and chlorine.

ii) They help maintain the acid-base, equilibrium e.g. sodium and potassium help maintain the PH of the body fluid.

iii) They form the building materials and so constitute structural components of tissues e.g. calcium and phosphorous are important constituents of bones and teeth.

iv) Some minerals are an integral part of some enzymes e.g. copper is a part of tyrosinase.

v) They help in oxygen transportation e.g. iron in haemoglobin

vi) They may form an integral part of hormones e.g. iodine in Thyroxine, Zinc in insulin.

vii) Deficiency of minerals usually result in various disease conditions in animals and birds.

viii) The quality and quantity of all animal products like milk, wool, egg and meat are affected by the presence or absence of minerals in the body.

ix) Some of the minerals like cobalt is essential to meet the needs of certain group of bacteria producing vitamin B12 in the forestomach of ruminants, in the large intestine of monogastric mammals and caecum of rabbits and birds.

The principal minerals are the calcium, phosphorous, sodium, potassium, chlorine, magnesium and sulphur. The important micro elements (trace elements) are cobalt, copper, zinc, iodine, iron, selenium and fluorine. These are required in very minute quantities for the animals and birds.

Minerals are mostly available for the herbivorous animals from the roughage and the carnivorous animals from the bones they eat along with the flesh.

DIET

A regulated selection of a feed ingredient or mixture of ingredients including water, which is consumed by animals on a prescribed schedule. A balanced diet supplies all nutrients needed for normal health and productive functions. It usually supply the needed proteins, fats, oils, carbohydrates, vitamins, minerals, fibres and water.

The diet or feed stuff can be classified into three main groups depending upon the amount of a specific nutrient they furnish.

(a) Concentrates: Concentrates are feed which contain relatively small amount (less than 18%) of fibre and comparatively high digestibility e.g. cereal grains, milling by products, pulses, oil seed meals, meat, bone, egg, whole carcasses, milk, fruit etc.

(b) Roughages or fibers: These are bulky feeds containing relatively large amount of less digestible material (crude fibre of more than 18 per cent) and a low digestible nutrients. They have low readily available carbohydrates as compared to cereal grains. The nutrient contents such as protein, mineral and vitamins of roughages are highly variable depending upon the kind of roughages, the method of harvesting and the degree of maturity at the time of harvesting. Ruminants and non-ruminants with functional caecums are fed with roughages to maintain healthy functional gastrointestinal activity. It ensures the secretary activity of the glands of the gut. Roughages are needed for animals and birds to get a favourable environment for multiplication of the micro organisms which aid digestion and produce such vital substances such as Vitamin B12. They fill up the belly and helps in preventing constipation. If the percentage of roughage is greatly increased it may cause impaction of rumen in ruminants and crop, gizzard or intestine in birds. Non-ruminants without functional caecum can utilise very little roughage.

Roughages include grass, tree fodder, chitin castings of insects, hair, feathers, outer skin of animals, bones etc.

(c) Vitamin and Mineral Supplements and other feed additives: By supplement it means feedstuffs that are used to improve the value of basal feed. Wild animals and birds under free-living conditions with a free choice from a wider range of feedstuff, consume almost all the vitamins and minerals required by them. But under conditions of captivity they have limited choice of feedstuff and so vitamin and mineral deficiencies may occur due to substitute diet or some vitamins may be lost during preparation of feed. Therefore, it is the usual practice to add vitamin and mineral supplements to the animals and birds of the zoos to avoid any probable deficiencies. Further their requirement also varies depending upon the age, size, sex pregnancy and nursing stages of the captive animal.

By feed additive, it means a non-nutritive product added to the basal feed in small quantities that affects better utilisation of the feed or productive performance of the animal e.g. flavouring agents supposed to increase palatability of the feed, grit for gallinaceous birds to enhance digestibility, antibiotics in small quantities for growth and production etc.

DIET CHART:

This chart embodies all the items of feed with their quantities issued per head per day for each and every species of animal and birds of the zoo. This chart should be kept ready always with the Commissary, Zoo Officer, Zoo Hospital and Zoo Keepers to act as guide for feeding the zoo livestock. Any change in the chart has to be made only with the approval of the zoo Director. Usually this chart is prepared by the Zoo Veterinarian and approved by the zoo Director. The quantity of each item of feed has to be calculated as per the stock of zoo livestock from time to time. Every zoo is expected to maintain diet chart which enables the zoo authorities to plan out the feeding programme of the zoo livestock annually.

Before prescribing the diet of the zoo animals one has to take into consideration the following facts.

i) Natural food of the species in the wild.

ii) Diet chart if any provided by the supplier

iii) Past experience of the zoo with this species

iv) Diet charts of other well managed zoos

v) Literature available on this subject

vi) Palatability and nutritional aspect of the proposed diet for that species

vii) Availability of the proposed diet in the locality.

Nutritional requirement and feeding habits of such a varied species of zoo animals vary. Quantity, frequency of feeding, location of feeding, size and consistency of feed items container size, animal's age, health, social status and climate etc. have to be taken into consideration at the time of actual feeding and for prescribing the diet. In captivity it is difficult to maintain those species which are very specific in their diet in the wild e.g. ants for Indian Pangolin. Slat licks are usually made available in all the enclosures of herbivorous animals for licking to avoid salt deficiency. All animals should have free access to clean fresh water.

SPECIAL DIET

Depending on the stage of life, the nutritional requirement in animal can be broadly divided into (a) Maintenance requirement, (b) production requirement and (c) Reproduction requirement. The normal diet chart is expected to meet the requirements of the animal under normal conditions. In the zoo, there is practically no much stress on the production requirement. But during the period of breeding or egg-laying season and nursing periods, special diet are sometimes given. Usually the large cats are not given any diet once a week. But the pregnout and nursing, cat mothers are not starved. Sick animals are also given special diet for easy digestion and acceptability by the sick animal. The special diet is usually prescribed by the zoo veterinarian in consultation with the zoo Director.

All feed items have to be checked for quality before feeding. Sometimes some of feed are sent to Feed Analytical Laboratory for analysis. The feed has to be stored properly to avoid damage by rats, insects etc. perishable feed items have to be given to the animals as quickly as possible. Before feeding some of the items of feed are cut into pieces, some are soaked overnight and some are cooked properly depending upon the requirement of the animals.

Timely supply of diet regularly is a must for all zoo livestock. A bland and monotonous diet over long periods should be avoided as far as practicable. Feeding by visitors should be avoided as it may cause over-feeding, digestive disturbances or feeding of unsuitable articles. The nocturnal animals are usually fed in the evening hours.

Sometimes hand feeding and rearing of young babies become a necessity in zoos as many mothers reject their babies of the first litter though the same mothers may rear up the offsprings of the subsequent births. The babies are kept separately and careful hand feeding with the help of feeding bottles is practiced. The milk thus fed needs to be supplemented with vitamin and mineral supplements (specially Calcium) as per requirement.

Hygienic storage and distribution and regularity of timely supply of clean nutritious food have a direct bearing on the health of zoo animals and birds.

SELECTED REFERENCES

Banarjee, G.C. (1988): Feeds and principles of Animal Nutrition, Oxford and I.B.H. Publishing Co. P.Ltd., Bombay, New Delhi, Calcutta.

Karsten, P. (1987) : Animal Nutrition, Part-II, Zoo Zen Vol.2 (12) : 1-40.

Karsten, P. (1987) : Animal Nutrition, Part-II, Zoo Zen Vol.3 (1) : 1-34.

Morrision, F.B. (1984) : Feeds and Feeding, CBS Publishers and Distributors, Delhi-32.

THE IDENTIFICATION AND EVALUATION OF DISEASE WITHIN SPECIES WITH DESIGNATED SPECIES SURVIVAL PLANS

Michael R. Cranfield, DVM*
Baltimore Zoo, Druid Hill Park, Baltimore, Maryland 21217 USA

Increased habitat pressure has lead to more extensive human management of wild and captive populations of animals. To various degrees, man controls the environmental factors to which these animals are exposed. The most effective and prudent role of a veterinarian working within a Species Survival Program (SSP) is the identification and evaluation of these factors relative to disease. This process should result in protocols to eliminate or reduce situations adversely affecting that species. In the broadest terms this would be the study of morbidity which can be defined as 1) a diseased state, ill health or 2) the result of exposing an organism or group of organisms to the causes of disease. Morbidity, as it relates to SSP's, can further be broken down into two categories: A) Syndromes which are the aggregate of signs, symptoms, or other manifestations considered to constitute the characteristics of a morbid entity and the term is usually used when the cause of the condition is unknown; and B) Disease which is a condition which alters or interferes with the normal state of an organism and is usually characterized by the abnormal functioning of one or more of the host's systems, parts, or organs. It may result from an inherent metabolic abnormality including congenital and hereditary defects and degenerative processes or from such factors as stress noxious stimuli, toxic agents, injury, or infection. A given disease is often manifested by a characteristic set of signs and symptoms although a host organism can be asymptomatic while having microscopic, serologic or immunologic evidence of disease.

Identification

The SSP veterinarian is responsible for the seemingly insurmountable task of identifying all of the possible causes of morbidity within a certain species. The sources of information are necropsy results, literature searches, surveys, serological screening, and prospective studies. Necropsy records accumulated through the years from zoos and other institutions that manage populations of that species need to be assembled and reviewed. The veterinarian should be concerned with both the wild and captive population and be aware of diseases that occur in either/or populations. The historical aspects of the species in captivity, can be obtained from the studbook keeper and the ARKS program. The detail and quality of the post-mortems will vary widely but in general, has improved in recent years. The importance of the completeness of a post-mortem and subsequent records will soon become apparent in that the animal may have several significant disease processes occurring as well as the cause of death. The literature search should include the morbidity of the wild and captive populations of concern as well as species that may transmit problems to the species in question when exposed in the wild or in captivity. Literature searches and necropsy results should reveal the most important and severe causes of morbidity.

However these sources may not expose the more chronic and less severe causes of morbidity in the population that, in the long term, may have significant impact on the viability of the species. These syndromes and diseases may be uncovered with management and viability surveys sent to institutions housing the species asking about difficulties and concerns. The veterinarian may have to conduct a survey of serological tests of the wild and captive population to elicit the incidence of carrier states with no clinical signs, eg, herpes viruses in cranes and primates. Management changes and behavioral data should be examined for possible causes of poor population viability, such as the high infant mortality in many species.

On a prospective basis the veterinarian should customize quarantine, movement, preventative medicine, and necropsy protocols to promote the identification and surveillance of morbidity. Of essential importance is sufficient, meaningful documentation which includes permanent animal identification, to compile medical records and pedigree.

Evaluation

The causes of morbidity that are of the most concern are those that pose a significant threat to the long-term survival of the captive and/or wild population. One of the most potentially devastating situations is the exposure of the species of concern to similar species with diseases which are foreign and may be more pathogenic in their new host. The largest concern to reintroduction plans is that diseases artificially introduced in captivity will be transported back to the wild. The advent of zoogeographic regions in zoos as opposed to houses holding all similar species will reduce but not eliminate this potential. Not all causes of morbidity by definition are perilous. Prioritization must be attempted since financial and personal resources are usually limited. Recently, at the Captive Breeding Specialist Group conference at Oakland, the Captive Disease Monitoring Working Group modified the Mace/Lande criteria for assessing extinction threats for species.[1] The purpose of this modification was to assess the threat of an infectious disease. The criteria must be applied for every infectious agent of the species under investigation. A further modification of the program is presented to include the wider definition of morbidity. The system is flexible enough to allow professional judgement of the veterinary advisor. The system needs periodic review, because of the emergence of new disease, changes in prevalence, new therapeutic and vaccine developments as well as the quantum leaps in diagnostic technology.[1]

Morbidity Risk Assessment
I. Assessment Criteria

Mace/Lande category of susceptible species	Endangered/critical Vulnerable Safe
Incidence of Morbidity	High Low Affects multiple species Vertically transmitted Has asymptomatic carrier
Prevalence of Morbidity in Population	High Low
Outcome of Morbidity	Usually fatal Causes permanent debility Rarely fatal Causes temporary debility
Availability of Prevention	Effective vaccine/ therapeutic agents available; management/ nutritional chang es possible. No effective vaccine, treatment available, no nutritional/management changes possible.
Diagnostic Tests	Reliable None/unreliable
Public Health/Agricultural Concern	High Low

If a species has been assigned to an SSP, it already has been designated as endangered or critical. Therefore the first category of the Mace/Lande criteria does not have to be included in the categories of morbidity risk assessment. For the purposes of this modification of the Mace/Lande criteria for the evaluation of morbidity, incidence is defined as the number of new cases arising after exposure while prevalence is the number of cases, old or new, existing within a population. In terms of infectious disease, incidence is synonymous with infectivity or virulence.

Morbidity Risk Assessment
II Categories of Risk

High Risk Morbidity:
A) is usually fatal or causes permanent debility, or
B) is rarely fatal or causes temporary debility but is of high incidence and prevalence, or
C) is rarely fatal or causes temporary debility but is vertically transmitted, or
D) is rarely fatal or causes temporary debility but has asymptomatic carriers and no diagnostic tests, or
E) affects multiple species and is of high incidence with no effective vaccine, treatment, or diagnostic test, or
F) is of public health or agricultural concern and has a high incidence.

Low Risk Morbidity:
A) is of low incidence and prevalence and causes temporary debility or is rarely fatal and has reliable vaccines therapeutics and diagnostic tests available, or
B) is of high public health or agricultural concern but low incidence or prevalence, or
C) is of low public health or agricultural concern.

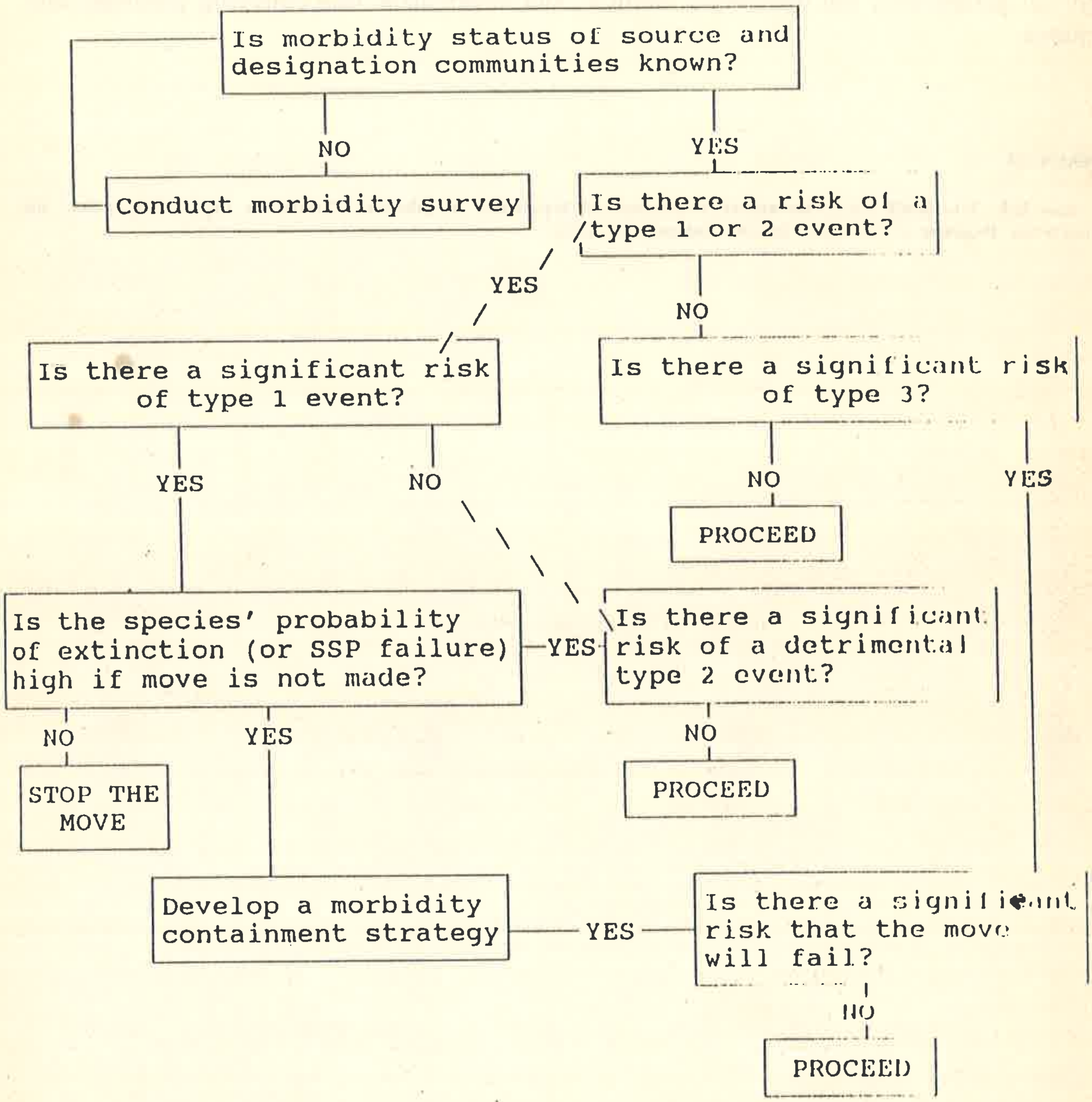
Roadblocks to making an accurate and valuable evaluation of the morbidity are numerous:

1) the lack of sensitive and specific diagnostic tests,
2) the lack of standardization between laboratories and test interpretation,
3) the reluctance of zoological institutions to disclose existing problems or survey for possible problems,
4) the general lack of knowledge and epidemiology of many of the morbidity problems we face within an SSP,
5) the inability to readily transport biological specimens across national boundaries for diagnostic purposes,
6) the difficulty accessing recent information.

Once morbidity has been prioritized, resources can be channeled to those problem areas of high concern. Members of the wildlife and zoo field, affiliated universities, and the infectious disease committee of the AAZV should be approached to help clarify problems.

Risk evaluation of interzoo movement for SSP management benefits could be accessed utilizing a modified decision tree designed by the Risk Assessment Working group at the CBSG meeting for reintroductions.

Decision Analysis Tree for Risk
Assessment for Interzoo SSP Movement



Type 1 event - morbidity occurs in the source animals but not in the destination community
Type 2 event - morbidity is common to both communities and there is concern of deleterious consequences from the disturbance of the dynamic relationship between the hosts and morbidity
Type 3 event - morbidity in the destination population only

The role of the SSP veterinarian is not only to identify and evaluate morbidity from a historical perspective, but document, monitor, and disseminate new emerging problems and solutions.

REFERENCES

1. Seal, U.S., P.L. Wolff (Ed.) International Conference on Implications of Infectious Disease for Captive Propagation and Reintroduction Programs of Threatened Species. Oakland, CA. 1992.

DISEASE MONITORING IN CONSERVATION PROGRAMS BY PATHOLOGY SURVEYS

Linda Munson, DVM, PhD
Dept Pathobiology, College of Veterinary Medicine, University of Tennessee, Knoxville, TN 37901 USA

Design of species or taxon conservation programs requires knowledge of the problems impeding preservation of the population. Disease is only one factor affecting population dynamics, but the impact of disease cannot be assessed without knowledge of the prevalent and serious diseases in the population. Furthermore, action plans to reduce the impact of disease on species survival cannot be initiated without this information. Not all SSP/TAG species will have disease problems requiring specific actions, but target species cannot be identified without preliminary surveillance. Then for the target species, diseases prevalence statistics can be used to assess if animal transfers should be restricted or if research resources should be invested.

When veterinary advisors are first assigned to American Association of Parks and Aquariums (AAZPA) Species Survival Plans (SSPs) or Taxon Advisory Groups (TAGs), they usually are disheartened by the shortage of published information on their assigned species. When Murray's book and Medline fail, they are left with the overwhelming task of acquiring this information from primary sources (clinical and pathology records). Substantial variation in the quantity or quality of these records can result in over or under-estimation of the prevalence of a disease. Furthermore, diseases that have been published may assume an importance that is out of proportion to the relevance of that disease to population survival. This also is true if serology or parasitology surveys are used as a measure of disease, because these data do not necessarily signify disease as much as exposure to an agent or a commensal relationship. Only through pathologic evaluation can the pathogenicity of an agent and true disease prevalences be determined.

Prospective pathology surveys are the optimal method of precise disease monitoring for SSP/TAG conservation programs because all animals that die can be systematically evaluated by the same method. Design and enactment of appropriate protocols for comprehensive pathologic evaluations will result in systematic recording of most clinical and subclinical diseases in the population within a few years. Information from retrospective analysis of clinical and pathology records then can be included with the prevalence statistics from the prospective study in a complete disease database for the SSP/TAG. Regardless of the impact of this survey on the subsequent SSP Action Plan, no disease surveillance in any species will be in vain, because any new knowledge will contribute to the enormous information shortage that currently exists for non-domestic animal disease.

SSP/TAG pathology surveys use epidemiologic methods

A disease database is built on information from individual animals, but disease concerns of a species are based on the prevalence statistics of epidemiology. The SSP/TAG veterinary advisor must focus on the predominant, fatal, or transmissible diseases in the population and forego concern for individual animals unless their genetic contribution is indispensable. This represents a fundamental departure from our veterinary training.

For the pathologist, this focus on epidemiology indicates that determining the cause of death of each individual animal becomes secondary to screening all tissues for pathologic changes. A minor lesion in an animal may be significant to the population if this lesion represents one manifestation of a prevalent disease. For example, mild veno-occlusive disease (VOD) may be an incidental finding in an individual cheetah, but a significant addition to the high prevalence statistic for VOD in the captive population. For that reason, all gross or histopathologic lesions should be recorded by a pathologist regardless of the severity or relevance to a clinical condition and/or death of an animal.

Guidelines for optimizing data collection in SSP/TAG pathology surveys

A prospective pathology survey provides vital information for conservation programs and can contribute significantly to the science of zoological medicine. However, these goals cannot be met if certain guidelines are not followed. The rationale for these guidelines is that consistent collection of compatible data results in information that can be collated and shared through common information networks. Compliance with these guidelines exacts a minimum of additional time, while yielding a maximum of information for zoological medicine.

The guidelines are as follows:

1. Develop a customized necropsy protocol using the CBSG/AAZV and Canid TAG prototypes: one for captive animals and one for free-ranging animals.

2. Provide copies of the protocols to veterinarians at all facilities housing the species/taxon and to key field personnel who may have access to free-ranging animals.

3. Necropsy <u>all</u> animals that die and have <u>all</u> organs examined histopathologically.

4. Designate a pathologist who is experienced with the species or taxon to evaluate the tissues.

5. Report all data using the selected zoological pathology "dictionary".

6. Enter your data into a network-accessible database.

7. Provide reports of your findings to contributing institutions and to the AAZPA.

Necropsy protocols

For any research project, planned data collection using standard methods results in more useful information. In order to promote consistent biomaterials collection during disease monitoring, a "generic" necropsy protocol was designed for captive wildlife at the 1992 CBSG/AAZPA/AAZV meeting on "International Conference on Implications of Infectious Diseases for Captive Propagation and Reintroduction Programs of Threatened Species". This protocol is designed for use by clinical veterinarians, veterinary pathologists, or highly trained staff and presumes a certain level of anatomical knowledge. In contrast, a prototype protocol for free-ranging animals was devised for the 1993 Canid TAG Manual that included anatomical illustrations for performance of a necropsy by untrained field personnel. Protocols for both captive and free-ranging animals should be customized for your species or taxon to include unique anatomic features, disease problems, or research protocols deemed important for SSP goals. Avoiding complexity in these protocols will increase your compliance rate, as will inclusion of special media or fixatives, packaging materials, and addresses.

Provide these protocols and materials to key international personnel at zoos and wildlife preserves who can contribute tissue or information to a global disease network for your species. Acquisition of necessary permits for importation of tissues to the species pathologist will facilitate international compliance. Providing feedback for their efforts in the form of necropsy reports and disease summaries to the contributing facilities and parks will give them the incentive to continue the disease monitoring protocols. Attempts also should be made to interface with IUCN/SSC and other regional conservation disease-monitoring programs that affect your species of interest.

Communicate to all facilities or parks supporting your species or taxon that necropsy of all animals is essential, regardless of the state of decomposition or the need to determine the cause of death. If only selected individuals are necropsied, then prevalence statistics will be biased, and important subclinical diseases will be overlooked that could be contributing to infertility or morbidity in your species.

The role of the pathologist

Designating a specific SSP/TAG pathologist to analyze all tissues from your species will result in increased recognition of disease patterns in the population and simplify communication of important data. Although expertise with the particular species or taxon is preferred, this is not always possible with the current shortage of zoo/wildlife pathologists. Therefore, any experienced, well-trained comparative pathologist with an interest in the species and willingness to consult with other pathologists would be appropriate.

SSP/TAG pathologists should examine all tissues histopathologically during the first stages of the pathology survey until the important diseases are identified in the species in question. Besides conducting the prospective pathology survey, the SSP/TAG pathologist should review all retrospective pathology records and interpret the "pathspeak" for the SSP/TAG clinical veterinary advisor. Through their experience in interpreting tissue responses to injury, the pathologist can determine if a disease may have a significant impact on a species or if that disease likely is inconsequential. Comparative pathologists also can focus research efforts by combining their observations of the SSP species disease problems with their understanding of disease pathogenesis in other species.

SSP/TAG pathologists should agree to code all observed lesions regardless of clinical importance and to use the coding methods and dictionary chosen by consensus for MedARKS. This zoological pathology-based dictionary in under development by a consortium of zoo and wildlife pathologists and will be available through ISIS/MedARKS within two years.

Networking

Our knowledge of human and domestic animal disease is founded on decades of meticulous pathologic studies correlated with clinical parameters. This work represents the consolidated efforts of thousands of physicians and pathologists who shared their information through a common medical language. In zoological medicine and pathology, we are still in our infancy, but the learning process can be accelerated with contemporary information management tools if the initiative is present among veterinarians to cooperate on this effort. Information networks require compatibility to work, which is why standardized necropsy protocols and pathology terminologies should be integral components of SSP/TAG disease monitoring programs. Use of the MedARKS Pathology Module by all SSP/TAG pathologists and veterinarians also would open new avenues of communication that will benefit all participants by increasing our knowledge of wild animal diseases.

SSP/TAG pathology surveys can benefit global conservation efforts by networking with disease monitoring systems globally. Currently, efforts are underway to obtain a consensus amongst zoo and wildlife pathologists and veterinarians throughout the globe to develop a single registry for wild animal disease. This universal wildlife disease database would permit entry and extraction of epidemiological data from a network of zoos, wildlife parks, and federal wildlife information banks. A wildlife disease reporting system has already been initiated through the collaboration of the IUCN/SSC Veterinary Group and the pre-existing IOE domestic animal surveillance program (M. Woodford, personal communication). The cooperation of AAZPA SSPs and TAGs with this program would significantly enhance the knowledge base of disease information in threatened species.

What zoos can do to assist SSP pathology surveys

1. Promote comprehensive necropsies of all animals and cooperation with SSP protocols.

2. Use a pathology data system that interfaces with global disease monitoring networks.

3. Initiate archiving of pathology specimens (wet tissues, blocks, kodachromes) and develop serum banks.

4. Support research on important diseases affecting critical SSP species

5. Support fellowship programs in zoo and wildlife pathology to address the need for veterinary pathologists with expertise in non-domestic species.

Prototype SSP pathology surveys

Evidence that pathology surveys work is best presented by successful examples. Prototype programs have been designed for the maned wolf, golden lion tamarin (R.J. Montali) and for the cheetah (L. Munson). These programs were originally motivated by recognition that diseases were a significant component of captive management. This concern led to the design of comprehensive necropsy protocols by the SSP pathologist and the rapid accumulation of information on the prevalence of diseases in these species.[4,6,10,12] These pathology surveys have been extended to include free-ranging species to determine if the disease identified in captive animals are unique to those populations or are inherent to the species. For example, cystinuria in maned wolves and diaphragmatic hernias in golden lion tamarins were identified in both captive and free-ranging animals, whereas veno-occlusive disease has been recognized only in captive cheetahs.[1-3,10,12] This type of information will be essential for resolving critical disease problems in other SSP species in the future.

LITERATURE CITED

1. Bush, M. 1981.Cystinuria in the maned wolf of South America. Science 212:919-920.
2. Bush, M. and Bovee, K.C. 1978.Cystinuria in a maned wolf. J. Am. Vet. Med. Assoc. 173:1159-1162.
3. Bush, M., Montali, R.J., Kleiman, D.G., Randolph, J., Abramowitz, M.D. and Evans, R.F. 1980.Diagnosis and repair of familial diaphragmatic defects in golden lion tamarins. J. Am. Vet. Med. Assoc. 177:858-862.
4. Montali, R.J. Pathology survey of captive golden lion tamarins. In: *The Biology of the Golden Lion Tamarin*, edited by Kleinman, D. 1993 in press.
5. Montali, R.J. and Bush, M. 1992. Some diseases of golden lion tamarins acquired in captivity and their impact on reintroduction. Proc. Jt. Conf. A.A.Z.V.and A.A.W.V. 14-16.
6. Montali, R.J. and Kelly, K. Pathologic survey and review of diseases of captive maned wolves (*Chrysocyon brachyurus*) and bush dogs (*Speothos venaticus*). In:.Sonderdruck aus Verhandlungsbericht des 31. International Symposiums uber die Erkrankungen der zoo- und wildtiere, edited by Dept.of Pathology, National Zoological Park,Smithsonian Institution,Washington,D.C. Berlin : Akademie-Verlag, 1989, p. 35-43.
7. Munson, L. 1990. Future directions for zoological pathology. J. Zoo Wildl. Med. 21 No.4:385-390.
8. Munson, L. 1991. Strategies for integrating pathology into single species conservation programs. J. Zoo Wildl. Med. 22 No.2:165-168.
9. Munson, L. Research priorities for disease monitoring in canids. In: Canid Action Plan, 1992, edited by AAZPA Canid Taxon Advisory Group, and IUCN Captive Breeding Specialist Group Global Canid Action Plan, Apple Valley: CBSG, 1993, p. 79-125.
10. Munson, L. 1993.Diseases of captive cheetahs (*Acinonyx jubatus*): Results of the cheetah research council pathology survey, 1989-1992. Zoo Biology 12:105-124.
11. Munson, L. and Montali, R.J. 1991. High prevalence of ovarian tumors in maned wolves (*Chrysocyon brachyurus*) at the National Zoological Park. J. Zoo Wildl. Med. 22:125-129.
12. Munson, L. and Worley, M.B. 1987.Comparative hepatic histopathology in snow leopards and cheetahs. Proc. Amer. Assoc. Zoo Vet. Pp.

Verh.ber. Erkrg. Zootiere (1992) 34
Akademie-Verlag

From the Zoological Gardens of Alipore, Calcutta[1] and Department of Zoology[2], Asutosh College, Calcutta, India

STUDIES ON HOST-SPECIFICITY OF COCCIDIAN PARASITES IN CAPTIVE AND WILD MAMMALS OF INDIA

By S. K. Chaudhuri[1] and S. K. Das[2]

Introduction

Coccidians are of widespread occurrence, with representatives attacking members of all major groups of the animal kingdom, especially birds and mammals. Since a large number of coccidia have so far been reported in the context of domestic, paradomestic, feral as well as wild birds and mammals, these parasites represent a focal point of attraction to veterinarians. Protozoologists, too, feel attraction to this group of protozoa, as they present a diverse morphology and biology, hinting on their inter-relationship.

These parasites provide an important tool to study host-parasite inter-relations and, thereby, assess the speciation problem of parasitic protozoa. This particular problem has been choosen as subject of this communication. Wild mammals that enjoy a free movement and those living in captivity are susceptible to coccidian infection. To be exact, various herbivores, carnivores, omnivores and species feeding on specialised diets, such as frugivores, insectivores and so on, harbour specific coccidian fauna, as may be seen from plenty of literature. An intensive probe through the available literature was undertaken by the authors to compile a list of coccidia and their Indian mammalian hosts, of course, excluding domestic mammals, to elucidate the host specificity of coccidians infecting captive and wild mammals.

Discussion

The host-parasite index on the following pages suggests quite clearly that some parasites exhibit a rather narrow specificity, while others are able to infect a wide range of hosts. For a parasite, the host body, especially its internal milieu, constitutes a special 'ecological niche'. It is at present well established that the phenotype is a multidimensional attribute of the genotype. It is the phenotypic structure that comes in relation to ecological factors, and for a parasite it is the physiological constituent of the host body. At a first glance, it may appear that coccidians of narrow specificity, such as *Eimeria ailuri*, *E. aurei*, *E. cati*, *Isospora ursi*, *I. pardusi*, are less pliable and adaptable in comparison to those of wider host specificity, such as *Eimeria arloingi*, *Eimeria crandallis*, *Eimeria parva*, *Isospora felis*. Nevertheless, there is no conclusive picture.

Present-day parasitologists feel that parasites with narrow specificity, in terms of evolution, should not be considered as a primitive group. Parasites, sometimes, are intimately connected with the speciation problem of the host species. Hence, hosts that have maintaining a status quo over a considerable length of time may be considered to have preserved their internal milieu and, thereby, provide very little chance for the parasitic group to diverge and to speciate. This situtation has been recognized for endemic host species with a more consistent coccidian fauna. For example, spotted deer *Axis axis*, endemic in the oriental region, is reported to harbour only four species of *Eimeria*. Such a situation might be taken as an old intimate association. This conjecture is additionally

---

This paper is dedicated to the 65th birthday of Prof. Dr. habil. R. Ippen.

Host - Parasite index :

(Recorded from captive and wild mammals of India)

Host	Parasite
ORDER : PRIMATES	
Bonnet Monkey *Macaca radiata*	*Isospora* sp. BHATIA et al., 1972
Slow loris *Nycticebus coucang*	*Eimeria coucangi* PATNAIK and ACHARJYO, 1970
	Eimeria nycticebi PATNAIK and ACHARJYO, 1970
ORDER : RODENTIA	
Commos giant flying squirrel *Petaurista petaurista*	*Eimeria petauristae* RAY and SINGH, 1950
Indian palm squirrel *Funambulus palmarum*	*Eimeria bandipurensis* RAY et al., 1965
ORDER : CARNIVORA	
African lion *Panthera leo leo*	*Eimeria felina* NIESCHULZ, 1924
	Isospora leonina MANDAL and RAY, 1960
	Isospora mohini AGRAWAL et al., 1981
	Isospora pantheri AGRAWAL et al., 1981
Corsac fox *Vulpes corsac*	*Isospora buriatica* YAKIMOFF and MATSCHOULSKY, 1940

Host	Parasite
Clouded leopard *Neofelis nebulosa*	*Isospora leopardi*, AGRAWAL et al., 1981
Indian fox *Vulpes bengalensis*	*Eimeria lomarii* DUBEY, 1963b
	Isospora buriatica YAKIMOFF and MATSCHOULSKY, 1940
Indian grey mongoose *Herpestes edwardsi*	*Eimeria pandei* (PATNAIK and RAY, 1965) PATNAIK and RAY, 1966
	Eimeria newalai DUBEY and PANDE, 1963
	Isospora dubeyi PATNAIK and RAY, 1965
	Isospora garnhami BRAY, 1954
	Isospora hoarei BRAY, 1954
Jackal *Canis aureus*	*Eimeria aurei* BHATIA et al., 1979
	Isospora tropicalis MUKHERJEE and KRESSNER, 1965
Jungle cat *Felis chaus*	*Eimeria cati* YAKIMOFF, 1933
	Eimeria felina NIESCHULZ, 1924
	Eimeria hammondi DUBEY and PANDE, 1963
	Eimeria mathurai DUBEY and PANDE, 1963
	Isospora rivolta (GRASSI,1879) WENYON, 1923

Host	Parasite
Leopard *Panthera pardus*	*Isospora felis* (WASIELEWSKI, 1904) WENYON, 1923 *Isospora pardusi* PATNAIK and ACHARJYO, 1971
Leopard cat *Felis bengalensis*	*Isospora felina* PATNAIK and ACHARJYO, 1971 *Isospora nandankanani* PATNAIK and ACHARJYO, 1976
Indian lion *Panthera leo persica*	*Isospora sp.* CHAUHAN at el., 1973
Red panda *Ailurus fulgens*	*Eimeria ailuri* AGRAWAL at el., 1981
Sloth bear *Melursus ursinus*	*Isospora ursi* AGRAWAL et al., 1981
Striped hyena *Hyaena hyaena hyaena*	*Isospora levinei* DUBEY, 1963a
Tigon (hybrid between tiger and lioness)	*Isospora felis* (WASIELEWSKI, 1904) WENYON, 1923
White tiger *Panthera tigris tigris*	*Isospora felis* (WASIESLEWSKI , 1904) WENYON, 1923
ORDER : ARTIODACTYLA	
Argali *Ovis ammon*	*Eimeria arloingi* (MAROTEL, 1905) MARTIN, 1909 *Eimeria crandallis* HONESS, 1942 *Eimeria faurei* (MOUSSU and MAROTEL, 1902) MARTIN, 1909 *Eimeria parva* KOTLAN et al., 1929

Host	Parasite
Barking deer *Muntiacus muntjak*	*Eimeria dawri* BHATIA et al., 1973 *Eimeria sardari* BHATIA et al., 1973 *Eimeria* sp. BHATIA, 1968
Blackbuck *Antilope cervicapra*	*Eimeria antilocervi* RAY and MANDAL, 1960 *Eimeria cheetali* BHATIA, 1968 *Eimeria mrigai* PANDE et al., 1972
Chinkara *Gazella gazella*	*Eimeria cheetali* BHATIA, 1968 *Eimeria chinkari* PANDE et al., 1970
Fallow deer *Dama dama*	*Eimeria intricata* SPIEGEL, 1925
Four-horned antelope *Tetracerus quadricornis*	*Eimeria chausinghi* PANDE et al., 1970
Hippopotamus *Hippopotamus amphibius*	*Isospora hippopotami* AGRAWAL et al., 1981
Hog deer *Axis porcinus*	*Eimeria parahi* PANDE et al., 1970
Indian bison *Bos gaurus*	*Eimeria gaurusi* PATNAIK and ACHARJYO, 1971
Ladhak goat *Capra ibex*	*Eimeria arloingi* (MAROTEL, 1905) MARTIN, 1909 *Eimeria crandallis* HONESS, 1942 *Eimeria ninakohlyakimovnae* YAKIMOFF and RASTEGAIEFF, 1930

Host	Parasite
Moufflon *Ovis musimon*	*Eimeria arloingi* (MAROTEL, 1905) MARTIN ,1909
	Eimeria crandallis HONESS, 1942
	Eimeria faurei (MOUSSU and MAROTEL, 1902)
	Eimeria parva KOTLAN et al., 1929
Mouse deer *Tragulus meminna*	*Eimeria ramgai* PANDE et al., 1970
Nilgai *Boselaphus tragocamelus*	*Eimeria nilgai* PANDE et al., 1970
	Eimeria tragocamelis BHATIA, 1968
	Eimeria yakimovi RASTEGAIEFF, 1930
One-humped camel *Camelus dromedarius*	*Eimeria cameli* (HENRY and MASSON, 1932) REICHENOW, 1953
	Eimeria dromedarii YAKIMOFF and MATSCHOULSKY, 1939
	Eimeria rajasthani DUBEY and PANDE, 1963
Rocky mountain bighorn sheep *Ovis canadensis*	*Eimeria arloingi* (MAROTEL, 1905) MARTIN, 1909
	Eimeria faurei (MOUSSU and MAROTEL, 1920) MARTIN, 1909
	Eimeria ninakohlyakimovae YAKIMOFF and RASTEGAIEFF, 1930
	Eimeria parva KOTLAN et al., 1929

Host	Parasite
Siberian wild goat *Capra siberica*	*Eimeria crandallis* HONESS, 1942 *Eimeria faurei* (MOUSSU and MAROTEL, 1902) MARTIN 1909 *Eimeria ninakohlyakimovae* YAKIMOFF and RASTEGAIEFF, 1930 *Eimeria parva* KOTLAN et al., 1929
Spotted deer *Axis axis*	*Eimeria cervis* MANDAL and CHOUDHURY, 1988 *Eimeria cheetali* BHATIA, 1968 *Eimeria* sp. BHATIA, 1968 *Eimeria wassilewskyi* RASTEGAIEFF, 1930
Two humped camel *Camelus bactrianus*	*Eimeria cameli* (HENRY and MASSON, 1932) REICHENOW, 1952 *Eimeria dromedarii* YAKIMOFF and MATSCHOULSKY, 1939
Wild boar *Sus scrofa scrofa*	*Eimeria neodebliecki* VETTERLING, 1965 *Isospora suis* BIESTER and MURRAY, 1934
Wild goat *Capra aegagrus*	*Eimeria ninakohlyakimovae* YAKIMOFF and RASTEGAIEFF, 1930 *Eimeria crandallis* HONESS, 1942

supported by the simple fact that these parasites do not produce any pathogenic symptom that might concern a veterinarian. In other words, it may be envisaged that the parasite has attained some sort of teleological evolutionary paradox turning towards mutualism.

This situation may as well be interpreted in a slightly different fashion. A parasite of narrow specificity might have been introduced to the body of suitable host species. It was established in the course of time, and since the host species were smoothly adjusted to local environment, they did not speciate. The parasite, too, had no innate impetus for diversification and speciation.

Parasites exhibiting a wider range of specificity might give an apparent impression of their advanced evolutionary status. Critical examination of the situation may lead to the conclusion that such parasites have a wider range of adaptability, since they are able to thrive within the body of more than one host species. However, these host species, taxonomically, in most cases, are not too different from each other but are closely related. It may be safely concluded that related host species have more or less identical genomes, although the gap between them is sufficient to prevent inter-breeding. Obviously, their internal physiological environments may be considered as quite identical. It is interesting to note that in such cases, parasites exhibit certain morphometric diversion, as depicted by morphometric measurements of their oocystic structure. It would be premature to difine them as separate species or sub-species either, because such determination would certainly demand experiments on cross-transmission and their successful establishment.

Since the inception of taxonomic studies into coccidia, DOFLEIN (1916), PINTO (1928) and HOARE (1933) laid emphasis on the morphological parameters of sporulated oocysts for species determination. The second school of thought represented by REICHENOW (1921) and WENYON (1926) hold that determination of species should encompass the biological phenomena exhibited by parasites at their life-cycle stages.

Leaving aside the existing dispute on taxonomy of coccidia and taking the determined species as valid ones, we may use the host-parasite index as a tool for determination of taxonomic <u>locus standi</u> of parasites and their hosts, as well. KENNEDY (1975) suggested that specificity and distribution of related parasites are very often restricted to related genera and species of the hosts. The evolution of parasites, as believed by SPRENT (1962) proceeds to an ultimate stage, when it becomes immunologically recognised as the 'self'. This condition might have been achieved by the coccidia recorded from captive and wild mammals. It is also evident from the work of various authors that a recently introduced parasite leads to manifestation of various recognizable symptoms in a host. Therefore, suitable prophylactic measures should be sought for, in order to prevent dispersion of coccidian parasites from one group of hosts to another.

This investigation is primarily intended to provide a comprehensive account of coccidian parasites of the captive and wild mammals in India. Although the present study is fairly theoretical, the index may be used as a convenient tool for reconnaissance, and the same would be of much help in adopting suitable prophylactic measures for eradication of coccidian infestation. This index, also, may be treated as the initiating study upon which future investigations may be untertaken, with the view to clearing up inter-relations between parasites and their hosts. undertaken.

<u>Summary</u>

<u>Studies on host-specificity of coccidian parasites in captive and wild mammals of India</u>

A large number of coccidian parasites has so far been reported in the context of wild and captive mammals of India. This paper reviews the coccidian fauna of said hosts with diverse feeding habits and tries to establish host-specificities of the parasites concerned. The coccidian species so far recorded fall into two categories, those of a restricted specificity and those of a wider range. A critical survey tends to indicate that narrow

specificity very often involves closely related host species. These parasites are less important from the stand-point of zoo management, but the second category deserves more careful concern.
The host-parasite index included in this paper can be used by personnel engaged in zoo and wildlife management, especially in tropical countries, for eradication of parasites.

Zusammenfassung

Untersuchungen zur Wirtsspezifität von Kokzidien bei Zoo- und Wildtieren in Indien

Im Zusammenhang mit Zoo- und Wildtieren in Indien gibt es Berichte über eine große Anzahl von parasitären Kokzidien. In der vorliegenden Arbeit wird die Kokzidienfauna bei den erwähnten Tierarten unter Bezugnahme auf unterschiedliche Fütterungsrégimes und die Wirtsspezifität der Parasiten zusammenfassend im Überblick dargestellt. Die bisher beschriebenen Kokzidienarten sind zunächst zwei Hauptkategorien zuzuordnen, nämlich Parasiten mit begrenzter und Parasiten mit breitgefächerter Wirtsspezifität. Eine kritische Betrachtung weist darauf hin, daß die Parasiten mit begrenzter Spezifität häufig bei miteinander verwandten Wirtsarten zu finden sind. Diese Kategorie von Parasiten ist aus tiergärtnerischer Sicht von geringerer Bedeutung. Die andere Kategorie dagegen verdient größere Beachtung.
Der in der Arbeit enthaltene Wirts-Parasiten-Index kann besonders in tropischen Ländern sowohl von Mitarbeitern zoologischer Gärten als auch von Wildhütern zur Parasitenbekämpfung genutzt werden.

Résumé

Etudes sur le caractère spécifique de l'hôte des coccidies chez les animaux gardés au zoo et chez les animaux sauvages en Inde

Plusieurs rapports mentionnent la présence d'un grand nombre de coccidies parasitaires en rapport avec les animaux gardés et les animaux sauvages en Inde. La communication donne un aperçu de la faune des coccidies chez les différentes espèces en se référant aux divers régimes alimentaires et au caractère spécifique de l'animal hôte. Les espèces de coccidies décrites jusqu'ici sont tout d'abord à classer en deux catégories principales, à savoir les parasites à spécificité limitée et les parasites à large spécificité de l'hôte. Une étude critique révèle que les parasites à spécificité limitée sont souvent à observer chez des espèces hôtes semblables. Cette catégorie de parasites n'est pas d'une très grande importance pour les jardins zoologiques alors que l'autre catégorie nécessite toute notre attention.
L'index sur les parasites et leurs hôtes contenu que renferme cet exposé peut être utilisé pour combattre les parasites, notamment dans les pays tropicaux aussi bien par le personnel de jardins zoologiques que par les gardiens des réserves d'animaux sauvages.

References

AGRAWAL, R.D., AHLUWALIA, S.S., BHATIA, B.B., and P.P.S. CHAUHAN (1981): Notes on mammalian coccidia at Lucknow zoo. Ind. J. Anim. Sci. 51, 125 - 128.

BHATIA, B.L. (1968): On hitherto unrecorded eimerian oocysts from wild ruminants. Ind. J. Microbiol. 8, 249-254.

BHATIA, B.B., AHLUWALIA, S.S., and P.P.S. CHAUHAN (1972): Further observation on *Eimeria intricata* Spiegel, 1925. Curr. Sci. 41, 118-119.

BHATIA, B.B., CHAUHAN, P.P.S., ARORA, G.S., and R.D. AGRAWAL (1973): Species composition of coccidia of some mammals and birds at the zoological gardens of Delhi and Lucknow. Ind. J. Anim. Sci. 43, 944-947.

BHATIA, B.B., CHAUHAN, P.P.S., AGRAWAL, R.D., and S.S. AHLUWALIA (1979): *Eimeria aurei* n. sp. from jackal. Ind. J. Parasit. 3, 40-50.

BIESTER, H.E., and C. MURRAY (1934): Studies in infectious enteritis of swine. J. Am. Vet. Med. Ass. 85, 207-219.

BRAY, R.S. (1954): On the coccidia of the mongoose. Ann. Trop. Med. Parasit. 48, 405-415.

CHAUHAN,P.P.S., BHATIA, B.B., ARORA, G.S., AGRAWAL, R.D., and S.S. AHLUWALIA (1973): A preliminary survey of parasitic infections among mammals and birds at Lucknow and Delhi zoos. Ind. J.Anim. Sci. 43(2), 153-158.

DOFLEIN,F. (1916): Lehrbuch der Protozoenkunde. Jena.

DUBEY, J.P. (1963a): Observation on coccidian oocystys from Indian hyaena (*Hyaena striata*). Ind. J. Microbiol. 3(3), 121-122.

DUBEY, J.P. (1962b): Observation on the coccidian oocysts from Indian fox (*Vulpes bengalensis*). Ind. J. Microbiol. 3(4), 143-146.

DUBEY, J.P., and B.P. PANDE (1963a): Observations on the coccidian oocysts from Indian jungle cat (*Felis chaus*). Ind. J. Microbiol. 3(3), 103-108.

DUBEY, J.P. and B.P. PANDE (1963c): A note on *Eimeria rajasthani* n.sp. from the Indian camel (*Camelus dromedarius*). Curr. Sci. 32, 273-274.

DUBEY, J.P., and B.P. PANDE (1963b): Observations on the coccidian oocysts from Indian mongoose (*Herpestes mungo*). Ind. J. Microbiol. 3, 49-54.

GRASSI, B. (1879): Die protozoi parasaiti e specialmente di quelli che sono nell' uomo. Gaz. Med. Ital. Lomb. (Milano) 39(8), 445-448.

HENRY, A., and G. MASSON (1932): Considerations Sur Le genre *Globidium globidium cameli* n. sp.parasite du dromedaire. Ann. Parasit. Hum. Comp. 10, 385-401.

HOARE, C.A. (1933): Studies on some new ophidian and avian coccidia from Uganda with a revision of the classification on the Eimeriidea. Parasitilogy 25, 359-388.

HONESS,R.F. (1942): Coccidia infesting the rocky mountain bighorn sheep in wyoming, with descriptions of two new species. Univ. Wyoming Agr. Expt. Sta. 249, 3-38.

KENNEDY,C.R.(1975): Ecological animal parasitology. Blackwell scientific publications.

KOTLAN,S.,MOCSY, J., and T. VAJDA (1929): A juhok coccidiosisanak okozoi egy uj faj kapscan (coccidiosis in sheep connected with new species). Allatoryosi Lapok. 52, 304-306.

MANDAL, L.N., and H.N. RAY (1960): A new coccidium *Isospora leonina*, n. sp. from a lion cub. Bull. Cal. Sch. Trop. Med. 8, 107-108.

MANDAL, D., and A. CHOUDHURY (1986): On the Parasitic - fauna of some wild animals of a mangrove forest, Sundarbans, India.

MOROTEL,G. (1905): La coccidiose de la chevre et son parasite. Rec. Med. Vet. 33, 243-244.

MARTIN, A. (1909): Les coccidioses des animaux domestiques. Res. Vet. Toulouse., 34, 201-211, 273-285, 423-421.

MOUSSU, G., and G. MAROTEL (1902): La coccidiose du Motion et son parasite. Arch. Parasite. 6, 82-98.

MUKHERJEE, A.K., and S.M. KRASSNER (1965): A new species of coccidia (Protozoa : Sporozoa) of the genus *Isospora* Schneider, 1881 from jackal, *Canis aureus*. Linn. Proc Zool. Soc. Cal. 18, 35-40.

NIESCHULZ,O. (1924): Over een geval van *Eimeria* infectie bij een ket (*Eimeria felina* n. sp.) T. Diergeneesk. 51, 129-131.

PANDE, B.P. BHATIA B.B. CHAUHAN, P.P.S., and R.K. GARG (1970): Species composition of coccidia ofsome of the mammals and birds at the zoological gardens, Lucknow (Uttar Pradesh). Ind. J. Anim. Sci. 40, 154-166.

PANDE, B.P. CHAUHAN,P.P.S., BHATIA, B.B., and G.S. ARORA (1972): *Eimeria mrigai* n. sp. (Eimeriidae : Sporozoa) in black buck (*Antilope cervicapra*). Acta Vet. Acad. Sci. Hung. 22, 225-230.

PATANAIK, M.M., and L.N. ACHARJYO (1970): *Eimeria nycticebi* n. sp. and *E. coucagni* n. sp. from Indian slow loris (*Nycticebus coucang*), and notes on *Isospora leonina* from African lion (*Panthera leo leo*). Orissa Vet. J., 5, 13-14.

PATANAIK, M.M., and L.N. ACHARJYO (1971): Notes on the coccidian parasites of wild mammals in capativity at Nandankanan. Orissa Vet. J. 6, 133-135.

PATNAIK , M.M., and L.N. ACHARJYO (1976): Remarks on *Isospora bengalensis* Pantnaik Acharjyo , 1971 from leopard cat . Orissa Vet .J., 11, 105.

PATNAIK ,M.M., and S.K. RAY (1965): Coccidia of Indian mongoose (*Herpestes edwarsi*). Ind .J.Anim .Health., 4, 33 - 36.

PATNAIK ,M.M., and S.K. RAY (1966): Letter to the Editor .Ind . J.Anim . Health ., 5, 203 .

PINTO , C.(1928): Classification des sporozoaires de la sous-classe Eimeridia. Comp . Rend .Soc. Biol. (Paris),98, 1571 - 1573.

RASTEGAIEFF , E.F. (1930): Zur Frage über Coccidien wilder Tiere. Arch .Protistenk. 7, 377 - 404 .

RAY , H.N. BANIK ,D.C, and A.K. MUKHERJEE (1965): A new coccidium *Eimeria bandipurensis* n. sp. from the Indian palm squirrel , *Funumbulus palmarum*. J. Protozool., 12, 478 - 479 .

RAY, R.N., and L.N. MANDAL (1960): A new coccidium *Eimeria antilocervi* n, sp from the antelope . Bull . Cal. Sch .Trop . Med.,8, 57 - 58.

RAY ,H.N., and H. SINGH (1950): On a new coccidium *Eimeria petauristae* n. sp from the intestine of a Himalayan flying squirrel, *Petaurista inornatus* (Geoffery). Proc. Zool .Soc. Cal.,3, 65 - 70.

REICHENOW, E. (1921): Die Haemococcidien der Eidechsen . Arch. Protistenk., 42, 179.

REICHENOW, E. (1953): Daffein's Lehrbuch der Protozoenkunde . 6th ed. Jena ,pp. 777 - 1213.

SPIEGEL, A. (1925): Ein bisher nicht bekanntes Kokzid beim Schaf. Z.Infektionskrankh., 28, 42 - 46.

SPRENT, J.F. A. (1962): Parasitism ,immunity and evolutition . In : G.W Leeper(Ed.). The evolution of living organisms. Melbourne University Press .Melbourne.

VETTERLING, J.M. (1965): Coccidia (Protozoa : Eimeriidae) of swine. J. Parasito., 51, 897 - 912.

WASIELEWSKI, T.(1904): Studien und Mikrophotogramme zur Kenntnis der pathogenen Protozoen, Leipzig.

WENYON, C.M. (1923): Coccidiosis of cats and dogs and the status of the *Isospora* of man . Ann. Trop. Med. Parasite ., 17, 231 - 288.

WENYON ,C. M .(1926): Protozoology 2 vols. Bailliere . Tindal and Cox , London.

YAKIMOFF, W.(1933):La coccidiose des animaux domestiques dens I' Azerbaidjan (Transcaucasis) . Ann. Soc. Belge. ed. Trop.,13, 93 - 130.

YAKIMOFF , W.L., and S.N. MATSCHOULSKY, S.N.(1939): On a new coccidium from camels, *Eimeria dromedarii* n. sp. J.Roy. Micr. Soc., 59, 26 - 29.

YAKIMOFF , W.L., and S.N. MATSCHOULSKY, S.N. (1940): Die Kokzidien der Gemse . Schweiz . Arch Tierrheilk., 82, 16 - 18.

YAKIMOFF , W.L., and E.F. RASTEGAIEFF (1930): Zur Frage über Coccidien der Ziegen. Arch . Protistenk ., 70, 185 - 191.

Address of authors: Dr. S. K. C h a u d h u r i

Zoological Gardens Alipore

Calcutta 700 027, India

DIAGNOSIS OF TUBERCULOSIS IN HOOFSTOCK

Susan M. Stehman, MS, VMD*, Christine Rossiter, MS, VMD, and Donald H. Lein, DVM, PhD
Diagnostic Laboratory, College of Veterinary Medicine, Cornell University, Ithaca, NY 14853-2801 USA

Tuberculosis in captive, exotic and native hoofstock is most frequently caused by *Mycobacterium bovis* and occasionally by *M. tuberculosis.*[20] For public health and regulatory reasons, infections caused by the agents listed above must be differentiated from infections caused by other mycobacterial species, such as *M. avium* and *M. paratuberculosis*, which are also isolated with some frequency from ungulates in zoos.[20]

Most mycobacterial species cause granulomatous lesions which cannot be differentiated grossly or by histopathology. Thus, the definitive diagnosis of tuberculosis still relies upon the isolation and identification of *M. bovis* in tissues of affected animals. Surveillance, which is the basis of the current federal TB Eradication Program, is a powerful method to monitor tuberculosis, and should include complete necropsy of all animals that die and culture of a representative sample of lymph nodes from all regions of the body.[4] Sampling of widely distributed nodes may be important in the detection of other mycobacterial species and thus differentiation from possible *M. bovis* infection.

Antemortem tests such as the tuberculin skin test (ST), the enzyme linked immunoassay (ELISA) and the lymphocyte stimulation test (LST) have been used as supplementary tests, but the results must be interpreted with caution due to the diversity of tests used and lack of validation in most zoo ungulate species. For example, currently over 12 protein antigens,[7] plus numerous polysaccharide and cell wall antigens, have been described and used in ELISA with varying serologic reactivities within both infected and uninfected individuals. To validate the accuracy of tests in individuals requires that test systems and protocols be standardized within a species, then evaluated in the species in known infected and uninfected individuals. True infection status must be determined by confirmatory culture of a comprehensive set of samples obtained at necropsy, or possibly by antemortem biopsy of infected animals. A system established by the zoologic community for centralized reporting of results and serum banks would enhance efforts to validate and improve the utility of antemortem tests for tuberculosis in zoo ungulates.

The standard national and international test used to screen for tuberculosis in humans and animals is the tuberculin skin test (ST) which measures delayed-type hypersensitivity to a protein derivative (tuberculin) prepared from *M. bovis*, *M. avium*, or *M. tuberculosis.*[2,21] The site of injection varies with the species and can have an effect on test reaction. A survey of tuberculin skin testing techniques used at different zoos revealed substantial variability in the type of tuberculin used, frequency of testing and disposition of reactors.[14]

False positive skin tests (lack of specificity) have been reported due to infection with other mycobacterial species.[12] The comparative skin test (CST) increases the specificity of the ST by testing reactor animals with both *M. avium* and *M. bovis* PPD antigens and comparing the relative response but at the expense of a lowered sensitivity.[8] False negative skin tests (lack of sensitivity) have been reported in animals with disseminated or advanced tuberculosis.

The ELISA test has been used in camelids,[9,22] bovids[10] and captive reared cervids[19] for detection of antibodies to *M. bovis*. Skin test negative (anergic) animals with advanced, disseminated disease generally respond with higher ELISA values than animals with more localized infections.[10] Multiple test systems and antigens have been described, but standardization of test procedures is necessary for comparison of results within species. The use of highly purified antigens in both ELISA and skin tests shows potential for increasing specificity of tuberculosis diagnosis but at the cost of decreasing sensitivity.[4] Different interpretations of ELISA cutoff values may be necessary when applied to infected versus noninfected herds.[9] Researchers have reported an increase in ELISA values after skin testing in *M. bovis* infected domestic cattle,[10] captive reared deer[6] and llamas.[18] The response does not occur in uninfected controls. Thus, this combination of tests shows some promise in increasing the accuracy of the individual tests.

Cell mediated immunity to *M. bovis* infection develops earlier than humoral immunity. In an attempt to detect subclinically infected animals with greater accuracy than is provided by the ST, alternative tests of cell mediated immunity to *M. bovis* have been developed. The lymphocyte stimulation test (LST) has been used in New and Old World Camelids to detect *M. bovis* infection and to differentiate *M. bovis* from *M. avium* infection.[11] The LST test requires viable cells and suffers from large within test and between test variability making interpretation difficult.

In cattle, specific induction of gamma interferon in whole blood cell cultures exposed to PPD *M. bovis* correlates well with the LST,[24] and may be a more sensitive measure of the cell mediated immune response to *M. bovis* infection than the ST.[25] Preliminary studies of lymphokines produced in response to *M. bovis* infection have been reported in cervids[3] but not in other species.

Griffin *et al* reported increased sensitivity and specificity over ST tuberculosis testing in deer by using a combination of ELISA, LST, fibrinogen, plasma viscosity, differential white cell count, and hematologic values.[8] The use of multiple tests to measure both cellular and humoral immunity may improve accuracy of tuberculosis diagnosis in the herd, but requires further development and validation in each species. The standard in the individual animal remains culture and isolation of *M. bovis* from tissues, which is reliable across all species.

A gene amplification technique, termed polymerase chain reaction (PCR) has been widely used in diagnostic microbiology to amplify the DNA of infectious agents and enhance detection. The application of PCR to aid in the rapid diagnosis of *M. tuberculosis* and *M. bovis* has been also reported.[5,16] Cousins *et al* used primers derived from a *M. bovis* secretory protein, (MPB70), to amplify a 372 bp DNA fragment, and found the technique to be very sensitive and highly specific.[5] The primers used positively identified 84 strains of *M. bovis* tested and did not react with 24 other species of mycobacteria, or strains from other genera including *Rhodococcus equi*, *Nocardia asteroides*, *Actinomycoses bovis*, and *Actinobacillus lignieressi*. The technique was sensitive enough to detect a single viable cell in serially diluted samples. However, the primers used by Cousins *et al* were not capable of discriminating between *M. bovis* and other members of the *M. tuberculosis* complex. Plikaytis *et al.*,[16] using primers derived from both IS6110 and GroEL to amplify the DNA fragments, found it possible to differentiate *M. tuberculosis* and *M. bovis.*

PCR technology has been applied to clinical samples such as sputum[1,17] and lymph node biopsies[15] for human tuberculosis diagnosis. When compared to culture as the standard for diagnosis, PCR has been reported to be as sensitive[1] as or possibly more sensitive than culture[17] in detecting *M. tuberculosis* in sputum samples. Further refinement of PCR, and possibly immunohistochemistry, applied to various tissue preparations would provide critically valuable methods for differentiating *M. bovis* infection when histopathologic lesions are compatible, but growth or confirmation by culture is unsuccessful. DNA probes and PCR techniques have already been used to identify *M. avium spp.* and *M. paratuberculosis* in both humans[13] and domestic animals.[23,26] The technique has the advantages of high sensitivity and specificity, and, like culture, can be used across species. Application of DNA probes and PCR techniques to clinical samples collected by biopsy or tracheal washes, can be an aid in rapidly differentiating mycobacterial infections in animals identified by immunologic tests as possibly infected.

LITERATURE CITED

1. Altamirano, M., M. T. Kelly, A. Wong, *et al.* 1992. Characterization of a DNA Probe for detection of *Mycobacterium tuberculosis* complex in clinical samples by polymerase chain reaction. J. Clin. Microbiol. 30(8):2173-2176.
2. Angus, R. D., 1978. Tuberculins for use in animals. *In* Montali, R. J., ed. *Mycobacterial Infections in Zoo Animals*. Washington DC, Smithsonian Institution Press:109-114.
3. Buchan, G.S., D. J. Grimmett, J.F. Griffin. 1991 Cervine T-lymphocyte growth factors and their measurement in tuberculosis. Immunol Immunopathol. 29(1-2):115-26.
4. Corner, L. A., L. Melville, K. McCubbin, *et al.* 1990. Efficiency of inspection procedures for the detection of tuberculous lesions in cattle. Australian Vet. J. 67(11):389-392.
5. Cousins, D.V., S.D. Wilton, B.R. Francis. 1991. Use of DNA amplification for the rapid identification of *Mycobacterium bovis*. Vet. Microbiol. 27:187-195.
6. Cross, J. P., G. E. Reynolds, C. G. Mackintosh, and J. F. T. Griffin, 1991. Evaluation of relationship between plasma fibrinogen concentration and tuberculin testing in red deer. J. Am. Vet. Med. Asso. 198(10):1785-1788.
7. Fifis, T., Costopoulos, L. A. Corner, and P. R. Wood, 1992. Serological reactivity to *Mycobacterium bovis* protein antigens in cattle. Vet. Microbiol. 30:343-354.
8. Griffin, J.F, and J. P. Cross. 1989. Diagnosis of tuberculosis in New Zealand farmed deer: an evaluation of intradermal skin testing and laboratory techniques. Irish Vet. J. 42:101-107.
9. Haagsma, J., and A. Eger, 1990. ELISA for diagnosis of tuberculosis and chemotherapy in zoo and wild animals. *In* Proceedings of the annual meeting of the American Association of Zoo Veterinarians: 21-26 Oct. 1990, South Padre Island, Texas. American Association of Zoo Veterinarians, Philadelphia, PA: 99-102.
10. Harboe M, H.G. Wiker, J.R. Duncan, *et al.* 1990. S Protein G-based enzyme-linked immunosorbent assay for anti-MPB70 antibodies in bovine tuberculosis. J. Clin. Microbiol. 28(5):913-21.
11. Kennedy, S. and M. Bush, 1978. Lymphocyte transformation in Bactrian Camels. *In* Montali, R. J., ed. *Mycobacterial Infections in Zoo Animals*. Washington DC, Smithsonian Institution Press: 139-144.
12. Kollias, G. V., C. O. Thoen, M. E. Fowler, 1982. Evaluation of comparative cervical tuberculin skin testing in cervids naturally exposed to mycobacteria. J. Am. Vet. Med. Asso. 181(11):1257-1262.
13. McFadden, J., J. Collins, B. Beaman, *et al.* 1992. Mycobacteria in Crohn's disease: DNA probes identify the Wood pigeon strain of *Mycobacterium avium* and *Mycobacterium paratuberculosis* from human tissue. J. Clin. Microbio. 30(12):3070-3073.
14. Montali, R. J., and P. G. Hirschel, 1990. Survey of tuberculin testing practices at zoos. *In* Proceedings of the Annual Meeting of the American Association of Zoo Veterinarians: 21-26 Oct. 1990, South Padre Island, Texas. American Association of Zoo Veterinarians, Philadelphia, PA: 105-109.
15. Narita, M., M. Shibata, T. Togashi, H. Kobayashi. 1992. Polymerase chain reaction for detection of *Mycobacterium tuberculosis*. Acta Paediatr. Scand. 81(2): 141-144.
16. Plikaytis, B.B., K.D. Eisenach, J. T. Crawford and T. M. Shinnick. 1991. Differentiation of *Mycobacterium tuberculosis* and *Mycobacterium bovis* BCG by a polymerase chain reaction assay. Mol. Cell. Probes 5:215-219.
17. Sritharan, V., and R. Barker, 1991. A simple method for diagnosis of *M. tuberculosis* infection in clinical samples using PCR. Molecular and Cellular Probes 5: 385-395.
18. Stevens, J., 1992. Animal Diseases Research Institute, Agriculture Canada (personal communication).
19. Sutton, P.J., G.W. de Lisle, E.P. Wall. 1985. Serology of tuberculosis in red deer. Biology of deer production. Proceedings of an

international conference held at Dunedin, New Zealand, 13-18 February 1983 [edited by P.F. Fennessy and K.R. Drew]. pp. 155-158.

20. Thoen, C. O., W. D. Williams, and J. L. Jarnagin, 1977. Mycobacteria isolated from exotic animals. J. Am. Vet. Med. Asso. 170(9):987-990.

21. Thoen, C.O. 1990. Tuberculosis in captive wild animals: diagnosis and control. Proceedings 94th Ann. Meet. U.S. Animal Health Assoc. pp. 553-560.

22. Thoen, C.O., R.M.S. Temple, L.W. Johnson. 1988. An evaluation of certain diagnostic tests for detecting some immune responses in llamas exposed to *Mycobacterium bovis*. Proceedings 92nd Ann. Meet. U.S. Animal Health Assoc. pp. 524-533.

23. Thoresen, O. V., and F. Saxegaard, 1993. Comparative use of DNA probes for *Mycobacterium avium* and *Mycobacterium intracellulare* and serotyping for identification and characterization of animals isolates of the *M. avium* complex. Vet. Microbiol. 34:83-88.

24. Wood, P.R., L.A. Corner, and P. Plackett. 1990. Development of a simple, rapid in vitro cellular assay for bovine tuberculosis based on the production of gamma interferon. Research in Veterinary Science. 49(1): 46-49.

25. Wood, P.R., L. A. Corner, J. S. Rothel, *et al.* 1992. A field evaluation of serological and cellular diagnostic tests for bovine tuberculosis. Vet. Microbiol. 31:71-79.

26. Vary, P. H., PR Andersen, E. Green, *et al.* 1990. Use of highly specific DNA probes and polymerase chain reaction to detect *Mycobacterium paratuberculosis* in Johne's Disease. J. Clin. Microbiol. 28(5):933-937.

PREVENTIVE MEDICINE CONSIDERATIONS FOR INTERZOO ANIMAL MOVES

C. Douglas Page, DVM*
Jacksonville Zoological Park, 8605 Zoo Road, Jacksonville, Florida 32218, USA

Introduction

Presently there are 63 Species Survival Plans (SSP), the majority of which use veterinary advisors to assist in establishing protocols for those aspects of husbandry related to medical management. Examples of these include protocols for vaccination, anesthesia, necropsy, and other areas of preventive medicine. As more of these programs are established, veterinarians will be called upon to participate as advisors. Veterinarians must prompt this involvement by stepping forward and offering their expertise.

Paramount to the successful transfer of a healthy specimen to another zoo is the recognition of disease processes that may be occurring in the species. This requires the practice of sound diagnostic medicine integrated with other disciplines such as pathology, parasitology and nutrition. Once a disease process has been identified, an effective antemortem diagnostic tool needs to be established and incorporated into the health screen. This may present the greatest hurdle for those involved in assessing the health of an animal prior to its transfer.

Establishing a minimal health screen

As a minimum, the pre-shipment health screen should include the signalment (age, sex, origin, and genealogy) and anamnesis. The anamnesis should provide information on past disease problems, tests performed to survey for specific diseases, and husbandry practices. Additionally, a complete physical exam, including an intestinal and external parasite screen, should be performed. A complete blood count, evaluation of serum chemistries with serum banked, screening for hematozoans, and fecal cultures for enteric pathogens may also be necessary depending on the species involved.

For example, in the recommendations for the interzoo movement of elephants,[4] banked serum is forwarded to the receiving institution prior to the transfer of the animal. This enables the receiving zoo to perform additional tests if necessary, and to conduct future epidemiology studies should disease occur following the transfer. Additionally, three negative fecal cultures are required prior to shipment of an elephant due to the occurrence of salmonellosis in these species.

Vaccination protocols and parasite prevention, or control programs, have been established for some of the SSP species. The appropriate husbandry manual should be consulted so the most effective method of prophylaxis or treatment can be instituted. Prior to shipment, communication with the receiving institution regarding tests or procedures requested may expand the list of the pre-shipment health screen.

Specific health screening

Additional tests will be required for those species where specific disease processes have been identified, and methods of surveillance are available. By consulting the literature and/or the husbandry manuals, the appropriate testing procedures can be employed. The following are examples of specific disease concerns for various species.

Atoxoplasmosis has been identified as a cause of fledgling mortality in the Bali mynah, *Leucospar rothschildi*. Research is being conducted to evaluate means of treatment and control of this organism.[2] The potentially devastating effects of this parasite are realized for the captive population, and for those specimens utilized in the reintroduction program.

The maned wolf, *Chrysocyon brachyurus*, is plagued with cystinuria. Diagnosis can be achieved with a complete urinalysis, cyanide nitroprusside test, radiography and ultrasound[3]. Specific treatment with the disulfide exchanging drug, thiola, and urinary alkinalizing agents is promising. Protocols have also been established for vaccination, parasite prevention and necropsy of this species.

The ophidian paramyxovirus is a threat to the captive population of Aruba Island rattlesnakes, *Crotalus unicolor*. A recent epizootic in a zoo killed 4 of these snakes and affected 24 other species.[1] Hemagglutination inhibition (HI) has been used to detect antibody titers to this virus. The presence of antibody suggests recent exposure, but does not confirm active infection. Ongoing research is directed towards prevention and serologic diagnosis of this disease.

Problem areas

As mentioned earlier, the actual monitoring and surveillance of disease in captive animals can present problems. Diagnostic tests may be unavailable, or the results of the test may be equivocal. Some of these problem areas are considered below.

The accurate diagnosis of tuberculosis continues to evade the zoo veterinarian. Additionally, pre-shipment surveillance of an animal for this disease may well result in more questions than answers. This is true in elephants, hoofstock, many species of primates, marsupials, and avian species, to name a few.

The intradermal skin test for TB is known to produce false positive reactions in certain species such as orangutans and Asian elephants. One of the problems we face with this diagnostic test is the lack of standardization in its application. Before we can determine the validity of a test, we must first eliminate the variables that exist. For example, for a given species, we must all use the same site for injection, and the same dose and strength of test antigen. After we have standardized the test, we must then develop a means to substantiate the results. The search for the latter has superseded the former, thus leading us to investigate ELISA tests, lymphocyte transformation, and DNA probes in an effort to identify TB positive animals.

In avian species, perhaps the most legitimate screen for TB involves a CBC, radiographs and a liver biopsy on the specimen(s) in question. Additionally, and not unlike *Mycobacterium paratuberculosis* in hoofstock, the history of the incidence of TB in the flock over the past 5 years is a good indicator of a specimen's TB status prior to its shipment. This last item exemplifies the need for accurate standardized record keeping, and a thorough anamnesis as part of a pre-shipment health screen.

For other diseases, another problem we face is interpreting the results of a true positive test, and applying the results to captive management and interzoo transfers. Specific examples involve the hoofstock with an antibody titer to malignant catarrhal fever (MCF), and the felid that tests positive for feline immunodeficiency virus (FIV). What do these results mean, and how do we use them to effectively manage a species? Does the positive test correlate with clinical disease, or the potential thereof? The extrapolation of disease surveillance data from one species to a closely related species can be an effective tool, however, we must be cautious in our interpretations of the test results for that species. Certain tests may be too sensitive for our needs, and may be as detrimental to a captive breeding program as is the lack of an effective test for the surveillance of a specific disease.

Conclusions

The successful transfer of a healthy specimen from one zoo to another requires communication and cooperation between the two institutions. Disease processes must be identified, and tests for surveillance of the disease must be established and utilized. An interdisciplinary approach to problem solving is required if we are to continue to improve upon existing, and develop new, aspects of preventive medicine for the many species within zoos. A commitment to actively participate in SSP programs, and to collaborate on research efforts with colleagues is critical to the advancement of the veterinarian's role in conservation programs.

LITERATURE CITED

1. Jacobson, E.R., J.M. Gaskin, S. Wells, *et al.* 1992. Epizootic of ophidian paramyxovirus in a zoological collection: Pathological, microbiological, and serological findings. J. Zoo Wildl. Med. 23: 318-327.

2. Norton, T.M. 1992. Protocol for evaluation of a therapeutic regimen to combat atoxoplasmosis in the Bali mynah, *Leucospar rothschildi*. Unpublished.

3. Norton, T.M. 1990. Medical management of maned wolves, (*Chrysocyon brachyurus*). Proc. Am. Assoc. Zoo Vet. Pp.61-63.

4. Page, C.D. 1988. Recommended protocol for health screening elephants. Proc. 9th Ann. Elephant Workshop. Pp.26-30.

Goals of captive propagation programmes for the conservation of endangered species

U. S. SEAL
VA Medical Center, Minneapolis, Minnesota 55417, USA

Interest by the conservation community in the use of captive propagation for the conservation of endangered species of vertebrates has increased during the past five years (Conway, 1980; Soulé & Wilcox, 1980; Frankel & Soulé, 1981; Schonewald-Cox *et al.*, 1983). Wild populations are under severe pressures. Conservation measures are providing temporary relief, but many populations are becoming so diminished and fragmented that they are not viable for two to ten generations much less on an evolutionary time scale. The survival of the Amur/Siberian tiger *Panthera tigris altaica*, the European bison *Bison bonasus*, the Sumatran rhinoceros *Dicerorhinus sumatrensis*, and many others will depend upon captive populations and propagation programmes.

Organised collaborative captive breeding programmes sponsored by professional zoo organisations are developing in North America (Foose, 1983) and the United Kingdom. Others organised around particular species are developing in Europe and Australia. A series of propagation plans, meetings on population genetics of small populations, and workshops on the application of these principles to the practical problems of a captive population have begun to delineate agreement on the scientific fundamentals for the development of workable species survival plans.

The clear and explicit definition of the goals of a captive propagation programme in the conservation of a species is the first task in every case. It is the single most important policy decision to be made and it will influence every aspect of the work. Confusion over goals will be detrimental to the efficient long-term captive propagation of the species and ultimately, therefore, to its survival. The options range from maintenance of stock suitable for wild habitat stocking and reintroduction to production of zoo-adapted 'domesticated' species.

The goal of a programme designed to maintain stock suitable for return to wild habitats may be stated as 'maintenance of the maximum amount of genetic diversity available in the founder stock that has evolved in the wild populations' (Flesness, 1977; Foose, 1983). The captive and wild populations must be managed to provide an effective population size which is sufficient to allow maintenance of a specified amount of genetic diversity for the planned duration of the programme (Denniston, 1978; Franklin, 1980; Senner, 1980), together with sufficient

SECTION - III

PLANNED BREEDING

numbers of animals within the appropriate sex and age distributions to protect against loss due to demographic fluctuations (Foose, 1980; Goodman, 1980).

Calculation of the rates of loss of genetic diversity, generation by generation, for any given set of starting conditions can be made rather easily. However, the time scale of a captive propagation programme has rarely been a definite part of policy for development of the detailed plan. The decision on the time scale of the programme and the allowable rates of loss of genetic diversity will determine the population size (N) that must be maintained to achieve these goals.

This policy implies a criterion for termination of a programme based upon the secure existence of wild populations of the taxon of such size as to allow long-term survival and for evolution by natural selection of the taxon.

How are such goals to be defined and achieved?

Two biological problems must be confronted if we are to develop captive breeding programmes for preservation of endangered species.

1. The first is an assessment of priorities for selection of taxa and allocation of resources to the taxa in greatest need of sanctuary in zoo-based captive breeding programmes. The captive habitat – our ark – is limited. The criteria for selection include: the animals' rarity in the wild, their taxonomic uniqueness, and their fitness for captivity. The development of criteria that can be used for quantitative evaluation of candidates for captive propagation that is being undertaken by the IUCN Captive Breeding Specialist Group and other organisations using information from the IUCN *Red data books* and ongoing field studies.

2. The second important consideration is the management of the captive collections as biological populations. A necessary beginning is the determination of our captive carrying capacity. The components of carrying capacity include logistic, conservation and genetic criteria. The logistic criterion perhaps places an upper limit on the 'mega' of the charismatic 'megavertebrates' since the Blue

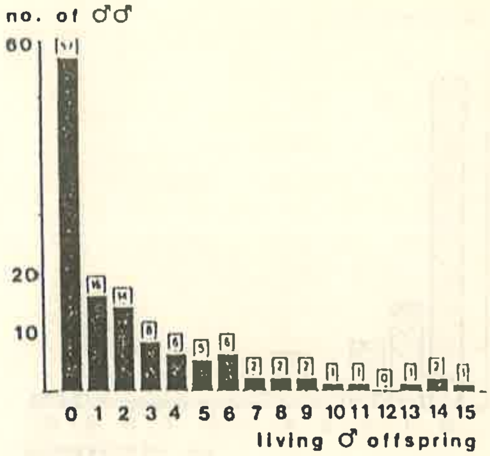


Fig. 1. Variation in number of living ♂ Siberian tiger *Panthera tigris altaica* offspring born before 1974 from ♂ parents. Only ♂♂ aged eight years and over were considered for tabulation in the zero offspring category.

whale *Balaenoptera musculus* is not yet on exhibit. The conservation interest appears to be an attempt to conserve as many species as possible within, as yet, undefined limits. A crucial aspect of carrying capacity is the minimum number of animals of a species necessary to meet our propagation objectives. A key concept is 'effective population size' (N_e), a measure of that proportion of the census population which is contributing to the next generation.

Factors affecting the effective population size are (1) the number of ♂♂ and ♀♀ that reproduce, (2) the sex ratio of the breeding animals, and (3) the variance in the life-time family size of the reproducing animals. The most critical factor in most zoo populations is variance in family size. Examples of severe variation in family size are available from the studbooks for the Tiger *Panthera tigris* ssp and the Gorilla *Gorilla gorilla* (Seifert & Müller, 1983; Kirchshofer, 1982). Among the tigers there have been many ♂♂ which have sired no offspring and of the remainder only a few with many surviving young (Fig. 1); the picture for ♀♀ is similar but not quite as extreme. The result is that this species is being managed at about 30% of the possible genetic efficiency. This means that much of the space used to house Siberian tigers is

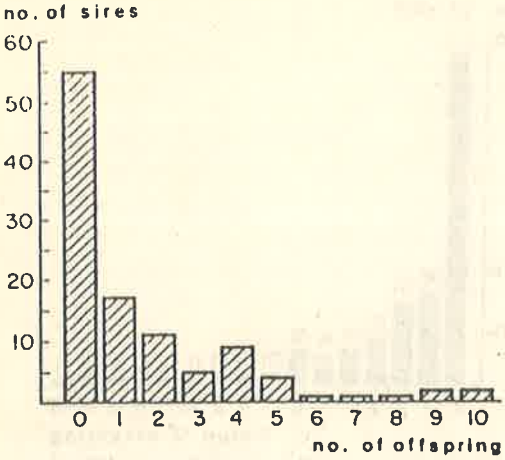


Fig. 2. Variation in number of Gorilla *Gorilla gorilla* offspring of both sexes from ♂ parents. Only ♂♂ aged ten years and over were considered for tabulation in the zero offspring category.

being wasted from a conservation point of view. A similar disparity in family sizes has occurred in the Western lowland gorilla *G. g. gorilla* although for different reasons. The result, however, is the same in terms of the management of genetic diversity. Thus of the ♂ gorillas in North America 53 have sired 173 offspring with seven ♂♂ responsible for 59 of the births (Fig. 2), and 55 ♂♂ have never produced offspring. The family size of ♀ gorillas is less skewed, although 12 ♀♀ have produced 60 births and 53 ♀♀ have not produced offspring.

What are some of the reasons and consequences of these unequal family sizes? As the *International tiger studbook* records (Seifert & Müller, 1976–1983), the number of living Siberian tigers in zoos has increased to about 1200 animals. Nearly all of these are captive born and most of the wild-caught animals are in the USSR. The number of potential founders or wild-caught animals is more than 60. However, the distribution of founder representation in the living tiger population shows that six animals have contributed about 70% of the genes (Seal, 1984). This means that much of the original genetic diversity is either lost or very poorly represented. One consequence has been a

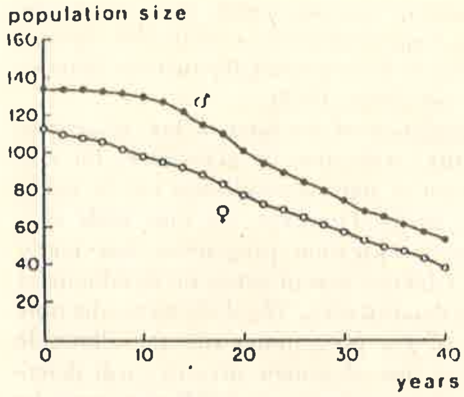


Fig. 3. Demographic projections for the Gorilla population in North America based on mortality and fecundity figures derived from this group with particular emphasis on its most recent five years.

relatively high level of inbreeding in the population dating from 1965.

The gorillas present a different picture. Demographic analysis of data from the studbook (Kirchshofer, 1982) and from ISIS for more recent years, indicates that gorillas are in serious trouble in North America with a forecast of a declining population (Fig. 3). Why? The population age and sex structure shows a steady recruitment of captive-born young into the population but not in sufficient numbers to match the projected losses. The population includes a number of gorillas older than 20 years. Examination of the age distribution of sires makes it evident that most of the production is by younger animals and that few young have been produced by animals older than 20 years. The picture has been strikingly similar for ♀♀ with few animals older than 20 years giving birth. If we plot the age distribution of those individuals that have never produced young and look at that portion in the mature age groups we find that many of the older gorillas have been totally non-productive (Fig. 4). The effective population size is smaller than the census population and a reproductive failure of both sexes appears to be a major factor.

A second determinant of the size of populations that must be maintained is 'for how long do we plan to preserve the species by captive propagation?' We can calculate the

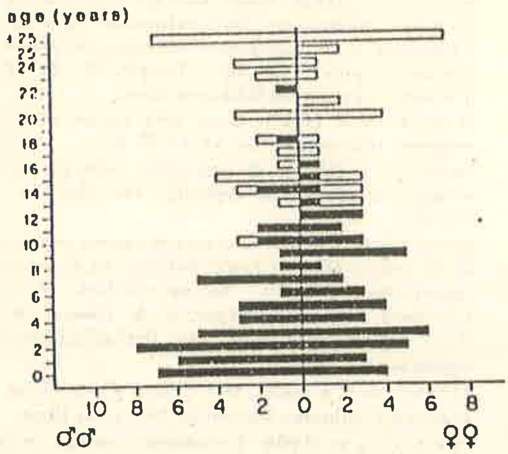


Fig. 4. Age structure of living non-reproductive ♂ and ♀ Gorillas in North America based on the international studbook (Kirchshofer, 1982), ISIS figures and a current survey of institutions. The captive-born proportion is indicated by black bars, and the wild-born proportion by unshaded bars.

decline of genetic diversity for different N_e over many generations. The number of years, the number of founders, and the size of the stable population chosen as an objective for the programme will determine the number of generations and the rate of decline. Thus, if we choose to plan for 200 years then the number of elephant generations may be only eight or nine whereas for tigers it may be about 40 and for mice 300 to 400 generations. If we set a criterion of maintaining 90% of the available genetic diversity in the population from the time it reaches the effective population size, then the population size required for tigers may be 180 to 200, for elephants about 25 to 50, and for mice perhaps 1300+.

These results indicate that efficient genetic management can increase the number of taxa that can be propagated in zoos for conservation. International collaborative programmes can further increase the number of species that can be propagated. Indeed if full use were made of available resources, perhaps all of the endangered species of megavertebrates could be maintained.

Another early step is the estimation of the amount of captive habitat available. Estimates for North American zoos have been constructed from ISIS data and are being constructed for the world's zoos with the data from the *International zoo yearbook*. By way of example, at one time approximately 82% of 32 000 mammal specimens in ISIS were primates, ungulates, or carnivores. Of the 5600 carnivores about 51% (3880) were felids and 60% (1750) of these were big cats. If we further examine the last figure we find that nearly half of the available living spaces were occupied by some 450 tigers and 380 lions. There are 82 extant named subspecies of the big cats and 45 of these are listed in the *Red data book*. Thus if we choose to maintain an effective population size of 100 animals we might maintain 18 forms in these same zoo spaces whereas only seven forms can be propagated if we require an effective population size of 250. The problem is more severe if we cannot manage with the effective population (N_e) size about equal to the census population (N), an objective number which has not been accomplished very often with traditional management procedures.

The tigers provide an example of the complex dilemma faced by captive breeding for conservation (Seal & Foose, 1984). There are eight named forms of the tiger. Should all of these forms be maintained in captive populations? How many? Which ones? A mixture? How to choose? When to choose? North American zoos currently maintain about 500 tigers with half *P. t. altaica*, about 40% *P. t. tigris*, a few *P. t. sumatrae* and *P. t. corbetti*, and the remainder of unknown or mixed ancestry.

The subspecies problem will become increasingly serious as each new request for captive breeding for conservation is examined. It will require additional research and the use of available techniques including chromosomal analyses, molecular studies (Ryder *et al.*, 1981, see also this volume; O'Brian *et al.*, 1983), and careful genetic analysis of pedigree information seeking evidence for inbreeding and heritability effects on components of fitness (Ralls *et al.*, 1979; Templeton & Read, 1984).

All of these analyses and programmes depend on the consistent collection and reporting of data. The correct kinds of data are essential (Seal & Flesness, 1979); essential elements for genetic and demographic analysis, and for management are (1) birth date, (2) death date, (3) sex, and (4) parentage (including parents' age at birth of offspring). This requires identification of individuals. The main collective sources of these data are the international studbooks and ISIS.

All management programmes are going to require the continued development of the international studbooks including the use of available technology for collection, distribution and analysis of the data that are necessary for scientific captive population management. Given the current projections for the rate of loss of habitat through expansion of human populations one can predict that by the year 2000, zoos will be almost entirely dependent upon captive breeding to supply their exhibit animals and that most captive species will need to be carefully managed. This implies the need for about 500 studbook-like programmes: overwhelming perhaps, but possible.

Indeed, if we agree that the preservation of genetic diversity (IUCN, 1980) is our unique responsibility to our children's children, then we will need to spend the time necessary to work through the practical problems until our friends, the reproductive biologists, can provide us with a full zoo in the freezer, and the surrogates to produce new specimens at that time in the future when reintroductions will be possible. It is the intention of the Captive Breeding Specialist Group of the IUCN/SSC to provide an international forum for the development of collaborative plans for captive propagation programmes designed for species survival.

Not to act is to act. The necessity for action always presents the possibility of unpleasant alternatives but it is possible to construct a safe-to-fail strategy which allows the opportunity for many trials and failures. The rewards are for us, our children and grandchildren.

REFERENCES

CONWAY, W. G. (1980): Where we go from here. *Int. Zoo Yb.* 20: 184–189.

DENNISTON, C. (1978): Small population size and genetic diversity: implications for endangered species. In *Endangered birds: management techniques for preserving threatened species*: 281–289. Temple, S. A. (Ed.). Madison: University of Wisconsin Press.

FLESNESS, N. R. (1977): Gene pool conservation and computer analysis. *Int. Zoo Yb.* 17: 77–81.

FOOSE, T. J. (1980): Demographic management of endangered species in captivity. *Int. Zoo Yb.* 20: 154–166.

FOOSE, T. J. (1983): The relevance of captive populations to the conservation of biotic diversity. In *Genetics and conservation*: 374–401. Schonewald-Cox, C. M., Chambers, S. M., MacBryde, B. & Thomas, W. L. (Eds). Menlo Park, CA: The Benjamin/Cummings Publishing Co. Inc.

FRANKEL, O. H. & SOULÉ, M. E. (1981): *Conservation and evolution*. Cambridge: Cambridge University Press.

FRANKLIN, I. R. (1980): Evolutionary change in small populations. In *Conservation biology*: 135–149. Soulé, M. E. & Wilcox, B. A. (Eds). Sunderland, MA: Sinauer Associates.

GOODMAN, D. (1980): Demographic intervention for closely managed populations. In *Conservation biology*: 171–195. Soulé, M. E. & Wilcox, B. A. (Eds). Sunderland, MA: Sinauer Associates.

IUCN (1980): *World conservation strategy*. Gland: International Union for the Conservation of Nature and Natural Resources/United Nations Environmental Program/World Wildlife Fund.

KIRCHSHOFER, R. (1982): *International studbook of the gorilla* Gorilla gorilla (*Savage and Wyman, 1847*). 3. Frankfurt: Frankfurt Zoological Gardens.

O'BRIAN, S. J., WILDT, D. E., GOLDMAN, D., MERRIL, C. R. & BUSH, M. (1983): The cheetah is depauperate in genetic variation. *Science, Wash.* 221: 459–462.

RALLS, K., BRUGGER, K. & BALLOU, J. (1979): Inbreeding and juvenile mortality in small populations of ungulates. *Science, Wash.* 206: 1101–1103.

RYDER, O. A., BRISBIN, P. C., BOWLING, A. T. & WEDEMEYER, E. A. (1981): Monitoring genetic variation in endangered species. In *Evolution today: Proceedings of the second international congress of systematic and evolutionary biology*: 417–424. Scudder, G. G. E. & Reveal, J. L. (Eds). Pittsburgh, PA: Hunts Institute for Botanical Documentation, Carnegie-Mellon University.

SCHONEWALD-COX, C., CHAMBERS, S. M., MACBRYDE, B. & THOMAS, W. L. (Eds) (1983): *Genetics and conservation: a reference for managing wild animal and plant populations*. Menlo Park, CA: The Benjamin/Cummings Publishing Co. Inc.

SEAL, U. S. (1984): An analysis of the demography and genetics of captive Amur tigers and a preliminary captive propagation plan (*Panthera tigris altaica*). In *Internationales Tigerzuchtbuch 1984*: 5–18. Seifert, S. & Müller, P. (Eds). Leipzig: Zoologischer Garten Leipzig.

SEAL, U. S. & FLESNESS, N. R. (1979): Noah's ark — sex and survival. *Proc. AAZPA Conf.* 1978: 214–228.

SEAL, U. S. & FOOSE, T. J. (1984): Siberian tiger species survival plan: a strategy for survival. *J. Minn. Acad. Sci.* 49: 3–9.

SEIFERT, S. & MÜLLER, P. (1976–1983): *Internationales Tigerzuchtbuch 1976–1983*. Leipzig: Zoologischer Garten Leipzig.

SENNER, J. (1980): Inbreeding depression and the survival of zoo populations. In *Conservation biology*: 209–224. Soulé, M. E. & Wilcox, B. A. (Eds). Sunderland, MA: Sinauer Associates.

SOULÉ, M. E. & WILCOX, B. A. (Eds) (1980): *Conservation biology: an evolutionary-ecological perspective*. Sunderland, MA: Sinauer Associates.

TEMPLETON, A. R. & READ, B. (1984): Factors eliminating inbreeding depression in a captive herd of Speke's gazelle (*Gazella spekei*). *Zoo Biol.* 3: 177–199.

CONSERVATION OF WILD ANIMALS UNDER CONTROLLED CONDITIONS

By Pushp Kumar, Principle Chief Conservator, Forest Department of Andhra Pradesh

Summary

Man in his interaction with nature has used Wild Animals to meet his requirements of domestication. For this he has kept and bred animals over the ages. The history of ex-situ conservation is traced. The conservation by captive propagation has been examined and its role in different forms enunciated. The factors leading to the depletion of Wild populations are enunciated and the need for taking up breeding of wild animals stressed as a tool of conservation.

Introduction

Ever since the dawn of life, humankind has always strained to modify and alter the environment around it. It continues to do so still. Initially it was for sheer survival against odds, thereafter for requirements of food, shelter from the elements from enemy forces. Other creatures in his environment were both enemies as well as a source of food and other necessities. Man was the prey to these predators, from whom he sought shelter in various ways. Later he must have by chance learnt the value of the creatures around him as a source of food, covering, tools and artifacts etc. It is during this period that the capture and taming of animals could have started as a chance happening. This process would have hastened the alteration of the enviroment as with the help of some of them he learnt to till the land, and in the process of doing so cleared vast tracts of forested land and grass lands.

The process of control of animals had thus begun. The slow process of domestication continued through the paleolithic or old stoneage to the neolithic to the iron-age, especially of such animals like the wild Goats, Sheep, Bovines etc. The concept of a pastoral life and settled cultivation arose as against nomadic or shifting cultivation as we have come to know in modern times. Human settlements grew and the process of domestication of more species progressed. Soon the idea of taming more species grew. It gave rise to the concept of producing desired attributes like better, bigger, tougher, tamer varieties of the species to suit the requirements of the day, which could be evolved through breeding. The process not only changed the end use but brought myriad changes in the wild species itself.

For example in the number of breeds the wild canines have given raise to, today not only the size and color have changed but even the shape of some varieties has undergone alterations. The resemblance to its possible ancestor the Indian Wolf *(Canis lupus pallipes)* is all but lost. Thus it could be said that present day pets like Dogs and Cats are the carefully bred descendants of the wild canines and felids which man first captured initially by chance and subsequently by design and learnt to tame and later on to breed under controlled conditions. The same could be said of other species found by man to be useful like the Cattle, Equids, gallinaceous birds etc. each required by him for a different purpose.

Thus the process of keeping animals useful to man has evolved over the years with selective and controlled breeding to obtain desired characteristics This process could be simply shown as:

1. Capture either incidential or desired.
2. Training to perform desired simple acts.
3. Taming making the animal docile
4. Domestication making animals dependent on man & Viceversa.

The keeping of wild animals at a stage short of domestication can be said to have started in pre-historic times, perhaps the neolithic age. It could have been for altruistic or religious purposes. However the first recorded instance of keeping of animals is in 1150 B. C. of a Chinese Emperor keeping animals in "Intelligence Parks". In India in the Moghal period records are available of the Emperor Jehangir keeping animals in captivity. However the first organised collection of animals was in 1793 in Paris. The first systematic collection of a Zoo, as we know it today was established at Schonbrunn, Austria. In the 19th century a number of Zoological Parks were set up notably at London (1829), Berlin (1844) etc. This coincided with the Industrial Revolution and at the same time the rousing of interest in Zoological specimens from round the world which were obtained from the colonies and housed in menageries. In India too, this interest resulted in the setting up a number of collections starting with, Madras (1850), Trivandrum (1857), Bombay (1863), Calcutta, Jaipur and Udaipur and so on. In this period the spread of Forests and the occurance of wild animals was comparatively abundant. The collection of a few specimens did not pose any serious threat to the wild animal population.

With the setting in of the Industrial age and consequent development in the world, the colonial powers bid to exploit the natural resources of the colonies resulting in the depletion of forests and wild animal resources. This process was accelerated in India with the advent of Independence. The Government during the period of Jawaharlal Nehru's Premiership laid great stress on the protection of the flora and fauna. However the rapid rise in population put pressures on the forests which continues even today.

It is estimated that during the period 1951-52 to 1980-81, natural forests were lost at the rate of 1.5 million ha. per annum as per estimates of the National Wasteland Development Board. The reconciled figures for the extent of natural forests are now accepted to be about 19.52% of the total geographical area as per the Forest Survey of India and the Natural Remote Sensing Agency. With the loss of this habitat many wild animals populations were lost. It is not known whether any species or rare-species of animals were also lost. Again in the natural forests, even if there has been no loss as changes that occured were (1) Fragmentation of the habitat leading to honey-combing of the forest into a chequered pattern. Isolation of small populations may have resulted in their genetic non-viability (b) Denudation or degradation of the natural forests even after the advent of the forest Conservation Act (1980) which puts restrictions on diversion of forest lands for non-forest pursoses, poses yet another threat to the wild animal populations due to change in habitat and its composition. (c) Conservation of forest or vegetal cover outside the forest ecosystem has also adversely affected Wild animal populations.

It is not only the Forest Ecosystem that is under threat. Other equally important habitats like grasslands, wetlands and aquatic ecosystems which hold a variety of wild animal populations are also under threat of conversion, diversion or over exploitation.

The factors enumerated above were sought to be mitigated if not altogether halted with the enactment of the Wildlife Protection Act in 1972. Schedule I of the Act listed the threatened and endangered species which required complete protection. These listed 46 mammals, 12 Birds and 17 Reptiles, a total of 75 species.

A commendable progress has been made in setting up a system of protected areas. As many as 58 National Parks and 368 Sanctuaries have already been set up in the country covering diverse eco-systems and encompassing many Wild animal species. In 1980 there were 19 National Parks and 205 Sanctuaries. Many of these are under pressure e. g. Bharatpur, Bandipur, Ranthambore to cite a few. The pressures may be for use for timber, fuel or grazing. There have been cases of outbreak of epidemics in these areas wherein large populations of ungulate species like Gaur *(Bos gaurus)* Cheetal *(Axis axis)* and Nilgai *(Boselaphus tragocamelus)* have been affected. Data on other species is in most cases lacking. Adaption of prophylactic measures very often is not feasible. Protected areas at best like oasis in "ecological deserts".

The list of species included in Schedule I of the Wildlife Protection Act 1972 had grown during the 17 years since it's passage to 66 Mammals 47 Birds, 22 Reptile i. e., a total of 130 species. More are being proposed for inclusion.

Captive or controlled Breeding

In the above scenario it is necessary that if the sustained existence of the endangered species is desired, viable supplemental efforts once have to be made. One of the most viable of such efforts is that of captive breeding especially of threatened and endangered species.

The National Wildlife Action Plan released in 1983 by Smt. Indira Gandhi includes among others, steps for conservation of endangered species. It also for the first time recognised the role that Zoological Parks could and should play in the conservation of wild animals, by allocating assistance for selected projects.

Captive breeding is carried out in different ways. These could be listed-out as follows:

i) *Keeping Pets:* Many people in the world especially the developed countries keep as pets wild animals which include Lions, Boa constrictors, Pythons and others, and a variety of birds to mention a few. Many try to create conditions in which the pet breeds. Bird fanciers especially are well conversant with the genetic possibilities and the need or maintaining pure lines. They also succeed in breeding different varieties of the species, which may not be of conservation value except for engendering a love for animals in general in the owner.

ii) *Private Collections:* These are collections of animals kept by private collectors and not usually open to the public. Such a collection was that of Mullick in Calcutta where a number of endangered species were not only kept successfully but were bred regularly. Some bird fanciers and breeders keep such collections not only for their own use but also for exchange with or supply to other similar collections. In such cases the accent is on breeding and maintaining pure lines of the breed.

iii) *Deer Parks:* A number of deer parks which are of a fairly large size have been set up. The Mrugavani near Hyderabad extends over an area of 700 Acres. In such parks usually only those species which were formerly found in and around the area are kept or released. However, due to reasons of security the area is usually completely fenced. Such areas whose habitat is carefully managed to see that it is as near to the original habitat as possible, give great scope for not only breeding the species found in that area formerly, but also provide a source for conservation education. A herd of 15 Blackbucks from Hyderabad Zoo released in Vanasthali Deer Park extending over 200 acres in 1975, increased to over 200 by 1985.

iv) *Zoological Parks:* By far Zoological Parks have come to epitomise the concept of "captive animals", for various historical reasons. As already mentioned, earlier they were set up for keeping of and display of a variety of animals at a time when neither the habitat nor the wild animal populations themselves were under pressure. With the change in scenario as outlined above, Zoos came to be looked upon with a little more respect. The Indian Board for Wildlife itself in 1952 recommended setting up of modern Zoological parks in major cities as a method of educating people about wild animals and their conservation.

Though the Zoo movement in India was as old as century, it has not made much progress as far as scientific management is concerned. The Government of India set up an Expert Committee in 1972 to examine and make suggestions for improving management of Zoos in India. Besides making a number of recommendations in its report it also defined the role that Zoos should play. The foremost was conservation, then education and research.

The role that Zoos can and should play is that of conservation. It requires to be restated again. This can be achieved in the following ways.

1. *Breeding of Endangered Species:—* Two types of this activity are important.

a) As survival centres for species facing threat of extinction in their native habitats. Classic cases that could be cited are those of Pere David's Deer of China, Prezewalskis Horse of Mongolia and Central Asia, Arabian Oryx of Hawaii etc. whose native populations in the wild had become extinct. However, a few specimens were taken earlier and kept in some zoos in Europe and U.S.A. The carefully captive bred populations had grown in size and a reintroduction programme was drawn up. By this way eventually the Nene Goose and Arabian Oryx were reintroduced into their former habitat.

b) As repositories of Endangered species for breeding and eventual reintroduction into the wild. The example of the Sangai or Brow-Antlered Deer of Manipur would be appropriate here. Population counts of the Sangai in their native habitat i. e. Keibul Lamjao in Manipur put the total population at less than 50. The area is under threat from the local population making the future of the Sangai questionable. However, in 13 Zoos in India 93 specimens of the Sangai have been raised as of present. A careful programme to further breed this extremely rare and threatened species could be worked out. Proposals have also been formulated for its reintroduction in a similar habitat. However, in such a case the need for avoiding the disadvantages of captive breeding have to be kept in mind and the area of release carefully selected. Mention may also be made here of the release of captive reared muggers from Hyderabad Zoo into Nagarjunasagar-Srisailam Sanctuary. The Crocodiles not only adapted well but eventually bred in the area of release. Breeding species for eventual restocking in the depleted areas in the wild. In this category would come many of the ungulates and gallinaceous Birds.

It can be seen from the International Zoo year Book that Indian Zoos have also bred a number of endangered species of animals. However, these successes were sporadic and not on a sustained basis. This situation is to be corrected by drawing careful programmes species wise for each Zoological Park and monitoring the results.

2. *Conservation Education:* Zoological Parks located as they are in or near major cities and towns attract a number of visitors, many of them who are not in a position to visit a National Park or a Sanctuary. The only introduction to live wild animals for a vast majority is through a Zoological Park. An idea of the visitation could be had from the fact that the 58 National Parks and 368 Sanctuaries in India are visited annually by less than 2,00,000 visitors. Compared to this in the about 100 Zoos and Mini Zoos now (the Expert's Committee had listed 44 Zoos) were visited annually by nearly 20 million visitors or more. In the case of National Parks and Sanctuaries mostly the well-to-do who can afford the cost of travel etc. visit whereas in the case of Zoological Parks, the proportion of the less fortunate citizen is sizeable. It is this citizen in whom the need for conserving the country's natural heritage has to be built up.

At present Zoological Parks with a few exceptions do not use this opportunity of having a "Captive" audience to achieve the goals of conservation. This could be done by a number of measures like (a) better housing and display of animals e. g. by eliminating bars, by planting up the animal area in a natural way etc. (b) better and effective signage e. g. replacing mere labels with attractive signage which informs the visitor regarding the ecological role of the species etc. (c) providing extension services through well-informed guides and volunteers.

These measures would go a long way towards creating sympathy for the wild animals seen by the visitors. Without this vital factor it would be difficult to carry the message of conservation convincingly to the people.

This potent tool of conservation has not been made use of adequately by both the Wildlife authorities (due perhaps to a puritanical approach) as well as by the Zoos themselves. It deserves to be re-evaluated, re-vamped and re-used to advance the cause of conservation of our natural resources more effectively.

The earlier draft Zoo policy which was under consideration, reflected this ambivalence when it sought to state that no zoo be set up within 100 kms. of a National Park or Sanctuary and that no new zoos be permitted to be set up. Such an approach would only mitigate against the cause of conservation itself and a golden opportunity to reach a vast captive audience with the message would be lost. Zoos can and should supplement the role of protected areas and not deplete them. What is required is the need to ensure that Zoos do play their correct role and that their setting up and management is supported and raised to a level where they can help to project the values of conservation. What is required is to over see and guide and development of Zoos by setting up of authority as suggested by the Experts Committee instead of banning zoos which cater to the psychological needs of man to see his forebearers.

5. *Safari Parks:—* Safari Parks are a recent phenomenon in the world and in India, where the first one was set up in 1974 in Hyderabad. Safari Parks are large areas as naturally maintained as possible where a group of wild animals notably Lions, Tigers etc., the large and spectacular carnivores are kept in semi-wild conditions. Due to the largeness in area, (usually 30 to 40 acres for one species as against less than 1 acre in Zoological Parks) the animal groups have a better chance to interact away from public gaze and disturbance. People usually go into the enclosure in vehicles and see the animals. The high cost of their setting up and maintenance results often in a commercial outlook in the management of such parks which is not desirable. However, the breeding potential of such parks in very high. The second advantage is that because of the large area the animals could be said to be in a semi-wild state. Such parks could be used for reversing the process of taming of wild animals, for their eventual return to the wild. However, the problem of large carnivores could still pose problems.

6. *Endangered Species Breeding Centres:* These are facilities being set up for the sole purpose of breeding endangered species for their eventual return to the wild. In these facilities the man-animal interaction is kept to the minimum, if not eliminated by keeping them out of bounds to visitors.

Such centres were set up for breeding the 3 endangered species of crocodilians found in India. These centres were set up in 20 locations in the country. In ten years over 300 gharial (*Gavialis gangeticus*) 2000 saltwater crocodiles (*Crocodylus porosus*) and over 8000 Muggers (*Crocodylus palustris*) were raised for eventual release into the wild. This was perhaps the most successful programme in India to not only save endangered species but to rehabilitate them in their former habitat. By 1986, 1456 Gharials 1022 Saltwater Crocodiles and over 1000 Muggers were reintroduced into various locations in the country.

A centre for breeding endangered species like Swamp Deer, Wolves etc. is being set up near Kukrail in Uttar Pradesh with the object of eventually releasing them into the wild.

An enclosure for breeding Swamp Deer *Cervus duvuaceli branderi)* was set up in the Kanha National Park in an effort to breed these endangered species and release them into suitable habitat.

Musk Deer (*Moschus maschiferus*) have been bred at the farm at Kufri in Himachal Pradesh with some success. But here again the breeding is not on a sustained basis, so that a viable programme for reintroduction would be drawn up.

Problems in breeding wild animals

Captive or controlled breeding of wild animals as pointed out earlier has been practised by man for a long time. However, the following few detetrious factors have to be borne in mind in undertaking any such programme in order to maintain genetic purity.

1. *Hybridization*: Occurs in interspecific breeding e. g. some zoos have specialised in producing hybrids of Lions' (*Panthera leo*) and Tiger *(Panthera tigris)*. The Expert Committee report on management of zoos in India, specifically refers to these as undesirable since they lead no-where. At best they could be experiments. Very often a desire for publicity lies at the back of such an enterprise.

2. *Racial mixing:* Often different geographical races of the same species get mixed either accidentally or by design in order to obtain of spring e. g. in some zoos the African Lion (*Panthera leo leo)* is often bred with the Asiatic Lion (*Panthera leo persica*) in the belief that a lion is a lion. The asiatic lion is the more endangered of the two and requires to be bred and conserved. Similarly on a more important level the two races of Swamp Deer (*Cervus duvaucelli duvaucelli*) and (C. d. branderi) require to be kept apart and bred seperately.

3. *Imprinting:* This is a phenomenon peculiar to zoos and wild animals kept as pets. It is often found that once an animal gets imprinted by humans, it is difficult to get it to breed. This often occurs when young wild animals are brought up by zoo directors or keepers when abandoned by their parents or on being orphaned.

4. *Inbreeding:* In Indian zoos usually very small group of animals of a species are kept together. Very often this is only a pair due to financial constraints. Once this pair breeds the population grows in which each animal is related to the other. When this happens inbreeding occurs and in course of time inbreeding depression occurs in the form of juvenile mortality, deceased fertility, disease and skeletal defects. An example of such a problem is the White Tiger where the progeny has come from two individuals in the beginning. Similarly the herds of Sangai in Indian zoos are also believed to be highly inbred.

Inbreeding in zoos can be managed if not totally eliminated by the use of stud books. Such records require maintenance at least for endangered species so that the genetic history of each individual is fully known before breeding is taken up. Only thus pure lineage could be maintained and inbreeding defects as pointed out above eliminated.

Conclusion

The term "captive" breeding or propagation has always given the connotation of a criminal and fearful animal, forcibly restrained in small cells or cages. This is far from the realities of present day programmes for keeping wild animals. Modern methods of keeping animals aims at providing the animal as much freedom as possible to more, to eat and to propagate. In fact it is the experience of most zoo keepers that a well settled animal is loath to leave the safety of its enclosure for the "freedom" of the world outside it. The anthropomorphic odium attached to the term "captive" mitigates against the achievement of a very object ie., conservation. A term that suggests itself is "controlled breeding or propagation". Controlled propagation for conservation should not and cannot be taken as supplementing conservation of our natural resources in the wild. It can only supplement such efforts in the various circumstances shown in the foregoing paragraphs. Controlled breeding by itself should not be taken as a matter of course but only as a last resort, in the hope that "having a species in captivity is better than not having it all"

Controlled breeding cannot always be an end by itself; it must lead to the rehabilitation or reintroduction of the species to its former habitat. This has to be done very carefully using some of the well known parameters like suitability of the habitat to the species being released, availability of food, presence or absence of predators, conditioning of the species prior to release releasing in viable groups, releasing in the appropriate season etc. Above all the process of taming wild animals referred to earlier would have to be reversed gradually till the animal is psychologically suited for return. For example the process would be zoos/breeding centres (Ex. situ) — Training (Phase I) in large Deer Parks or Safari Parks (Ex situ) — Training (Phase II) in accessible enclosures) (in situ) — Release in habitat.

This tool of conservation of our genetic diversity has not been adequately used in the past. It is time, it is tried out before the inevitable fact of extinction of any species occurs.

Literature consulted

1. Conway, W. G. 1978 — Breeding Endangered Birds in Captivity, from Endangered Birds by Temple Stanley, A.
2. Davis, P. D. C./Dent A. A. 1968 Animals that changed the World.
3. Indian Forester 1986 Vol. 112, No. 10.
4. International Zoo Year Book Vol. 20 to 22.
5. Martin R. D. 1975, Breeding Endangered Species in Captivity.
6. Rare and Endangered Animals of India, Z. S. I. 1981.

Talk presented at National Symposium on the Conservation and Sustainable Management of India's Genetic Estate, as part of the Jawaharlal Nehru Centenary Celebrations sponsored by WWF - India, 3-4 November, 1989, New Delhi. Permission to print given by author.

Studbooks: the basis of breeding programmes

ANGELA R. GLATSTON

The Biological Research Dept, The Royal Rotterdam Zoological and Botanical Gardens, 3039 KE Rotterdam, The Netherlands

In order to understand the function of studbooks and the role they can play in breeding programmes, it is necessary to look at the breeding of domestic stock where the studbook system has its roots. Traditionally studbooks have been used as an aid to stock improvement by facilitating selective breeding. Each registered specimen is awarded a breeding value, which is an indication of the extent to which a desired trait is represented in the individual concerned. The value is assessed on the merits of the specimen itself, of its relatives or a combination of both. Thus the selection of a suitable breeding animal, to improve, say, the quality of milk production in a dairy herd, is assisted by use of the studbook and by the advice of the studbook keeper.

Although verbal and informal written stock records have existed for centuries, the oldest official studbook is the *General studbook for thoroughbred horses* which was established in England in 1791. For most domestic animals, however, the studbook records date from the last century.

Studbooks for wild animal species have had an even shorter history: the oldest is that for the European bison *Bison bonasus* which was established in 1932. It cannot be said, however, to have started a trend and by 1966, when the first studbook list appeared in the *International zoo yearbook*, it contained only eight mammalian species: the European bison, the Przewalski horse *Equus przewalskii*, the Anoa *Bubalus depressicornis*, the Onager *Equus hemionus onager*, the Addax *Addax nasomaculatus*, the Scimitar-horned oryx *Oryx dammah*, the Arabian oryx *Oryx leucoryx* and the Père David's deer *Elaphurus davidianus*. At this time studbooks were officially recognised and endorsed by the International Union of Directors of Zoological Gardens and the Zoo Liaison Committee and began to be expanded. By 1969 21 studbooks were planned or in existence, ten years later 38 studbooks were acknowledged in the *Year-*

book and five years later, in 1984, the figure had increased to 61.

THE VALUE OF WILD ANIMAL STUDBOOKS

The growth in the number of wild animal studbooks reflects the zoo establishment's recognition of their intrinsic value. As with domestic species, the importance of studbooks lies in the role they can play in planned breeding programmes. In the case of wild animals, however, such programmes do not involve the same type of selective practices. The aim is not to alter or exaggerate certain characteristics but rather to maintain the original diversity of the founding stock.

A typical studbook provides a list of all specimens registered (both living and dead), their sexes, dates of birth, parentage, locations and, where appropriate, dates and places of death. At the most elementary level the data assist a zoo in locating a new specimen of the correct age and sex for inclusion in its collection. A far more important function of the studbook, however, is its role in preventing inadvertent inbreeding and in facilitating the design of breeding programmes which preserve genetic diversity. Mohr (1968) and Jarvis (1969) both emphasised that without adequate records it is difficult, sometimes impossible, to know if serious inbreeding is occurring, for the identity of an individual can be lost when it is transferred from one institution to another. Recent authors (among them Denniston, 1978; Seal & Flesness, 1979; Chesser *et al.*, 1980) have stressed the importance of genetic diversity to long-term captive breeding and conservation projects. Carefully planned breeding programmes based on studbook data help to preserve the original gene pool. When the lineage of all the individuals used in a breeding programme can be traced, matings can be planned to try to ensure that all the bloodlines are equally represented in the captive population so that the rate of loss of genetic diversity over generations of captive breeding is reduced as much as possible. At the same time the studbooks provide raw data from which demographic analyses of the population can be undertaken, inbreeding coefficients can be calculated and pairings made to obtain maximum outbreeding.

Exploited to the full, studbook data offer further possibilities. As Professor Kurt Benirschke has stated, the records can be used to assist in the identification of hereditary defects and to deduce the pattern of their inheritance (Olney, 1980). The removal from the breeding population of animals carrying the deleterious genes, therefore, becomes a practical possibility. If, as is recommended in the official rules and procedures, a studbook keeper also collects autopsy reports on registered specimens, a body of knowledge can be built up on the health problems to which that species is susceptible. By combining such pathological data with other information available in the studbook, it is possible to identify those age-sex classes and bloodlines most at risk. Studbook data can also be used to improve husbandry because, if longevity and fertility rates for animals maintained under different conditions or in different climates are compared, it is possible to deduce which are the most appropriate to the needs of the species.

ACHIEVEMENTS AND PROBLEMS

There can be little doubt that the current system has a number of solid achievements to its credit. The exchanges of the Okapi *Okapia johnstoni* between Europe and the United States made use of both studbook data and the good offices of the studbook keeper. The current plans for developing a stable population of the Siberian tiger *Panthera tigris altaica*, as well as an earlier study examining the evidence for inbreeding depression in the North American captive population, utilise data available in the studbook (Seal, unpubl., a,b). The warning that the captive population of the Brown hyaena *Hyaena brunnea* is destined for extinction derives from the work of the studbook keeper (Shoemaker, 1983). Other species are being, or have been, analysed for population trends, among them the Przewalski horse, the Gaur *Bos gaurus*, the Okapi (Foose, 1978, 1980) and the Red panda *Ailurus fulgens* (Veeke & Glatston, 1980).

Just how powerful a tool a studbook can be in the formation of a breeding and management policy is illustrated by the Golden lion tamarin *Leontopithecus r. rosalia* studbook, which was first established in 1970–1971 and transferred to the present holders, the National Zoological Park, Washington, DC in 1974. The species as a whole is critically endangered in the wild and in the early 1970's the captive population of *L. r. rosalia* was steadily declining following a ban on imports from the wild. In 1968 the *Yearbook* reported 102 specimens in zoos but only 19 were shown as captive born. At the end of 1975 Kleiman (1977) reported that the number of registered specimens (which excluded those held at the Tijuca Biological Bank in Brazil) stood at 83 individuals. Although 40 young had been born during the year this had been more than offset by 43 deaths. A further problem was the preponderance of ♂♂ in the new births. Thanks to the research carried out at the National Zoological Park and the careful use of the studbook data in less than ten years there was a healthy population of 330 individuals nearly all captive bred. In fact the population is now large enough for discussions to arise on the placement of 'surplus' animals, and indeed a number of specimens have now been reintroduced into the wild (Ballou, 1985).

It has to be recognised that the work on the Golden lion tamarin was helped by two factors at least. One, nearly all the founding stock was owned by the studbook holders, and secondly, the animals are small so that transporting individuals in the course of implementing the breeding programme is less difficult than for larger species. Nevertheless, it remains an excellent example of the proper use of a studbook.

Inherent in the studbook system as it now stands are also a number of problems and limitations. To begin with the basic organisation of the system, the problem is essentially one of too few resources unequally distributed. Despite the recent growth of international studbooks, even the 61 studbooks officially recognised in 1984 are few given the number of species for which data should be collected. This relatively small number is associated with the fact that the production of a studbook is a service which the institution concerned provides free of charge to its colleagues. One possible discouragement to extending the service is insufficient personnel; studbook production is a very time-consuming process. As the studbook keeper for the Red panda, I estimated that, over the course of the two-year publication cycle, an average of 10–15% of my working week is spent on matters connected with the studbook. A studbook is also a financial burden to the holding institution. In the case of the Red panda studbook production costs $50 per year for every living specimen registered.

Apart from the paucity of studbooks, those which do exist are unevenly distributed across the taxa. It is no coincidence that the first studbooks to be produced were for the large mammalian species which were of special interest because of their strong public appeal. Even by 1984 there was only one studbook for a reptile and three of the eight bird species were for pheasants which are of particular interest to specialists. Of the 51 mammal species covered there was only one international studbook for a marsupial while there were ten for primates, three for rhinoceroses and five for large cat species (within which subspecies are recorded separately). The situation is gradually improving as more studbooks are initiated but at the present time the uneven distribution remains.

Other difficulties arise with the collection of data and even the reliability of data collected. In my experience it is difficult and time consuming to obtain adequate information from all the holders of studbook animals. In some cases two or three reminders are necessary to elicit the return of the annual questionnaire. Even then not all data are always provided. In particular it seems to be difficult to obtain photographs to facilitate individual recognition, detailed autopsy reports and information on husbandry and management practices.

The quality of the data collected can be in doubt if there is a problem in identifying individuals. Individual identification is the nub of the studbook system and it was the original intention to link studbooks with an adequate system of animal identification (Jarvis, 1969). This has not yet been achieved, and misidentification still occurs. For example, there have been two separate instances where Red pandas were confused and sent to the wrong zoos. Had these gone unrecognised it would have resulted in 5% of the small breeding population being incorrectly identified, and this represents only the known cases. It is of concern too that this occurred with a species which is housed in small groups, pairs or trios. With animals in large herds or flocks the possibility of error is even greater. Without reliable techniques for individual recognition the data from even the most carefully maintained studbook are open to dispute.

The recommendations of the 1979 International Studbook Symposium at Copenhagen (Olney, 1980) and the more recent review in 1984 by the Captive Breeding Specialist Group have gone some way towards providing uniform studbooks from which data are easier to extract and which provide a greater wealth of data. In addition there has been an attempt to tighten up the requirements concerning the frequency with which studbooks are circulated. Enforcement of these recommendations will improve the service considerably by overcoming the problem of infrequent circulation of data and will facilitate the analysis of data.

SUGGESTED REORGANISATION

There is currently a great deal of duplication between ISIS and the studbooks. Both provide listings of animals, their locations and dates of birth. ISIS, and some studbooks, collect information on mortality factors, markings and clinical laboratory data. Tom Foose has commented that studbook and ISIS data differ in that the former represents what demographers designate cohort or historical data while ISIS consists of static or non-historical data. (Cohort data are defined as ages at death and reproduction of a large number of animals of known birth dates while static data are the survivals and fertilities during a specific interval of time for a number of animals of each age class entering that interval of time (Foose, unpubl.).) Many of the data recorded by ISIS, however, can be derived from studbooks.

The essential differences between the two systems is that, at present, studbooks collect data from more zoos than are participating in ISIS, many studbooks collect data on management techniques, and they benefit from the personal attention of a studbook keeper. ISIS, on the other hand, has the capacity for collecting and collating data for a large number of species and, at $1.50/registered specimen, it is less costly than the studbook system.

Given the different scopes and the regions of overlap, it might be more efficient if the two systems could be integrated. Such a combined system would have the advantage of reducing paperwork, both for the participating zoos, which would need to complete only one questionnaire, and for the collecting agents. In addition, studbook keepers would benefit from closer ties with and support from the ISIS facilities.

Since the current studbook service is free to participants and ISIS is not, there would naturally be financial consequences for the owners of the animals, who would, presumably, have to pay the normal registration fee to ISIS. This might discourage some zoos from participating but it would alleviate the financial burden of the studbook-producing zoos.

Under the system which I am proposing the role of ISIS as the collector of data would remain unchanged; it already has the facilities for large-scale data collection and storage. If it were to fulfil this role world-wide, it would release studbook keepers from many of the routine tasks now undertaken and allow them to function as 'species managers'.

The idea of an altered role for studbook keepers is not totally new; a similar suggestion was made during the 1979 Studbook Symposium (Olney, 1980) and reiterated by Conway (1980). Lovejoy (1980) also suggested that the studbook keepers might have a role to play in the managing of joint programmes for both wild and captive animals.

My present proposal is that ISIS should form the normal channel of data collection and storage, and that a studbook should be produced only for those species which are currently involved in captive management programmes. In these cases the IUDZG, in co-operation with the Species Survival Commission, would decide, on the basis of ISIS records and species' status in the wild, which species require captive management programmes; the IUDZG and the SSC would then select a suitable person to act as studbook keeper. This procedure reflects that now used by the AAZPA when establishing a regional Species Survival Programme.

The studbook and its keeper would be central to the management programme. The studbook keeper would administer and supervise the programme and monitor its progress. He/she could not be expected to work alone but should be the chairman of a team of species managers who in turn should have the support and advice of an expert committee.

For practical reasons most management programmes would need to be organised on a regional basis (Glatston, 1982; Foose, 1983). The actual divisions would depend on the species concerned and/or on the presence of an existing regional zoo organisation; they might be national, multinational or continental. Each region would formulate its own regional management policy under the leadership of a regional co-ordinator/studbook keeper as in the case of the Species Survival Programmes in North America. The regional studbook keeper, in addition to monitoring and administering the breeding programme within the region, would collect information on husbandry, medical care, etc., and participate in the international management team.

The international studbook keeper should collate the regionally collected data and monitor the management programme at an international level. In addition he/she should provide regular reports in the studbook on the current status of the population together with advice on housing, management and so forth. These reports should be produced at regular, preferably yearly, intervals.

There can be little doubt that most animal management programmes would benefit from the results of scientific research. The establishment of studbook management programmes should be coupled with adequate research programmes either within zoos or in collaboration with universities and wildlife organisations. The results of such research should be reviewed by the studbook team, relayed to studbook participants and, where necessary, incorporated into the management programme itself.

CONCLUSION

In summary, the studbook system offers numerous potential benefits to captive breeding. Under the present system, while many of these benefits do indeed acrue, the full potential of the personal attention of a studbook keeper is not exploited and studbooks remain banks of collected data. As such they fulfil a similar role to that performed by ISIS.

Coupling the two systems would allow ISIS to function as the major collector and collator of data, while studbooks could be developed for those species involved in captive management plans giving them the benefit of a studbook keeper's personal attention.

This suggested combination would streamline our data collecting services, increase efficiency and reduce costs. It would also allow us to plan for a more representative distribution of studbooks across the taxa.

Without some such reorganisation, if ISIS continues to expand and the number of studbooks to grow, we could develop an unwieldy species registration bureaucracy with many data collected, often in duplicate, but not incorporated into effective breeding programmes. This in turn could result in the devaluation of the studbook system. In this event, a revolutionary, far-sighted idea will have failed and with it perhaps the chances of survival for a number of endangered species in our zoos.

ACKNOWLEDGEMENTS

I would like to thank Dr R. Latter and Dr U. S. Seal for reading and correcting the manuscript and for their constructive comments.

REFERENCES

BALLOU, J. D. (1985): *1984 International studbook, golden lion tamarin* Leontopithecus rosalia rosalia. Washington, DC: National Zoological Park.

CHESSER, R. K., SMITH, M. H., BRISBIN, JR, I. L. (1980): Management and maintenance of genetic variability in endangered species. *Int. Zoo Yb.* 20: 146–154.

CONWAY, W. G. (1980): Where we go from here. *Int. Zoo Yb.* 20: 183–189.

DENNISTON, C. (1978): Small population size and genetic diversity. Implications for endangered species. In *Endangered birds: management techniques for preserving threatened species:* 281–290. Temple, S. A. (Ed.). Madison: University of Wisconsin Press.

FOOSE, T. J. (1978): Demographic and genetic models for the management of the okapi (*Okapia johnstoni*) in captivity. *Acta zool. path. antwerp.* 73: 119–195.

FOOSE, T. J. (1980): Demographic management of endangered species in captivity. *Int. Zoo Yb.* 20: 154–166.

FOOSE, T. J. (1983): The species survival plan (SSP) of the AAZPA. *Int. Zoo News* 30 (2): 29–33.

FOOSE, T. J. (unpublished): *Demographic models for management of captive populations with application to wild horse* (Equus przewalskii) *and Arabian oryx* (Oryx leucoryx). Unpublished report, July 1976.

GLATSTON, A. R. (1982): Proposal for a cooperative breeding programme for the red panda. In *The red or lesser panda studbook No. 2.* Glatston, A. R. (Ed.). Rotterdam: Stichting Koninklijke Rotterdamse Diergaarde.

JARVIS, C. (1969): Studying wild mammals in captivity: standard life histories with an appendix on zoo records. *Int. Zoo Yb.* 9: 316–328.

KLEIMAN, D. G. (1977): 1975 World register of golden lion tamarins *Leontopithecus rosalia rosalia*. *Int. Zoo Yb.* 17: 232.

LOVEJOY, T. E. (1980): Tomorrow's ark: by invitation only. *Int. Zoo Yb.* 20: 181–183.

MOHR, E. (1968): Studbooks for wild animals. *Int. Zoo Yb.* 8: 159–166.

OLNEY, P. J. S. (Ed.) (1980): Report on the international symposium on the use and practice of wild animal studbooks. *Int. Zoo Yb.* 20: 485–490.

SEAL, U. S. (unpublished a): *Genetics and demography of studbook siberian tigers in North American zoos with evidence for inbreeding depression.* Unpublished manuscript.

SEAL, U. S. (unpublished b): *An analysis of the demography and genetics of captive Amur tigers* (Panthera tigris altaica) *and a preliminary propagation plan.* Unpublished report to the IUDZG, 1983.

SEAL, U. S. & FLESNESS, N. (1979): Noah's ark: sex and survival. *Proc. AAZPA Conf.* 1978: 214–228.

SHOEMAKER, A. H. (1983): 1982 studbook report on the brown hyaena, *Hyaena brunnea;* decline in a pedigree species. *Zoo Biol.* 2: 133–136.

VELKE, H. & GLATSTON, A. R. (1980): Demographic study of the captive population of the red panda. In *The red or lesser panda studbook No. 1.* Glatston, A. R. (Ed.). Rotterdam: Stichting Koninklijke Rotterdamse Diergaarde.

MAINTAINING GENETIC VIABILITY OF SMALL POPULATIONS

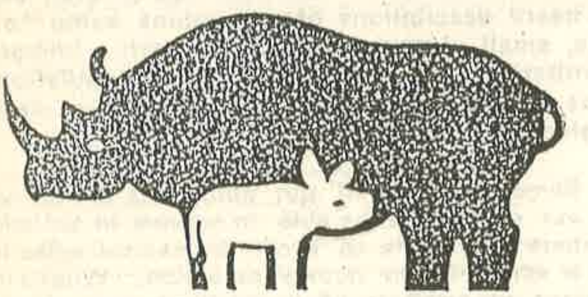
By Dr. U. S. Seal, Chairman, Captive Breeding Specialist Group, I. U. C. N.

The Captive Breeding Specialist Group is one of the nearly 100 specialist groups in the Species Survival Commission of I.U.C.N., the International Union for Conservation of Nature and Natural Resources. In this Group or Committee we develop techniques to prevent the extinction of species. Most of the time we are responding to crises.

To try and prevent the extinction of species we use a combination of captive propagation, field techniques and the most up-to-date conservation sciences, such as population biology and conservation biology.

Master Planning - to prevent extinction

In order to make it work, or to turn theory into practice, we go through a rather elaborate planning process for each species. This planning process has different names in different continents and in different zoo associations. In the American Association of Zoological Parks and Aquariums the plan is called the Species Survival Plan, or S. S. P. In Europe it is called the European Breeding Programme (E.E.P.). Great Britain and now Australia also have these plans which are constructed species by species. The rhinoceros is used as the symbol for the AAZPA Species Survival Plan and the EEP has adopted the same animal as its symbol.



Species Survival Plan

The core idea is to use captive populations as a technique for protecting the gene pool of the species, both captive and wild. Captive propagation is no longer designed or intended to simply provide exhibit animals for zoos. It is intended in a conservation role to provide a genetic and demographic reservoir to insure the survival of rare species. If a species is totally extinct in the wild as has happened many times this century, captive propagation may be the very last foothold on survival the species has.

Many of our wildlife species in the world today consist of very small populations that aren't large enough to assure their survival over the long term- even if habitat protection is provided. Over decades, attrition of a population due to genetic and demographic problems can prove as fatal as poaching, or more so-because it can sneak up on you unseen. Or the population may be reduced to a single population like your Gir lion and not be secure against extinction in the event of a catastrophe, perhaps a disease or some other event. Some of the species we've worked with in the U.S.A. have been wiped out by a hurricane. A disease in the case of the Black-footed Ferret nearly destroyed it in the wild.

In essence what we wish to do over the long term is to make sure we protect populations in the wild. Not only protect them for the present but also protect them under circumstances in which they can continue to evolve by natural selection.

Insuring the long-term evolution of species is not so simple or easy but it does provide immediately some guidelines for the numbers we want to work with and how we want to work with them .. how we must manage them.

Viable Populations

Our "buzz-word" here is "viable populations". The term is used in many different combinations: "minimum viable populations," "evolutionarily viable populations", "population viability analysis," etc. The word "viability" then has to be defined and thought about very carefully. In the context of conservation strategy, which we base entirely on the notion of viable populations, much of the meaning has to do with genetics and demographics.

Loss of Population Viability due to Genetic Drift

The problems that small populations encounter- populations in the sizes of a few hundreds or less- is that they are so small or get so small that the loss of genetic material occurs by random event, not by selection. Once a population drops down to a size of about one hundred breeding adults then the loss of genetic material is dominated by random events. We call this *genetic drift*. With the loss of genetic variability- by accident, or random events, - there can be a loss of fitness.

Loss of fitness means also loss of reproductive capability, which will slow the growth of a populations significantly. It will get smaller and smaller and continue to lose genetic variability until it becomes demographically unstable. At this point the population enters what we call the "extinction vortex", the circle to extinction.

So, small populations have problems of genetics with the loss of genetic material through random events rather than natural selection. This means, of course, that they can lose some of their best survival material.

Loss of Viability due to Demographic Problems

Small populations can have demographic problems. We heard Fred talking about his Nilgiri tahr. In the past three years they've had 17 or 18 male births and only one or two female births. That, if it continues for a few more years, will mean serious trouble. It can - and does - happen in the wild also - demographic randomness, demographic stochasticity. These terms apply to random events, accidental events. Stochasticity, things that happen just by chance, no longer driven by evolutionary forces. They happen, and if such a trend continues, in this case an all male predilliction, the species can go extinct because of a lack of demographic variation. This is another problem of a small population.

Loss of Viability due to Environmental Events

Environmentally then, what are some of the causes of loss of species in a small population?

Let's take for instance that a population has reached very low numbers and for some reason four or five of them are killed, say by poaching or hunting or some other accidental or human-caused event. There's a good chance that such an event can wipe out all the reproductive females or the reproductive males and destroy the entire population. These small populations are very vulnerable then to human events.

It can be hunting, it can be a dose of a toxic chemical as recently happened to us in the U. S. A. with the Florida panther. We've got 24 panthers in the wild now ... we just recovered one which died of mercury poisoning. We don't know where or how mercury got into the environment, but here we've got an environmental event that took out one of our twenty-four Florida panthers.

We've checked now another 16 of those panthers and at least 8 of them have got excess mercury loads. So we've got a random event, mercury poisoning, completely unexpected which, unless or maybe even if the source is found will take out the entire population.

It also happens that there was a policy NOT to vaccinate these animals. The Park Service in North America maintained that those animals are "natural" and therefore it is their policy not to vaccinate them, even though they handle them. Two months ago one of them died of rabies. When you have such a small population you can't really call it "natural" anymore; there's no way those animals are going to survive on their own. It requires human intervention.

The Park Service captures them and treats them when they are sick and when they get hit by cars they bring them into the hospital and then take them back out. But it took a major crisis, a case of rabies, to convince them to vaccinate the animals.

Then there are natural catastrophes such as volcanos, floods, forest fires, etc.

You always lose ...

So we have summarised the three major sources of random events or variations that can influence small populations. That is the most important single message I want to convey to you: you will always lose if your species is restricted to a small population ... ... a single population.

Our problem then is how do we avoid - or at least reduce the risk - of that loss? All of the actions - all of the scenarios - that we have talked about of managing small populations of endangered species in the wild or in zoos relate to the fact that chance events will always catch up with us. So what we try to do then is reduce the risk of losses by chance events. That in a nutshell is what I've tried to summarise in terms of demography, genetics and environment - stochastic or random events.

What is small?

Now another concept that is key to our understanding of small populations is ... what constitutes smallness? When I say a small population, what do I mean actually? In the last two or three days, I've heard descriptions of populations being "o.k., large, small, intermediate". We can, however, quantitatively talk about the size of a population in terms of smallness from a genetic and a demographic and environmental point of view.

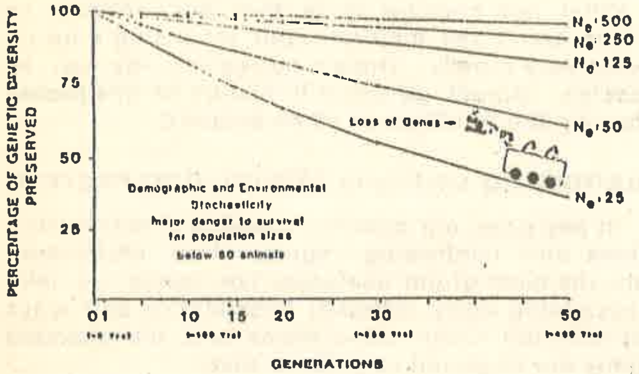
Remember, one of our guidelines is that we'd like our species to be able to survive in sufficient numbers to be able to evolve by natural selection, that is adaptation by natural selection. What kinds of sizes or numbers of populations are necessary to allow that?

A seperate problem is how many populations are necessary to reduce the risk of extinction due to accidental, environmental random events.

How many Asiatic lions for example would we like to aim for to ensure the continuance of the species ... how large a population may be scattered across three or four different populations in the wild and over 10, 20 or 50 zoos in captivity? What's the total population that we might manage as a single unit ... how large does it need to be?

One of the major guidelines to deciding this question relates to the tension between genetic variation or the loss of genetic variation by drift and the maintenance of new genetic variation by mutation. The balance between those two is the balance we're looking for: a population large enough to accomplish that goal - the possibility of evolutionary adaption. Our graph shows a series of lines from top to bottom, the effective population size ranges from five hundred to twenty five. The bottom line generation then is the number of

DECLINE OF GENETIC DIVERSITY FOR VARIOUS EFFECTIVE POPULATION SIZES (N_e) POSSIBLE FOR A TOTAL POPULATION (N) OF 250



generations - those lines show the loss of genetic variation over generations.

The percentage lost is shown on the vertical axis and looking at the N_e or effective population size of 25 we see that in 50 generations we've lost perhaps 60% of our genetic variability whereas with an N_e or effective population size of about 500 we've lost little or no genetic variation during that time.

In fact if we added in the gain of new genetic variation by mutation we'd find that that population was not losing any genetic variation from its starting point.

Effective Population vs Census Population

Five hundred is an approximate number or rule of thumb that can be used to estimate the population size needed to protect a species from loss of genetic variation to give it sufficient size for potential for evolution and survival by adaption and selection. And so a number that's useful as a guideline is that number 500, the effective population size.

What does that mean in terms of census population size. The effective population size refers to the genetically effective population size, approximately those breeding individuals that transmit their genes in the population from one generation to the next. The census population size at any one time may be 1000 or 2000 or 3000 to have an effective population size of 500.

In general for most of the large mammals we deal with, the census population size required to achive an effective population size of 500 is in the neighborhood of two to three thousand. Again a raw form of guideline to guide your thinking when you are talking about some of these survival plans.

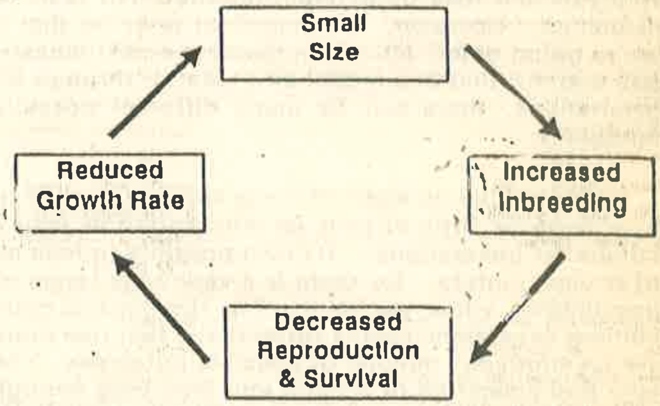
In terms of your Asiatic lion, this suggests in the long term, - for the survival of the Asiatic lion as a seperate distinct taxon or subspecies with the potential for continuing evolution as such a taxon - that we want to achieve a census number of lions on the ground at any one time of about 2000. And we'll show how to get at that number in a few minutes.

Turn the logic around. One way to look at the effective population size of something like the Gir lion is to get an estimate of the number of breeding adults over a period of five years.

Let's say just for the sake of discussion there are at any one time 250 lions out there - I have no idea of the age or sex structure, but lets say that there are in that population 100 breeding adults right now. Then the effective population size would be about 100. Thats a rough, rule-of-thumb way of estimating the effective population size: count the breeding age adults. Then you start correcting for family size and other things but that first cut is not a bad guideline - its a useful way to think about it.

The Asiatic lion once numbered in the tens of thousands throughout its range. Right now its maybe 300. A large gene pool of thousands and thousands of lions that had a chance to respond to changes in changing environments has now been reduced to a gene puddle. That's very little left and very little reserves to meet the challenges of a changing world through geological time.

This diagram is a summary of the idea of the extinction vortex. We've been through it several times now: small size, increased inbreeding, loss of fitness, loss of birth rate and then the circle to extinction. One definition of the minimum viable population is a population size over a time period that is just large enough to prevent this extinction vortex from happening.



The MVPS Trap

That is a very arbitrary definition and I want to emphasize that its very important not to get TRAPPED in the idea of a minimum viable population. That's happened on two or three occasions in North America and Australia and the first thing the developers did was say "Ah ha! There's 2000 owls out there. You tell me the minimum viable population size is 500. Therefore I can take all that habitat that those other 1500 owls have got and develop it." Thats exactly what happened with the Northern spotted owl. It created a great crisis and it was very bad thinking on the biologists part to get trapped into a m. v. p. s. which is an arbitrary definition.

The only meaningful definition for myself and to which all of us as professionals might subscribe is that of *long-term biological survival for all species wherever possible.* And you are going to see for some species it may seem impossible, but there are at least ways to cope with that.

Loss of Species due to Age

We've summarised some of the places where we can get into trouble and we've already talked about demographic stochasticity and biased sex ratios and the problems that can create. In addition, its entirely possible that a population can age out and not be able to reproduce. This has happened to us in the U. S. with several species. We have experienced those problems, again with the small numbers.

Exceptions Prove the Rule. Do We want to Risk it?

Often when I'm giving a talk to a group of people with a wide range of experience somebody always comes up with a species that has lost much of its genetic variation, such as the cheetah, the Asiatic Lions etc. and it hasn't gone extinct. "Therefore", they conclude "losting genetic variation doesn't mean your species has to go extinct."

Agreed. It may not ...but in fact we find very few of those species. Everything we know today suggests the loss of genetic variation can lead to extinction. However, it's important to know that if we're going to talk about randomness and stochasticity and put that in a model and take it through 50 generations, there can be many different possible outcomes.

Its possible in some of those simulation runs to lose none or little of your genetic variation over a number of generations. Its also possible to lose all of it very rapidly. So there is a very wide range of possibilities when you're flipping the genetic coin. Finding exceptions simply reflects the fact that there are an enormous number of possible outcomes. You may find almost all of them if you look long enough and hard enough across enough species or populations.

The world is probabilistic; its stochastic and that means any given outcome may happen sometime but one of the things you can be sure of is that ultimately we're going to lose. Its' sort of the second law of thermodynamics, but ultimately every species will be caught in a catastophe or in an evolutionary vise or crunch that it won't survive.

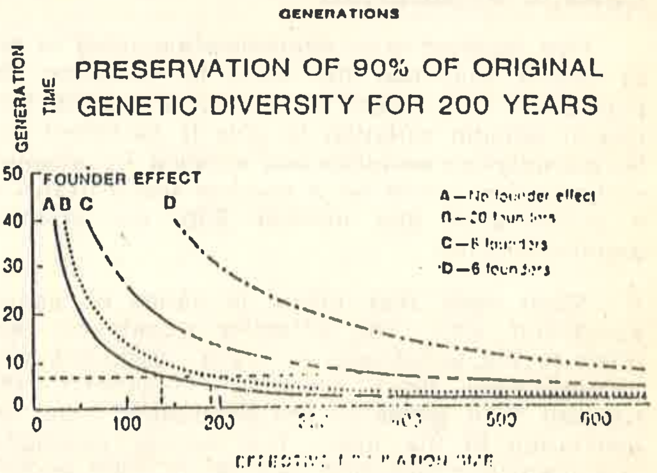
What our concern is is that our actions as humans aren't the major reason for losing a lot of species very rapidly. There's no reason why we, as a species, should go down in history of this planet as having the intelligence of an asteroid.

Maximising options Minimising regrets

In any case, our strategy consists of maximising options and minimising regrets. That philosophy forms the basis of our analyses. The routes we take in examining many different possibilities and ways of structuring viable populations and management options are designed to achieve that.

Now when you begin the planning process based on all the things I have talked about, the notion of the viable population is going to depend on these three items that we've described here. One is the objectives of the programme, genetically and demographically. Another is the biological characteristic of the species and of the particular population. The third is our ability to get an estimate of random and stochastic events.

All those together then will lead into the construction of our idea of a viable population size for that particular species. We have the chance or choice of certain genetic and demographic objectives. For many of our captive populations we have chalked out programmes with the objective of retention of *90% of thegenetic diversity of the species over 200 years.*



The retention of 90% of the genetic diversity of species for 200 years is an arbitrary choice designed to meet certain objectives that relate partly to the numbers of animals that are required and partly to the amount of space that we see available in our zoos.

One can choose different objectives and in fact we've had several examples where we can't even begin to achieve that objective if we're talking about sampling the original wild populations of species.

How Many Founders?

Here is another useful Rule of Thumb. How many founders does one need to start a captive population of a species to represent at least 95% of the genetic variation in that population. The Rule of Thumb is 20 to 30 ... 20 is minimum and 30 is better. Many more than 30 is not really useful. So there's an upper limit or upper bound that you can set and a lower bound. And when we say "founder," it means animals that breed. Capturing 30 bodies and bringing them in and having only four or five of them breed doesn't constitute 20 founders. So it means 20 *breeding* animals and that means that you have to know which is breeding and keep count. It may take 40 animals to produce 20 breeders, or "founders."

That doesn't mean that if you can't get 20 founders, you give up. You just recognise that you're not going to be able to achieve the same goals or objectives. For me, the overriding objective in all these instances is to save that species so that it has another chance, or the next generation of people, our children, grandchildren, grandchildren, great grandchildren have the opportunity to make further choices. we shouldn't simply serve to remove choices from the future. The species may be impoverished but at least it has a chance of existing.

When we started with the Black Footed Ferrets in the United States, for example, the last poulation had been discovered by accident, and we ended up with about 17 founders. Four of those were related. We had about 8 effective founders. Not only that, the population has been in a bottleneck for at least 30 years. It had lost about 50% of its genetic variation in the species when WE got to it.

Nonetheless we undertook the programme. We started out with 17 ferrets 3 years ago; we'll have about 500 in two years and then we'll start a reintroduction programme. If we find a sufficient habitat to provide for sufficient numbers then hopefully this population may have the opportunity to regain genetic variation through time.

This graph shows theoretically and quantatively the number of founders needed to retain a certain amount of genotic diversity as a function of the generation time of the species. Actually the number of founders required can vary with generation time and with goals of the programme. But again that's just to document the fact that there are qualitative aspects to this that you can pursue if you choose.

Sex Ratios and Family Size

Up until just a few years ago in our North American zoos, many, many of our animal species were managed as herd species with a single breeding male 10, 20, 30 and sometimes as many as 40 females. The thinking was that if that male bred this year, he was a "winner" so you kept breeding him until he either died or couldn't breed anymore.

An extreme example of that is the one male white rhino that is responsible for 52 of the captive born white rhino offspring in the international studbook. That accounts for something like 50% of rhinos born in captivity at one time which is a tremendous distortion and loss of genetic material.

That loss comes clear with a little arithmetic. If we have 10 rhinos and one male is used to breed all five of the females, the effective population size is really 3.3. The equations are available if you want to work through the logic of it.

What that means is that our census population is 10 but our effective population is 3.3. If all five males bred all five females, the effective population size is ten.

What this means is in terms of the efficiency of your breeding programme, in terms of the use of your space and resources, in terms of the number of animals you feed, you get much more genetic effectiveness by having equal sex ratios in your breeding.

Now if you have a herd species this means rotating the male every year. There are a variety of strategies to achieve this but it means in effect that those 10 animals bred in equal distribution are three times as effective as with an unequal distribution. Therefore there is an enormous payoff for you in your planning to think through the sex ratio in managing your species to meet your genetic goals.

Another problem is family size. In the population of 10 females and in the next generation of 20 animals there may be one female that produces 25% or 50% of the offpring with the other females producing only one of them. If this occurs, the outcome is an enormous distortion of family size with the net outcome an over representation of that one animal with gross underrepresentation of the others. Therefore, you need to equalise family sizes in a well managed population.

Meta Population Management

Lets use the Gir lion as an example to illustrate our next concept. The problem with the Gir lion is that in the forest or reserve that's currently available to it is at about capacity. Certainly I don't think you're going to get 2000 lions in any reserve out there now.

Therefore, if we're going to achieve our goal of larger numbers of lions, we need to have several populations scattered around, preferably what was its historical range, India and other countries, wherever seems most appropriate.

These populations then can be managed as a single population by the movement of genetic material periodically. We call this procedure or this concept *meta population* and *metapopulation* *management.* Metapopulations can be a series of wild populations managed as units or it can be a combination of captive and wild populations.

The metapopulation approach has several major advantages to it in our current world. One of them is the fact that eventually we can try to plan for and get a large enough number of animals out there to achieve and insure genetic variability, but another is that those populations being seperated from one another in space and exposure to random events, greatly decreases the risk of extinction.

For the sake of argument, if you say the probability of extinction of a given population was say 10% in 5 years, if you have two populations well separated from one another and not exposed to the same potential environmental catastrophes all at once, then the probability of extinction of the species is reduced to the product of the probabilities of the extinction of each individual species which would be 10% of point one 0.1 times 0.1, or .01. That means that the probability of extinction would suddenly drop from about 10% to about 1% by simply having those two populations well seperated from one another.

So there is a tremendous advantage to having seperated populations and multiple populations, to prevent extinctions. This is one of the reasons that for virtually all the Species Survival Plans or population viability analyses we've done we've recommended a minimum of three wild populations. This helps spread out the population over far enough seperated space so that all of them won't be subjected to the same hurrican or the same disease epidemic or whatever that might be. And the captive population can count as one of those populations and help reduce the risk of extinction.

For each species there will be the need to work out ways to do this. We won't easily move tigers from one population to another so we will probably want to make use of other kinds of technology. In the case of tigers we are now working on reproductive technology as a means of moving embryos from one population to another. We now have the technology to a point where we could capture a female, start treating her with hormones, and collect eggs within a week. We can mix those with semen using *in vitro* fertilisation and produce embryos.

These embryos can be transferred to different tigresses then or we can collect them for freezing. Once they're frozen, we have the flexibility to move around between reserves or even between continents to wherever whatever is needed to transfer genetic material. Transferring embryos and putting them in the female would not be as socially disruptive as trying to introduce a new male.

The fact is that all this planet is already so fragmented and the human population is so widely distributed and the land as well as the marine areas have become such that we can no longer talk about the planet as an entire integrated unit. All the wildlife managers-or all of you here - will end up becoming small population managers. Probably, this is going to become the case even with the more common species which populations are also becoming rapidly fragmented in their habitats.

How many species in how many zoos?

For you as zoo managers one of the exercises in arithmetic that becomes important is how many species can you manage. You are limited in space and people and resources. If we are at all correct that there are 1500 species that are going to need captive management within the next 50 years, it is clear that we can't manage them all. We have to choose.

This also provides a constraint on the size of the populations and some of the goals that we can achieve. It is something that you will have to give serious thought to over the next five to ten years as your programmes continue to develop. It will take a continuing further effort on your part and indeed it is going to put a tremendous pressure upon us to continue to develop reintroduction programmes so that we can reduce the sizes of populations we have to keep in captivity to much smaller numbers while the wild populations carry more of the burden.

This distribution is going to vary widely depending on the species. Animals such as ferrets I would hope we could maintain entirely in the wild. Some of the tiger subspecies are going to require both captive and wild maintenance.

The Indian tiger you are managing very successfully in the wild but in course of time you will need to give real thought to metapopulation management. Many of the tiger reserves hold only 25 to 50 and as you can see those numbers are small. There's going to be a loss of genetic variation and as a result, an occasional extinction. Over the long term there is going to be a need to develop a plan for this management and movement of genetic material.

We have to plan now to prevent in the long term the animals we managed either becoming domesticated or losing much of their original genetic variation through our management. This could happen either through neglect (carelessness), artificial selection or whatever may occur. We don't want the art to turn wild animals into a series of dolls and wooden toys as a result of accident or our neglect.

Stickey anomalies

Demographically we have to give some thought to the population age structure. We want a continuously reproducing population with a balanced age structure, but many times the animals will live far beyond their reproductive life span and long after they have produced their genetic "allotment" of offspring for the next generation.

For some species this has presented a serious management problem since we can't easily cull them or euthanise them as we do with domestic species.

There is a real dichotomy in our attitudes towards many of our domestic species for which we have intense breeding programmes whether its dogs or cats or horses or goats and have no hesitation about selection if to maintain some characteristic whether its phenotypic or genetic or otherwise. These same ideas have not transferrerd directly into the zoo world for a lot of reasons - and that's true across countries and many cultures and its placed real constraints and problems on managing programmes with strict genetic and demographic goals. And each region is going to have to wrestle with that problem itself.

Cooperation between zoos

How do you develop your cooperative plan-we struggled also in the United States with how we insure the cooperation we need from each other. We talked about contracts and monitoring and many other things. Fundamentally it comes down to the issue of peer agreement to undertake a programme and having a process of continuing peer review. Peer pressure, or moral pressure from colleagues, is the most effective means of insuring cooperation.

We decided long ago that there's no way we want to have national legislation telling us what to do in these matters. What we do is to meet annually-all these groups and discuss the moves that are best for the species and the Plan. Then the Directors have to sit there and struggle with issues such as "Can I give this gorilla to Boohoo Zoo on breeding loan without being sacked?" That's the way it goes with some of your rarer "charasmatic megavertebrates".

But there are all these problems that people have to sit down at a table and work out and it: always better that they do so in a spirit of coopera-tion and mutual interest and in the interest of the species rather than being legislated. We have worked out a number of devices to help us with that in North America and they've done the same thing in U.K. and in Europe and in Australia. The basis of all these programmes of course is a studbook with which concept you are quite familiar.

I.S.I.S. - the International Species Information System

The other key event that's become increasingly important for our ability to manage populations not only regionally but globally is the growth of I S I.S. I know many of you met Nate Fleisness, the Director of ISIS at your last meeting.

I just call your attention now to the fact that ISIS is used in 343 countries as of 2 months ago. We're adding almost 10 zoos a month now around the world. It's finally gotten out of just North America and is really becoming global. There are about 15 zoos in India that are members that I am aware of and about five of those are sending in data. I want to urge the other ten to start sending in data till you've got enough of your animals in for it to be useful to you as a tool.

It takes some initial commitment to developing your records system to serve as a base for your management to go on and then see the payoff and its going to take several years to do it. There's no point in saying its simple or easy or that its nothing other than frustrating but I think listening to your discussion on studbooks that you are going to see the value of this in a short time.

I am really delighted with the number of you that have showed an interest in ISIS and have agreed to start doing it. I think we've got something of great value together and I think this can pay off for you.

Actually you can get a payoff if you are a member by just seeing whats out there. Every member of ISIS gets a book like this twice a year called a Species Distribution Report which lists all the animals being held in all the member zoos (now nearly 350 remember) in the world. So you can see what other zoos have in surplus that you might require and what they lack that you might have and come up with an intelligent exchange proposal that might come though in months rather than years.

Any zoo interested in joining this can do so free of cost as we now have grants to make this work.

Captive Breeding Specialist Group

C.B.S.G. - The Captive Breeding Specialist Group

As I mentioned before we have this Captive Breeding Specialist Group as part of the Species Survival Commission and I want to encourage any of you if you have an interest in doing some specialised work to let me know. If I try and recruit people I don't know by mail, it doesn't really work. That's one reason I am here is to recruit people - it gives a chance to be personally known to you and personally acquainted so if you have interest and want to work we can use you.

We've got 150 members in 37 countries right now and the reason all those people are in and participating is because they've got ideas of things they want to do in the field of preserving endangered species. I would be delighted to see and help develop here an Indian sub-continent network as part of the CBSG programme.

To give a bit more background, the Captive Breeding Specialist Group applies to everything that reproduces. We advise on all matters concerning the use of captive breeding or captive propagation for conservation.

As an instrument of the International Union for Conservation of Nature (IUCN) we serve as an advisory group to the global conserveration community. Our function is to help provide the interface between the entire captive propagation community and the conservation community so naturally our membership includes many many zoo directors — for two major reasons. For one thing they represent an enormous reservoir of expertise. Second, they represent a significant reservoir of power. The power relates to their ability to commit their institutions to programmes.

Fundamentally if captive propagation is going to be used in the context of institutions that have the skills and abilities as well as the willingness and power to put these concepts into practice.

So a very important part of our function in meetings is the ability for people to make decisions and choices. Therefore, a significant portion of our membership is from the International Union of Zoo Directors IUDZG as Roger Wheater discussed. We are linked very closely to the IUDZG in our goals and objectives and the kinds of things we want to accomplish. We provide a framework for doing certain things more conveniently than any of the regional zoo associations although we work very closely with all of those.

Other members are academicians, people that are specialists in population biology in molecular genetics, in nutrition and certain types of veterinary epidemiology. We've even got some decision theorists. We've got many curators and keepers but all those people are people who have offered to work on specific projects, who want to work on programmes and to make things work.

Right now we're very flexible. We're trying to find out the best ways of making things work. There's no cost except your time and your inclination to use your time to contribute to a particular project. We do not have funds to pay to come to meetings and thats way we stage our meetings along with the IUDZG and move around the world each year with them so that in a region we attract as many people as members as can come conveniently to the meetings. But we have nearly 150 members and when we met in San Antonia, Texas, about 90 of them attended from around the world. Saudi Arabia, Korea, S. America etc.

Now we are trying to work out ways to meet regionally as well. That's one reason I am here. If members of the Indian Zoo Director's Association want to develop some programme and require the cooperation and advice of C.B.S.G., I anticipate that I myself or one of my colleagues could attend your meeting at your invitation if it was appropriate and even schedule a regional meeting for some of the things that are important globally.

Perhaps the most valuable thing about an international network is just like this meeting we can get together and talk and to try and work out programmes. So that when we have a problem or want to put together a working group we may meet 3 or 4 times a year to get a project off the ground but then it runs because the people have got something going.

The primary condition for membership is interest and expertise in regards to matters of small populations in captive propagation. But you have to tell me or one of my colleagues that your're interested. Thank you.

Management and maintenance of genetic variability in endangered species

RONALD K. CHESSER, MICHAEL H. SMITH & I. LEHR BRISBIN, JR
Savannah River Ecology Laboratory, Drawer E, Aiken, South Carolina 29801, USA

Many species have or will soon become increasingly dependent upon captive breed-breeding populations has been recognised as necessary to avoid the undesirable effects of inbreeding and drift (Falconer, 1960; Flesness, 1977; Wright, 1978). Changes in selective forces are also likely to occur anytime a species is propagated outside its natural environment (Lerner, 1954). Selection and drift, as well as their interaction, influence the success of any breeding programme, but when programmes are designed these factors are usually considered separately.

The primary objective of captive breeding is usually the continued reproduction of the species in question. Conservation of natural levels of genetic variability within each species is also desirable, especially if there is any idea of re-establishing it under natural or seminatural conditions. If genetic variability is not maintained, the end result could be a series of inbred species that are forever dependent on intensive management and energy supplements by man. Without such management, species that have lost their genetic variability are prime candidates for extinction in future variable environments (Wright, 1951). Mutation is the only way to re-establish genetic variability but, when viewed on ecologically relevant time scales, this is an extremely slow and ineffective process.

Besides mutation, three other factors, selection, genetic drift and dispersal, affect genetic variability within local populations (Smith *et al.*, 1978), and the question is how to use these to maintain variability in captively propagated species. The size and number of populations are also important in that they modify the responses to the actions and interactions of the three factors. The selection of management programmes can be misguided by an exclusive focus on the size of the population and the consequent effects of drift.

Genetic variability is defined by the occurrence of alternative forms of alleles (polymorphisms) within a population. It may be contained within a population by individuals that have at least two different alleles (heterozygotes) or by individuals which have only one allelic type (homozygotes) but not ing for their survival (Lang, 1977). The importance of maintaining large effective necessarily the same as those in other individuals. The only way that the homozygotes can persist is for populations to be organised into relatively isolated subunits, but conversely it is impossible to maintain high levels of individual heterozygosity with small isolated populations. Thus, there are two main options for maintaining genetic variation: (1) maintaining a high frequency of heterozygous individuals, or (2) maintaining isolated subunits of the population that are homozygous for one allele and other subunits that are homozygous for alternative alleles. Management for homozygosity at a large proportion of the loci can lead to difficulties associated with inbreeding depression. On the other hand, management for high individual heterozygosity in a small randomly breeding population is not effective because of drift. An appropriate management strategy is perhaps one that is some combination of these two alternatives rather than one or the other. Our purpose in this paper is to examine the ways in which changes in selective forces, drift and various breeding schemes can affect genetic variability over time and to make recommendations for management programmes aimed at maintaining genetic variability in captive species.

MAINTENANCE OF GENETIC POLYMORPHISM

The primary objective in maintaining genetic variability must be the preservation of existing polymorphisms. Polymorphisms are best maintained when individuals are reared in heterogeneous rather than homogeneous environments (Levene, 1953). Prout (1968), Deakin (1966, 1968) and Christiansen (1974, 1975) showed the importance of population subdivision, such as would occur when animals are kept in several zoos, to the maintenance of genetic polymorphisms. When the subdivisions of the overall population are maintained in different environments, both selection and drift will be important in maintaining polymorphisms. Denniston (1978), however, felt that inbreeding depression would make the continuation of such isolated subpopulations impossible. However, many threatened and/

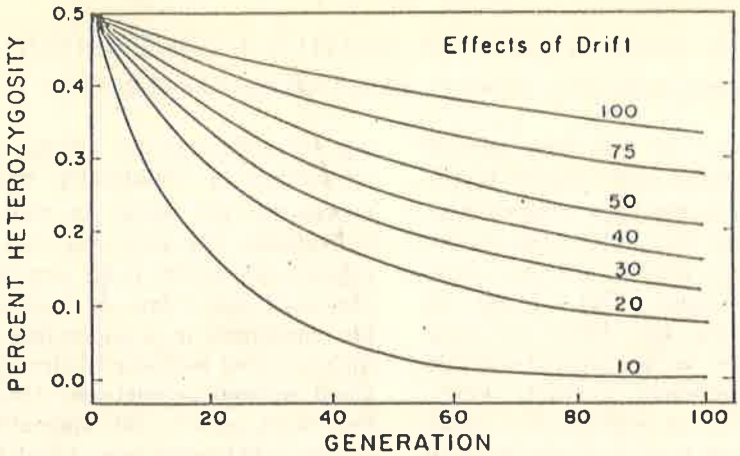


Fig. 1. Loss of heterozygosity due to genetic drift over generations in populations ranging in size from 10–100 individuals, and as indicated above each curve; 100% heterozygosity is calculated as being the case of two equally frequent alleles assuming a Hardy-Weinberg equilibrium and a 1 : 1 sex ratio.

or endangered species are already subdivided into relatively inbred lines as captive populations in zoos or reserves (Foose, 1977; Flesness, 1977). The gathering of large numbers of individuals of an endangered species at a single site is a bad management strategy from a genetic point of view, as well as increasing the risk of loss from catastrophe or disease. However, because of the manner in which resources are made available, it seems probable that a few sites will continue to be utilised for the maintenance of most endangered species presently under captive propagation. The problem therefore becomes one of managing a subdivided population for a high degree of genetic polymorphism while at the same time minimising the effects of inbreeding within each subdivision. This can be done for a given population structure by optimising effective population size and the exchange of animals among subdivisions. The effective population size (N_e) is roughly equivalent to the number of breeding individuals in a population and the exchange of breeding animals among subdivisions maintained in captivity (outbreeding) is genetically equivalent to the dispersal under natural conditions.

Loss of genetic variability occurs at a predictable rate which is inversely related to the effective population size and increases with the resultant inbreeding. In a sexually reproducing, diploid population of organisms, the probability of homozygosity (f) is described by

$$f_t = \frac{N_e - 1}{N_e} f_{t-1} + \frac{1}{2N_e} f_{t-1} \qquad (1)$$

(Crow & Kimura, 1970), where t represents the generation number. When N_e is small, the loss of heterozygosity is rapid (Fig. 1). Even in what may be considered a relatively large zoo population ($N_e = 100$), heterozygosity cannot be maintained unless other factors, such as selection, come into play. On the other hand, if different alleles become fixed in the subpopulations and no outbreeding (effective dispersal) occurs among the subdivisions, most of the polymorphism will be maintained. As outbreeding among subpopulations increases, the population essentially becomes one randomly breeding unit. Since outbreeding among subpopulations will tend to eliminate polymorphisms but is necessary to avoid excessive inbreeding, some selection for heterozygotes may be desirable.

When selection is operating, maintenance of polymorphism becomes a function of three factors: (1) the proportion of the population

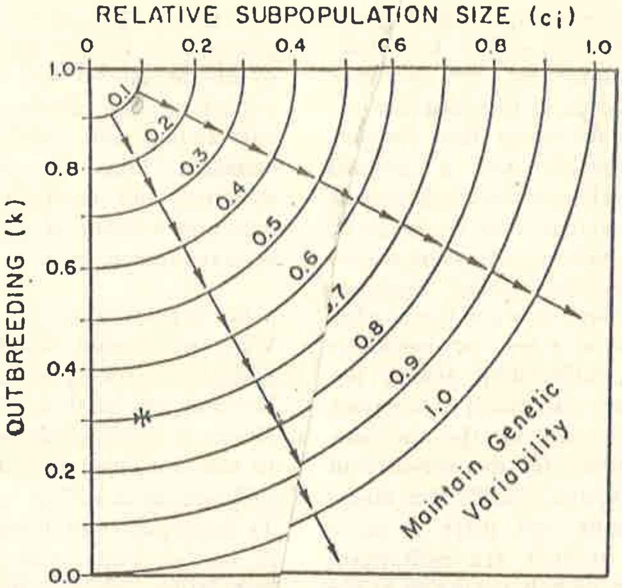


Fig. 2. Proportional degree of exchange of breedig animals or outbreeding (k) between subpopulations of different relative sizes (c_i) which will maintain gestic variability with various levels of differential selection between heterozygotes and homozygotes (w_i), agiven along each curve. For example, as indicated by the asterisk, if $w_i = 0{\cdot}70$ and the population is divid into ten equal subunits ($c_i = 0{\cdot}10$), then the maximum exchange (k) which could take place between suknits without lowering the genetic variability would be 30% of the total population.

exchanged among subdivisions (k), (2) the proportional size of the subpopulations relative to the total population (c_i = size of the ith subpopulation/total population size) ($\Sigma c_i = 1$), and (3) the fitness of the homozygotes (w_i) relative to that of the heterozygous individuals in each subpopulation. Fitness is a measure of the animal's contribution to the next generation. Polymorphism will be maintained if a subpopulation exists such that

$$1 - \frac{(1-k) + kc_i}{w_i} < 0 \qquad (2)$$

or, in general, if for any subpopulation

$$1 - w_i \geqslant k \qquad (3)$$

(Christiansen, 1974). In other words, with higher rates of exchange of animals between institutions (k), intensity of selection for heterozygotes ($1 - w_i$) must increase for polymorphisms to be maintained. If conditions for equation 2 or 3 are not met for any subpopulation then, for maintenance of polymorphism, it is sufficient that

$$1 - [\,\Sigma \frac{c_i}{1-((1-w_i)/k)}\,]^{-1} > 0 \qquad (4)$$

(op. cit). Thus, the relationships between c_i, w_i and k may not lead to maintenance of polymorphism in a particular subpopulation, but may when the summed effect of these factors is considered across all subdivisions within the total population. However, as will be discussed later, this is only true if N_e within subpopulations is not too small. Some outbreeding among subpopulations is possible while maintaining polymorphisms, but the maximum amount of exchange that can take place is contingent on the differential fitness between homozygotes and heterozygotes (Fig. 2). Equations 2, 3 and 4 are for large populations. Thus, conditions for the maintenance of polymorphism in relatively undivided populations (Fig. 2) seldom exist when N_e is small.

Selection for heterozygotes is necessary for the simultaneous maintenance of both polymorphism and population vigour. In a randomly breeding population, the selective advantage of heterozygotes (overdominance) may be important for some loci (Berger, 1976) but is probably not a general phenomenon across all loci (Cavalli-Sforza & Bodmer, 1971). If heterosis were the result of the release from inbreeding depression within isolated subpopulations, then heterosis (heterozygote advantage at many loci) rather than overdominance at a few loci would be expected. Limited outbreeding among the subpopulations would then result in heterosis and provide a mechanism for the maintenance of polymorphisms for the majority of loci. Since most captive species are maintained in small units and there is some outbreeding when animals are exchanged, selection is probably already occurring as the unplanned result of heterosis, rather than as a planned part of the management programme. In other words, the current practices employed for the maintenance of most zoo animals may not be much different from the theoretically optimal system described here for the maintenance of polymorphism.

Population subdivision may be a common phenomenon under natural conditions even for highly mobile species (Manlove *et al.*, 1976; Kleymann, 1976; Smith *et al.*, 1978). In addition, there is evidence for the effects of heterosis in natural populations where the most heterozygous animals have either higher reproductive rates (Smith *et al.*, 1975; Johns *et al.*, 1977), different levels of aggressive behaviour (Garten, 1976) and/or higher growth rates (Singh & Zouros, 1978). An overwhelming amount of evidence also exists for the positive effects of heterosis in common domestic and laboratory species (Falconer, 1960). As an example of the importance of general heterosis, let us assume a w_i value of 0·70. The maximum allowable exchange and hence outbreeding rate in a population divided into ten equal subunits ($c_i = 0{\cdot}10$) is then 0·30 if the degree of polymorphism is to be maintained (Fig. 2). If the heterosis is due to outbreeding and the elimination of inbreeding depression then this effect is temporary and cannot be maintained by further outbreeding in future generations. Ideally, the exchange of animals should be pulsed and occur at times when inbreeding has become high enough that outbreeding will yield optimum levels of heterosis. Thus, the effects of population structure and heterosis resulting from an optimum amount of outbreeding must both be taken into account.

MAINTENANCE OF HETEROZYGOSITY

With population subdivision and pulsed exchange, recovery of heterozygosity is possible and will result in a vigorous population. Within a single small population not subject to selection, loss of both heterozygosity and polymorphism will be rapid (Fig. 2, equation 1). Since pulsed exchange among inbred lines is not possible within a single undivided population, selection for heterozygotes must be more intense to maintain genetic variability. The amount of selection *(s)* at a locus under these conditions is approximated by

$$s = \frac{1}{\left(1 - \frac{1}{2N_e}\right)^t} \qquad (5)$$

(Fig. 3). In addition, the selection for heterozygotes must act on large numbers of loci simultaneously.

Other suggestions not emphasising selection, such as just increasing N_e have been made for the maintenance of genetic variability. For example, incorporating equal numbers of offspring from all possible matings (Foose, 1977; Flesness, 1977), thereby equalising family sizes (Denniston, 1978), increases N_e by reducing the variance in the number of offspring (Kimura & Crow, 1963). However, these procedures have the effect of reducing any selective advantage of heterozygotes and the increased N_e will not be sufficient to avoid ultimate fixation in most managed populations which consist of relatively few individuals. If N_e were increased from 30 to 40 by such a procedure for example, then the selection for heterozygotes would be reduced from 0·05 to 0·00 and heterozygosity would no longer be

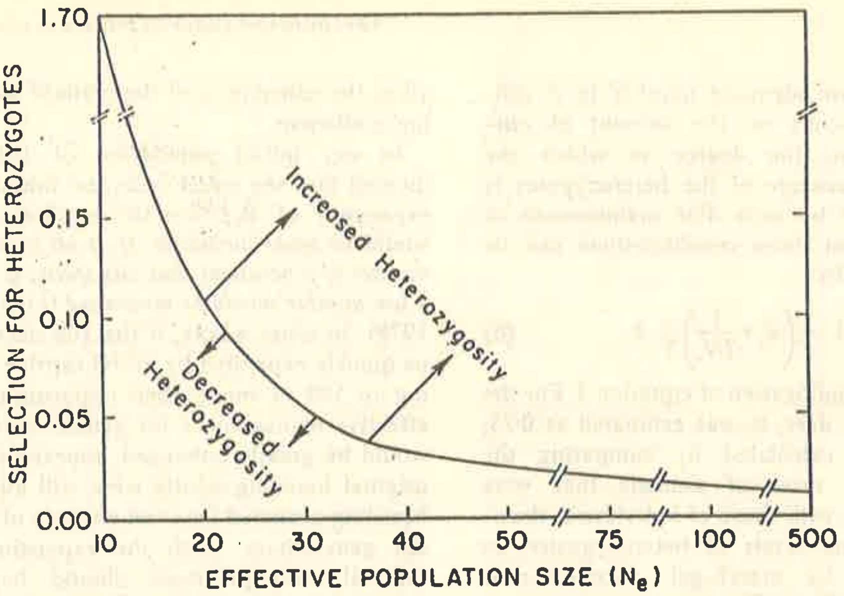


Fig. 3. Amount of selection for heterozygotes which is required to maintain a constant level of heterozygosity at various levels of effective population size. For example, with an effective population size of 30, any selection for heterozygotes less than about 0.05 will result in a loss of heterozygosity.

maintained under the new conditions (Fig. 3). In populations with very low N_e (less than 10) drift will always override selection and lead to a loss of heterozygosity (Figs 1 and 3) and/or extinction due to excessive inbreeding within the subpopulations. Subdivision of these small populations would not help since the amount of outbreeding necessary to avoid inbreeding depression would effectively result in a randomly breeding population and rapid loss of genetic variability (Crow & Kimura, 1970).

In small populations that cannot be increased in numbers for some reason, or where there is insufficient selection for heterozygotes (Fig. 3), loss of genetic variability will always occur. If the inability to increase population size is temporary then Flesness' suggestions (1977) would slow the rate of loss of genetic variability, but even so the end result, for a small population, must be the establishment of an inbred line.

EXAMPLE AND RECOMMENDATION

Since the effects of overdominance have not yet been documented for any captive endangered species, we will use data from a naturally occurring population of White-tailed deer *Odocoileus virginianus* to illustrate the development of a management programme. This species was chosen for three reasons: (1) a considerable amount is known about the multilocus genetics of its natural populations (Smith *et al.*, in press), (2) an estimate can be made for the heterosis effects that are possibly due to natural genetic subdivision and outbreeding, and (3) a number of endangered species have similar biological characteristics. Let us assume as a hypothetical case that the White-tailed deer, having become extinct in the wild has been reduced to a single zoo population of 100 breeding animals with a 1:1 sex ratio. *The first objective is to take the existing animals and distribute them into as many subpopulations as possible with each containing an adequate number of animals.* We propose that the 100 deer should be equally distributed into ten different zoos. The relatively high number of subpopulations is to ensure the maintenance of some of the rarer alleles within some of the subdivisions. The problem of what constitutes an adequate number in a subdivision depends on the amount of outbreeding and the degree to which the selective advantage of the heterozygotes is counteracted by drift. For maintenance of polymorphism these considerations can be summarised by

$$1 - \left(w_i + \frac{1}{2N_e}\right) \geqslant k \qquad (6)$$

which is a modification of equation 3. For the White-tailed deer, w_i was estimated as 0·75, which was calculated by comparing the reproductive rates of animals that were homozygous with those of individuals showing maximum levels of heterozygosity, as determined by starch-gel electrophoretic analysis of a South Carolina population.

The maximum amount of outbreeding which would maintain polymorphism in a zoo population would then be 20% of the 100 individuals in the ten subdivisions of equal size ($c_i = 0{\cdot}10$), as indicated by the ** in Table 1 which presents a generalised consideration of the problem of balancing inbreeding and outbreeding for various levels of effective heterosis. This means that up to one-fifth of the animals in the respective zoos could be transferred between them whenever the reproductive rate in the subdivisions approaches 0·75 of the initial average reproductive rate across all subdivisions. If, by some chance, certain of the subpopulations are more dissimilar than others, then, to achieve maximum heterosis exchanges should take place between them rather than between more similar subpopulations (Falconer, 1960). *The amount of outbreeding necessary to maintain genetic variability is determined by the N_e of the respective subdivisions and of the total population and the rate at which inbreeding accumulates over generations. In addition outbreeding should be pulsed, with exchanges of breeding animals between zoos occurring at times during which the greatest reversal of the inbreeding depression can be achieved by outbreeding.* This time will be determined by the occurrence of signs of inbreeding depression in the subpopulations. Use of electrophoretic techniques, such as described in Manlove *et al.* (1975), would allow the calculation of the realised inbreeding coefficient.

In our initial population of 100 deer divided into ten equal units, an initial rapid expansion of the overall population size would be most desirable. *If at all possible the number of generations that any species is kept at a low number should be minimised* (Denniston, 1978). In other words, if the 100 deer could be quickly expanded by initial captive breeding to 500 or more, then opportunities for effective management for genetic variability would be greatly enhanced, especially if the original breeding adults were still alive and breeding occurred between animals of different generations. With the expansion, additional subpopulations should begin to be established. Both Père David's deer *Elaphurus davidianus* and the Przwalski horse *Equus przewalskii* have undergone rapid population growth in zoos (Foose, in press; Flesness, 1977) and application of this principle seems warranted now. *The choice of animals as breeders in the new subpopulations or as outbreeders for exchange should be at random, with the restriction that approximately equal proportions of animals should come from each subpopulation over longer time intervals.* All of the animals chosen for outbreeding could be of one sex with the other sex remaining stationary and this could lead to enhanced effects of selective differences due to local environments in the various zoos. If ♂♂ were chosen, the costs of transporting sperm for artificial insemination would be much lower than transportation of animals. However, in this case, the effects of selection due to intrapopulational competitive interactions would be lost.

Successful expansion of the total captive population creates the option of expanding the size of the subunits rather than creating more of them. *In general ten individuals should be viewed as the minimum number required.* With a relatively low selective advantage for the heterozygotes, maintenance of polymorphism with fewer than ten individuals in a subdivision is impossible (Table 1, Fig. 3). The rate at which the inbreeding depression grows decreases as the number of individuals within the subdivisions increases and the

	TOTAL EFFECTIVE POPULATION SIZE 20		50		100		300	
w_i	5	10	5	10	5	10	5	10
0·95	−0·08*	−0·20*	0·00	−0·05*	0·02	0·00	0·04	0·03
0·90	−0·02*	−0·15*	0·05	0·00	0·08	0·05	0·09	0·08
0·85	0·02	−0·10*	0·10	0·05	0·12	0·10	0·14	0·13
0·80	0·08	−0·05*	0·15	0·10	0·18	0·15	0·19	0·18
0·75	0·12	0·00	0·20	0·15	0·22	0·20**	0·24	0·23
0·70	0·18	0·05	0·25	0·20	0·28	0·25	0·29	0·28

* Maintenance of polymorphism may be impossible.

** In the hypothetical example developed in the text, a maximum of 20% of a population of 100 White-tailed deer, equally divided among ten zoo subpopulations and showing a relative fitness of 0·75 for homozygotes, could be exchanged between collections without affecting the maintenance of genetic polymorphisms.

Table 1. The maximum amount of exchange of breeding animals or outbreeding (k) necessary for the maintenance of genetic polymorphism within each subpopulation with various total effective population sizes (N_e) and varying relative fitness levels of the homozygotes (w_i). In each case the total population has been divided into groups of five and ten animals. The k values were calculated according to equation 6.

interval between the pulses of outbreeding becomes longer. One advantage of increasing population sizes without increasing the number of subpopulations is that the lower rate of outbreeding necessary reduces transportation costs. Furthermore, the larger the population the less chance there is of inbreeding depression accumulating to a critical point before the problem can be detected.

The creation of isolated subpopulations in zoos and reserves is an effective method for maintaining genetic variability within species, while limited movements of individuals between subpopulations can serve as an effective means of maintaining existing polymorphisms. Moreover, the economics of the management strategy outlined above are more favourable than those for other more complex proposals, where conscious, artificial selection may need be implemented (Flesness, 1977; Foose, 1977; Denniston, 1978). Continued management does require the periodic break up of inbred groups, but this is already an accepted practice. The proposed system is very similar to that already in use and, moreover, is similar to that found in natural populations.

Although present management programmes are often the result of financial and logistical constraints imposed without any apparent biological reasoning, we suggest that the current system be recognised as being a valid approach but that, wherever possible, it be modified to take into account the important biological considerations outlined in this paper.

ACKNOWLEDGEMENTS
We wish to thank James Joule, E. Gus Cothran, Karen Stueck and Nils Ryman for critical readings of this manuscript. Financial support was obtained through contract number DE–AC09–76SR00819 between the U.S. Department of Energy and the University of Georgia.

REFERENCES

BERGER, E. (1976): Heterosis and the maintenance of enzyme polymorphism. *Am. Nat.* 110: 823–839.

CAVALLI-SFORZA, L. L. & BODMER, W. F. (1971): *The genetics of human populations.* San Francisco: Freeman.

CHRISTIANSEN, F. B. (1974): Sufficient conditions for protected polymorphism in a subdivided population. *Am. Nat.* 108: 157–166.

CHRISTIANSEN, F. B. (1975): Hard and soft selection in a subdivided population. *Am. Nat.* 109: 11–16.

CROW, J. F. & KIMURA, M. (1970): *An introduction to population genetics theory.* New York: Harper and Row.

DEAKIN, M. A. B. (1966): Sufficient conditions for genetic polymorphism. *Am. Nat.* 100: 690–692.

DEAKIN, M. A. B. (1968): Genetic polymorphism in a subdivided population. *Aust. J. biol. Sci.* 21: 165–168.

DENNISTON, C. (1978): Small population size and genetic diversity. Implications for endangered species. In *Endangered birds. Management techniques for preserving threatened species:* 281–290. Temple, S. A. (Ed.). Madison: Univ. of Wisconsin.

FALCONER, D. S (1960): *Introduction to quantitative genetics.* New York: Ronald.

FLESNESS, N. R. (1977): Gene pool conservation and computer analysis. *Int. Zoo Yb.* 17: 77–81.

FOOSE, T. J. (1977): Demographic models for management of captive populations. *Int. Zoo. Yb.* 17: 70–76.

FOOSE, T. J. (in press): Demographic and genetic status and management of Père David's deer (*Elaphurus davidianus*). *Biol. Captive Mgmt.*

GARTEN, C. T. (1976): Relationships between aggressive behaviour and genic heterozygosity in the oldfield mouse. *Evolution* 30: 59–72.

JOHNS, P. E., BACCUS, R., MANLOVE, M. N., PINDER, J. E., III & SMITH, M. H. (1977): Reproductive patterns, productivity and genetic variability in adjacent white-tailed deer populations. *Proc. Conf. Southeast. Assn. Game Fish Commnrs* 31: 167–172.

KIMURA, M. & CROW, J. F. (1963): The measurement of effective population number. *Evolution* 17: 279–288.

KLEYMANN, V. M. (1976): Beiträge zur kenntnis der Infrastrukturen bein Rotwild. III. Zur Genetischen struktur von Rotwildpopulationen anhand von Blutgruppenvergleichsuntersuchungen. *Z. Jagdwiss.* 22: 121–134.

LANG, E. M. (1977): What are endangered species? *Int. Zoo Yb.* 17: 2–5.

LERNER, I. M. (1954): *Genetic homeostasis.* New York: Wiley.

LEVENE, H. (1953): Genetic equilibrium when more than one ecological niche is available. *Am. Nat.* 87: 331–333.

MANLOVE, M. N., AVISE, J. C., HILLESTAD, H. O., RAMSEY, P. N., SMITH, M. H. & STRANEY, D. O. (1975): Starch gel electrophoresis for the study of population genetics in white-tailed deer. *Proc. Conf. Southeast Assn. Game Fish Commnrs* 29: 392–403.

MANLOVE, M. N., SMITH, M. H., HILLESTAD, H. O., FULLER, S. E., JOHNS, P. E. & STRANEY, D. O. (1976): Genetic subdivision in a herd of white-tailed deer as demonstrated by spatial shifts in gene frequencies. *Proc. Conf. Southeast Assn. Game Fish Commnrs* 30: 487–492.

PROUT, T. (1968): Sufficient conditions for multiple niche polymorphism. *Am. Nat.* 102: 493–496.

SINGH, S. M. & ZOUROS, E. (1978): Genetic variation associated with growth rate in the American oyster (*Crassotrea virginica*). *Evolution* 32: 342–353.

SMITH, M. H., BACCUS, R., HILLESTAD, H. O. & MANLOVE, M. N. (in press). Population genetics of the white-tailed deer. In *Biology of the white-tailed deer.* Halls, L. K. (Ed.).

SMITH, M. H., GARTEN, C. T. & RAMSEY, P. E. (1975): Genetic heterozygosity and population dynamics in small mammals. In *Isozymes 4, genetics and evolution.* Markert, C. L. (Ed.). New York: Academic Press.

SMITH, M. H., MANLOVE, M. N. & JOULE, J. (1978): Spatial and temporal dynamics of the genetic organization of small mammal populations. In *Populations of small mammals under natural conditions.* Snyder, D. P. (Ed.). Pittsburg: Univ. of Pittsburg.(The Pymatuning Symp. Ecol.)

WRIGHT, S. (1951): The genetical structure of populations. *Ann. Eugen.* 15: 323–354.

WRIGHT, S. (1978): *Evolution and the genetics of populations. Variability within and among natural populations.* Chicago: Univ. of Chicago.

Deleterious effects of inbreeding in a herd of captive Dorcas gazelle

Gazella dorcas

KATHERINE RALLS, KRISTIN BRUGGER & ADAM GLICK

Department of Zoological Research, National Zoological Park, Smithsonian Institution, Washington, DC 20008, USA

Many studies on laboratory and domestic animals have shown that inbreeding usually leads to a reduction in viability and fertility (Falconer, 1961; Wright, 1977; Lasley, 1978). Inbreeding causes an increase in homozygous genotypes which, together with the general tendency for deleterious alleles to be recessive and the occurrence of overdominance at some loci, provides the genetic basis of the deleterious effects. Characters expressed early in life, such as survival after birth and growth rate to weaning, are usually more severely affected by inbreeding than characters which develop later in life and contribute little to fitness, such as feed-lot performance or carcass quality (Falconer, 1961; Lasley, 1978).

Several authors have been concerned about the possible deleterious effects of inbreeding on zoo animals (Flesness, 1977; Seal, 1978; Senner, 1980). However, the main thrust of this work has been to provide theoretical models, through computer simulations, of the genetic results to be expected from various breeding practices. Few actual cases of inbreeding depression in zoo animals have been documented. Because many zoos have not kept detailed parentage records, studies of the effects of inbreeding have, for the most part, been possible only in species for which a studbook is maintained. Thus Bouman (1977) was able to show that highly inbred Przewalski horse *Equus przewalskii* mares produce fewer foals than less inbred mares and Seal (unpubl.) was able to assess the deleterious effects of inbreeding in tigers *Panthera tigris*. Adverse effects have also been reported in a highly inbred herd of captive Eland *Taurotragus oryx* for which careful records were kept (Treus & Lobanov, 1971).

The National Zoological Park, Washington, has kept unusually complete records on many species maintained in its collection. A survey of these records provided data on 12 ungulate species; data on four more were obtained from other sources. In 15 of the 16 species juvenile mortality of inbred young was higher than that of non-inbred young (Ralls *et al.*, 1979). However, further investigation seemed necessary because of the many other variables which might influence

INBREEDING COEFFICIENT	FEMALE	PERIOD IN BREEDING HERD	AGE AT FIRST CONCEPTION (days)	YEARS BET FIRST/LAST BIRTH	NO OF BIRTHS	NO OF SURVIVING YOUNG	BIRTHS PER YEAR	SURVIVING YOUNG PER YEAR
0	Granny	1960–74	unknown	10·04	13	7	1·3	0·70
0	Reem	1961–73	190	11·20	14	6	1·25	0·54
0	Greeny	1962–77	599	13·4	19	14	1·41	1·04
0·25	Whitey	1962–75	247	9·04	11	3	1·21	0·33
0	Holiday	1966–71	685	2·43	3	0	1·23	0
0·25	Kelly	1968–75	1143	2.64	2	0	1·32	0
0·125	Dottie	1970–	900	4·7	7	4	1·50	0·85
0·25	Judy	1971–76	969	0·96	2	2	2·08	2·08
0	Flame	1972–	462	4·3	7	4	1·62	0·93
0	Christmas	1972–	unknown	4·3	8	8	1·86	1·86
0	Gretchen	1975–	669	1·08	2	2	1·85	1·85
0	Daffodil	1975–	635	1·03	2	2	1·94	1·94
0	Crinkle	1975–	418	1·13	2	1	1·77	0·88
INBRED ♀♀ (4)		mean	815			mean	1·53	mean 0·82
NON-INBRED ♀♀ (9)			523				1·58	1·08

Table 1. Breeding records of inbred and non-inbred Dorcas gazelle *Gazella dorcas* ♀♀ at the National Zoological Park, Washington.

juvenile mortality, such as birth season, management improvements, birth order of the young, and possible differences between wild and captive-born ♀♀.

We report here on a detailed investigation of the effects of inbreeding in the Dorcas gazelle *Gazella dorcas*. We selected this species for further study because it had produced the most offspring of any of the NZP species and both medical and management records were available.

MATERIALS AND METHODS

Data on the parentage, longevity, and cause of death of the 93 gazelle calves born from 1960–1978 were compiled from NZP records. One stillborn calf was not included in the study because its parentage was unknown. Inbreeding coefficients were calculated by hand for the remaining 92 calves using the simple formula $\frac{1}{2}\Sigma[(\frac{1}{2})^n]$, where n is the number of steps in a path relating one parent of the individual whose coefficient is being calculated to a common ancestor back to the second parent (Lasley, 1978).

We refer to specific animals by name in the text. Males used as sires were: 'Pappy'; 'Black-and-White'; 'Red'; 'Blue'; 'Detroit'; and 'San Antonio'. Names of ♀♀ are given in Table 1.

The herd was founded in 1960 with a single pair. These animals ('Granny' and Pappy) were assumed to be unrelated although, since both were a gift from the President of Tunisia, there is a possibility of some relationship. Only three individuals from outside sources ('Christmas', Detroit and San Antonio) have been introduced since the herd was founded; these were assumed to be unrelated to the original stock. The assumption is probably true for the ♀ Christmas, which was wild caught, and also for the ♂ Detroit, which was obtained from the Detroit Zoo in 1971. The NZP did not send any animals to Detroit Zoo until late in 1970 and this ♂, at the time of his arrival at NZP, was estimated already to be 12–18 months old. However, the assumption of unrelatedness is almost certainly not true in the case of the ♂ San Antonio, which was obtained from the San Antonio Zoo in 1976, as the founders of the latter herd were a pair that originated from NZP in 1964. Because of these assumptions our inbreeding coefficients may in some cases be slight underestimates.

	INBRED CALVES	NON-INBRED CALVES	n	χ^2	p
Data from all 13 ♀♀					
No. lived	17	36	92	9·29	0·003
No. died	25	14			
Data from 11 NZP-born ♀♀ only					
No. lived	15	23	71	7·89	0·005
No. died	24	9			

Table 2. Comparison of juvenile mortality (under six months of age) amongst inbred and non-inbred calves.

For the purpose of comparing juvenile mortality rates in inbred and non-inbred calves we divided the calves into only two categories: 'non-inbred calves' which consisted of those with 'unrelated' parents (inbreeding coefficient of 0) and 'inbred calves' which consisted of those with an inbreeding coefficient greater than 0. Two of the inbred calves had inbreeding coefficients of 0·125; all the rest had inbreeding coefficients of 0·25 or more.

The calves were also divided into two categories on the basis of longevity: those that survived six months or more and those that survived less than six months. The latter group was considered to represent 'juvenile mortality' and included premature births, stillborns, and live-born calves dying of all causes.

The causes of death listed in zoo records were classified into seven categories: premature, stillborn, perinatal - cause undetermined, inanition, miscellaneous, trauma, and unknown. The 'perinatal - cause undetermined' category includes all calves dying from unknown causes within ten days of birth. In some of these cases no necropsy records were found; in others, a necropsy was performed but no evident cause of death was discovered. The term 'inanition' refers to a lack of vigour or vitality, often resulting from lack of food or liquids. Inanition usually occurs because a calf is too weak to suckle properly and/or receives inadequate maternal care. These two events are often related, because a ♀ may refuse to care for a weak or lethargic calf. Weak calves may also be injured by their mother or other animals in the enclosure. Most traumas to older calves occur when surplus animals must be caught and removed to unfamiliar environments. Traumatised animals may subsequently develop inanition. It is thus not surprising that several records listed both 'inanition' and 'trauma' as causes of death. We classified these cases under whichever factor seemed to have occurred first. The 'miscellaneous' category consists of miscellaneous medical problems and infections. The 'unknown' category consists of one animal which died at 90 days of age for which we found no record of the cause of death.

We also calculated *total* perinatal mortality in order to compare our results with those of Benirschke *et al.* (in press). As in their work, we considered *total* perinatal mortality to consist of premature births, stillborns, perinatal deaths of undetermined cause, and calves which died of any cause before 11 days of age.

RESULTS

Thirty-nine calves died before the age of six months. More inbred (25) than non-inbred (14) calves died, in spite of the fact that fewer inbred (42) than non-inbred (50) calves were born. The mortality rate of the inbred calves was 31% higher than that in non-inbred calves and the difference was statistically significant (Table 2).

The number of births and the number of juvenile deaths in the Dorcas gazelle herd at NZP for each year from 1961 to 1978 are shown in Fig. 1. Juvenile mortality was initially low, increased gradually to high levels in the early 1970's and declined substantially after 1972.

The herd consisted entirely of the original pair (Granny and Pappy) and/or their descendants until 1972, when a wild-caught ♀ (Christmas) and a ♂ from the Detroit Zoo (Detroit) were added to the group. Until the arrival of Detroit, all calves had been sired

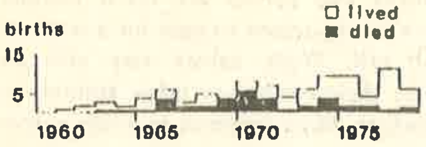


Fig. 1. Number of births and juvenile deaths in the NZP herd from 1961 to 1978.

either by Pappy or one of his sons: Black-and-White, Red, and Blue (Fig. 2). By 1969, most calves born were inbred and the juvenile mortality rate was high. The introduction of the new animals in 1972 was correlated with an immediate decrease in both the number of inbred calves born and the juvenile mortality rate (Figs 1 and 2).

However, several management changes introduced at about this time might have contributed to the decrease and should be taken into account. A programme of neonatal care, consisting of an intramuscular injection of a long-acting penicillin and the application of an iodine preparation to the remaining portion of the umbilical cord, was initiated for all NZP ungulates in the spring of 1972. Juvenile mortality rates of inbred and non-inbred calves born before and after the initiation of this programme are shown in Table 3. While the mortality of non-inbred calves was lower in those born after the programme started than in those born before (that of the latter being due in three of five deaths to trauma), the mortality rate of

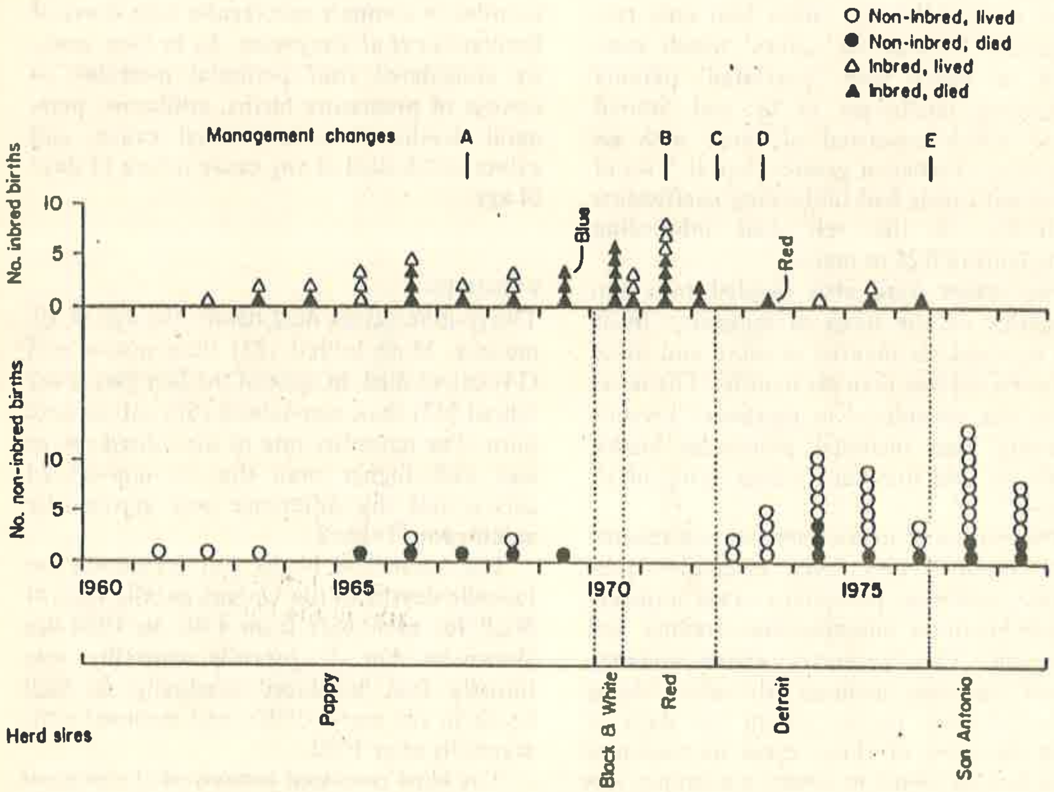


Fig. 2. Births and juvenile deaths in relation to inbreeding and to management changes. Management changes are indicated as follows: A. herd moved to new enclosure; B. selenium/vitamin E added to diet; C. unrelated ♂ 'Detroit' introduced as herd sire; D. herd moved to new enclosure; E. unrelated ♂ 'San Antonio' introduced as herd sire after death of Detroit. All calves born during a given year are shown as a single column except for 1970 births which are divided into two groups, those sired by 'Black-and -white' and those sired by 'Red'. Calves were all fathered by the herd sire shown, with the exception of a single calf fathered by Red during Detroit's tenure as herd sire.

CALF NO.	INBRED ♀♀ BORN IN NZP				NON-INBRED ♀♀ BORN IN NZP							NON-INBRED ♀♀ REC'D AS ADULTS*	
	Whitey	Dott	Judy	Kelly	Greeny	Reem	Flame	Hol'y	Daff	Gret	Crink	Granny	Ch'mas
1	I/D	N/L	N/L	I/D	I/D	I/L	I/L	I/D	N/L	N/L	N/L	N/L	N/L
2	I/L	N/L	N/L	N/D	I/L	I/D	I/L	I/D	N/L	N/L	N/D	N/L	N/L
3	I/D	N/L			I/L	I/L	I/D	I/D				N/L	N/L
4	I/D	N/D			I/L	I/L	I/D					N/D	N/L
5	I/D	N/D			I/D	I/L	N/L					N/D	N/L
6	I/D	N/D			I/L	I/D	N/L					N/L	N/L
7	N/L	N/L			I/D	I/D	N/D					N/D	N/L
8	N/L				I/D	I/L						N/L	N/L
9	N/D				I/D	I/D						N/D	
10	N/D				I/L	I/D						N/D	
11	N/D				I/L	I/L						I/D	
12					N/L	I/D						I/L	
13					N/L	I/D						I/L	
14					N/L	I/D							
15					N/L								
16					N/L								
17					N/L								
18					N/L								
19					N/L								

*These ♀♀ may not have been primiparous when they produced their first calves at NZP.

Table 5. Breeding records of individual ♀ gazelles. I = inbred; N = non-inbred; L = lived; D = died.

The second possibility examined was that most of the inbred calves were firstborns and that the observed difference in juvenile mortality rate thus reflected superior survivorship of calves born to multiparous mothers rather than superior survivorship of non-inbred calves. (This seemed possible because perinatal mortality in many mammal species, including cattle, is known to be higher in the firstborn young (Hafez, 1968)). However, examination of the breeding records of the individual ♀♀ (Table 5) and a simple tabulation of the data showed that this was not the case (Table 6). The mortality rate of inbred calves born to primiparous mothers was slightly higher than that of those born to multiparous mothers. However, all of the firstborn calves which died were inbred and the mortality rate of inbred calves born to multiparous mothers was 26% higher than that of non-inbred calves born to multiparous mothers. The exclusion of data from the two ♀♀ which were received as adults (it being uncertain whether or not they were primiparous at the time of their first calving at NZP) did not appreciably change the results (Table 6).

Inbreeding coefficients of the individual ♀♀ are shown in Table 1. Four of the breeding ♀♀ born at NZP were themselves inbred. Only one of seven inbred calves born to inbred ♀♀ survived (Table 5), suggesting that inbred calves born to inbred mothers might have a particularly low chance of survival. However, six of the seven cases were offspring of 'Whitey' and non-inbred calves born to this ♀ also had a high mortality rate.

The breeding performances of inbred and non-inbred ♀♀ are compared in Table 1. Inbred ♀♀ did not conceive successfully until an average age of 815 days while non-inbred ♀♀ first conceived at an average of 523 days. This difference was not statistically significant at the 0·05 level (Mann-Whitney U test, one-tailed). Because of their relatively advanced age at first conception, inbred ♀♀ produced fewer young per year spent in the breeding herd. Once they gave birth, however, they produced young at the same rate as non-inbred ♀♀. Inbred ♀♀ produced an aver-

	INBRED CALVES			NON-INBRED CALVES		
	NO. BORN	NO. DIED	% JUVENILE MORTALITY	NO. BORN	NO. DIED	% JUVENILE MORTALITY
Offspring born:						
before NCP	36	21	58	10	5	50
after NCP	6	4	67	40	9	23

Table 3. Comparison of juvenile mortality amongst inbred and non-inbred calves before and after the initiation of the neonatal care programme.

inbred calves showed no marked change and remained high.

The pattern of births and juvenile deaths in relation to both inbreeding and management changes is shown in Fig. 2. Moves to new and larger enclosures in 1967 (A) and 1973 (D) did not produce any noticeable reduction in the rate of juvenile mortality, nor did dietary supplements introduced in 1971 (B). Selenium and vitamin E had been added to the diet at this time following upon the diagnosis of a deficiency of these substances in many of the ungulate species at NZP (Sauer & Zook, 1972). The addition did not produce any immediate reduction in the rate of juvenile mortality but may have contributed to the higher survival rate of non-inbred calves born after the initiation of the neonatal care programme. Intestinal parasites in the gazelle herd are one of the NZP's most chronic problems. Intense efforts have succeeded in some measure of control but have not yet eradicated them, and it seems unlikely the treatment was responsible for the reduction in juvenile mortality after 1972. The distribution of births by month was similar in inbred and non-inbred calves and many of the inbred calves which died were born in the warm months of March, April and May (Table 4).

Two additional analyses were performed in order to explore the possibility that the difference in mortality rates between inbred and non-inbred calves was due not to inbreeding *per se* but to some other variable with which inbreeding happened to be associated. The first possibility examined was that the non-inbred calves were born primarily to imported ♀♀ and the inbred calves were born primarily to captive-born ♀♀. If this were true, the difference in juvenile mortality rates might reflect some difference between imported and captive-born ♀♀, such as superior maternal performance by imported ♀♀, rather than superior survivorship of non-inbred calves. The origins and breeding records of the individual ♀♀ are shown in Table 5. Eleven of the 13 ♀♀ were born at NZP. When the analysis was repeated using only the data from these ♀♀, the results were similar to those obtained using the entire data set and remained statistically significant (Table 2), thus excluding the possibility that the observed difference in juvenile mortality rates, reflected some difference between imported and captive-born ♀♀.

MONTH OF BIRTH	INBRED CALVES		NON-INBRED CALVES	
	LIVED	DIED	LIVED	DIED
Jan	0	0	1	1
Feb	0	0	2	0
Mar	4	5	5	1
Apr	1	4	6	3
May	4	5	6	3
Jun	1	2	6	2
Jul	0	3	0	1
Aug	2	1	0	0
Sep	2	1	3	1
Oct	2	3	5	1
Nov	0	0	1	1
Dec	1	1	1	0
Total	17	25	36	14

Table 4. Distribution of juvenile mortality in inbred and non-inbred calves according to month of birth.

	INBRED CALVES			NON-INBRED CALVES		
	NO. BORN	NO. DIED	% JUVENILE MORTALITY	NO. BORN	NO. DIED	% JUVENILE MORTALITY
Data from all 13 ♀♀						
Primiparous	6	4	67	7	0	0
Multiparous	36	21	58	43	14	32
Data from 11 NZP-born ♀♀ only						
Primiparous	6	4	67	5	0	0
Multiparous	33	20	61	27	9	33

Table 6. Comparison of juvenile mortality amongst inbred and non-inbred calves born to primiparous and multiparous mothers.

age of only 0·82 surviving young per year and non-inbred ♀♀ an average of 1·08 (Table 1), even though the proportion of inbred young born to inbred ♀♀ (7 : 22) was smaller than that born to non-inbred ♀♀ (35 : 70) (Table 5). This difference in rate of production of surviving young was also not statistically significant at the 0·05 level (Mann-Whitney U test, one-tailed).

Cause of death in relation to inbreeding and age is shown in Fig. 3. Sixty-nine percent (27/39) of the juvenile mortality occurred within ten days of birth. The total perinatal mortality rate for the gazelles was 29%, which is considerably higher than the average rates of 18% for all artiodactyls and 19% for all bovids reported from the San Diego Zoo (Benirschke *et al.*, in press). The total

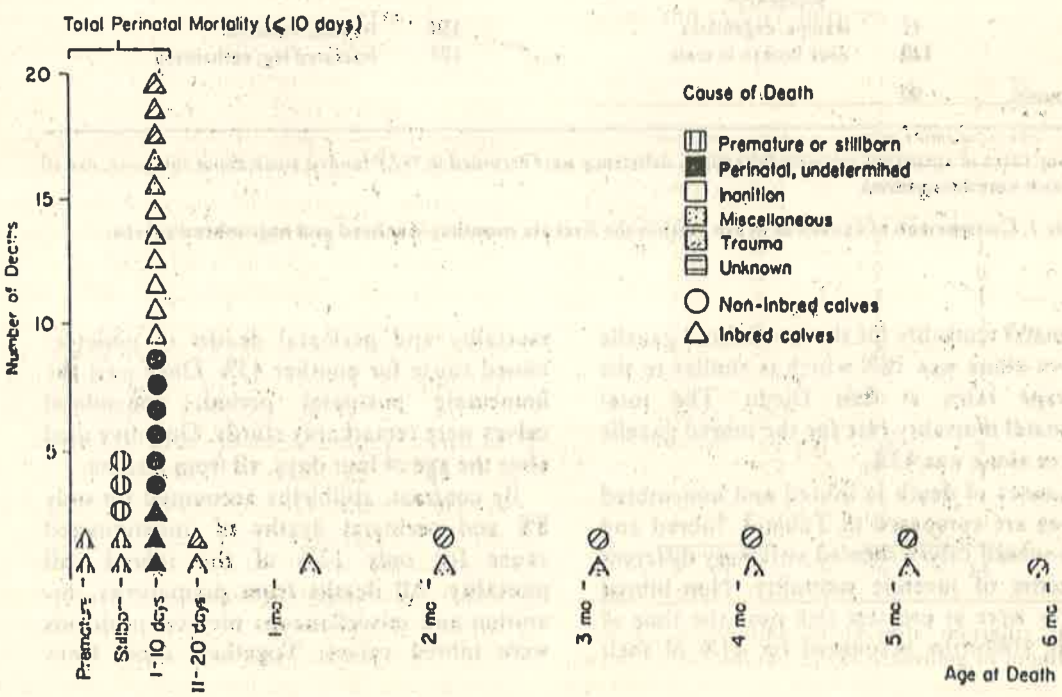


Fig. 3. Causes of death in calves in relation to inbreeding and age.

	INBRED CALVES		NON-INBRED CALVES	
	AGE (days)	DIAGNOSIS	AGE (days)	DIAGNOSIS
Premature	(2 births)			
Stillborn	(2 births)		(3 births)	
Perinatal—cause undetermined	1	found dead	1	perinatal, not evident
	1	found dead	1	perinatal, not evident
	3	stress, failure to thrive	1	perinatal, not evident
			2	perinatal, not evident
			4	hand-reared
			4	stress, failure to thrive
Inanition	1	Se/vit E deficiency*		
	1	inanition		
	2	stress and starvation		
	2	failure to nurse		
	4	inanition, trauma, enteritis		
	6	inanition		
Miscellaneous	1	impacted terminal colon		
	5	pneumonia, hepatitis		
	17	pneumonia, hepatic necrosis, skeletal muscle myopathy		
	45	digestive colitis		
	75	endocardiosis, cholangitis, ureteritis		
	150	nematodiasis, skeletal muscle myopathy, cardiac myopathy		
Trauma	1	killed by ♂ waterbuck	60	broken neck
	1	subdural haematoma	90	trauma, inanition
	1	trauma, cagemates, Se/vit E deficiency*	119	pelvic fracture, euthanised
	12	trauma, cagemates	150	trauma, inanition
	120	neck broken in crate	177	fractured leg, euthanised
Unknown	90			

*Many cases of suspected selenium/vitamin E deficiency were recorded in NZP hoofed stock about this time, not all of which were documented.

Table 7. Comparison of causes of death (within the first six months) in inbred and non-inbred calves.

perinatal mortality for the non-inbred gazelle calves alone was 18% which is similar to the average rates at San Diego. The total perinatal mortality rate for the inbred gazelle calves alone was 43%.

Causes of death in inbred and non-inbred calves are compared in Table 7. Inbred and non-inbred calves showed strikingly different patterns of juvenile mortality. Non-inbred calves were at greatest risk near the time of birth: stillbirths accounted for 21% of their mortality and perinatal deaths of undetermined cause for another 43%. Once past the immediate postnatal period, non-inbred calves were remarkably sturdy. Only five died after the age of four days, all from trauma.

By contrast, stillbirths accounted for only 8% and perinatal deaths of undetermined cause for only 12% of the inbred calf mortality. All deaths from prematurity, inanition and miscellaneous medical problems were inbred calves. Together, these three categories of mortality not found in the non-inbred calves accounted for 56% of the inbred calf mortality.

DISCUSSION

Wright's early experiments clearly demonstrated that inbred strains of guinea pigs tended to be inferior to non-inbred strains in number of young born, percentage of young born alive, and percentage of young born alive which survived to 33 days of age (Wright, 1922). This general pattern of decreased fertility and increased juvenile mortality as a consequence of inbreeding was subsequently found in many other mammalian species including humans, mice, rabbits, pigs, sheep, beef cattle, and dairy cattle. Wright (1977) gives an excellent summary of much of this experimental evidence.

A recent review of the effects of inbreeding in livestock is given by Lasley (1978), who concludes: 'Studies to date point out rather conclusively that increased inbreeding (or homozygosity) is accompanied by a decline in traits closely related to physical fitness. Among such traits are fertility, mothering ability, viability, and growth rate.'

The NZP Dorcas gazelle herd thus showed two typical deleterious effects of inbreeding: increased juvenile mortality in the calves and decreased fertility in the inbred ♀♀. The conclusion that much of the juvenile mortality in the gazelle herd was due to inbreeding seems inescapable: the higher mortality rate of the inbred calves was statistically significant; improvements in management over the years, except for the introduction of unrelated animals into the group, had little effect on juvenile mortality; and possible confounding effects of differences between calves of imported and captive-born ♀♀ and calves of primiparous and multiparous ♀♀ were excluded. The decreased fertility of the inbred ♀♀ was caused by two effects: increased age at first conception and reduced survivorship of their young, which were not statistically significant. This may have been due to the small sample size: we had data on the breeding records of only 13 ♀♀ whereas we had survivorship data on 92 births. It seems probable that inbred ♀ gazelles are in fact less fertile than non-inbred ♀♀ as has been found in so many other mammalian species.

Inbred calves succumbed to three causes of death not recorded for non-inbred calves: prematurity, inanition, and a variety of miscellaneous medical problems and infections. Many of the adverse effects of inbreeding are due to several pairs of recessive genes affecting the same trait. Although each pair of genes may have only a slightly deleterious effect, their combined effects produce an animal which, to quote a current textbook on livestock genetics, is 'usually less able to cope with its environment than are non-inbred animals' (Lasley, 1978). The large proportion of inbred gazelle calves dying from inanition and miscellaneous medical problems and infections clearly illustrates this reduced 'coping' ability. Calves dying of inanition are often small and weak. Genetic factors are known to influence susceptibility to many non-infectious and infectious diseases in both domestic animals (Lasley, 1978) and humans (Cavalli-Sforza & Bodmer, 1971). It is usually not the disease itself which is inherited but a weakness in the body which increases the probability that the disease will appear. Many examples may be found in Cavalli-Sforza & Bodmer (1971), who also illustrate the way in which inbreeding can increase susceptibility to disease (threshold model of disease). It is thus not surprising that many inbred gazelle calves died from miscellaneous medical problems and infections.

All calves recorded as suffering from selenium/vitamin E deficiency, and/or skeletal muscle dystrophy, which Sauer & Zook (1972) list as a lesion associated with selenium/vitamin E deficiency, were inbred. As noted on Table 7, not all cases given this diagnosis were actually documented. Sauer & Zook (1972) list the clinical signs of selenium/vitamin E deficiency as follows: failure to conceive, stillbirths, juvenile deaths, low birth weights, retarded growth, and transient and shifting lameness in both juveniles and adults. All of these signs, except the last, are also typical signs of inbreeding. Inbred calves may be more susceptible to selenium/vitamin E deficiency; it is also possible that some of the cases given this diagnosis may have simply been small, weak inbred calves.

Our results clearly show the value of keeping detailed records at zoos. Births of inbred and non-inbred animals are usually spread over a number of years, which may greatly exceed the period for which any individual staff member is directly involved with a particular species. Under these conditions, even a considerably higher mortality rate in inbred animals may remain undetected unless records are carefully maintained and analysed.

The NZP Dorcas gazelle herd has generally been regarded as a successful breeding group, which in fact it has been. Ninety-three calves have been born over an 18-year period, and so many young animals have been sent to other zoos that most of the Dorcas gazelles in the United States are related to the NZP herd. The herd should be even more productive in the future, as NZP plans to import two new ♂♂ in 1980 to combat the inbreeding problem.

ACKNOWLEDGEMENTS

We thank the many NZP staff members who recorded data over the years; Judith Block for her care in maintaining the animal records and her assistance in using the files; Mitchell Bush and David Montali for providing us with the medical records; Karl Kranz and Jonathan Ballou for checking the accuracy of the data; Lee Ann Hayek and Maureen Anderson for statistical advice; and Robert L. Bromwell, Jr, Mitchell Bush, John Eisenberg, Paul Harvey, Devra Kleiman, Richard Montali, and Theodore H. Reed for helpful comments on an earlier draft. We also thank the Fluid Research Fund of the Smithsonian Institution and the Friends of the National Zoo for financial support for this project.

REFERENCES

BENIRSCHKE, K., ADAMS, F. D., BLACK, K. L. & GLUCK, L. (in press): Perinatal mortality in zoo animals. In *Proceedings of a symposium on the comparative pathology of zoo animals*. Montali, R. J. & Migaki, G. (Eds). *Symp. Natn. Zool. Park.*

BOUMAN, J. (1977): The future of Przewalski horses *Equus przewalskii* in captivity. *Int. Zoo Yb.* 17: 62–68.

CAVALLI-SFORZA, L. L. & BODMER, W. F. (1971): *The genetics of human populations*. San Francisco: W. H. Freeman Co.

FALCONER, D. S. (1961): *Quantitative genetics*. New York: Ronald Press.

FLESNESS, N. R. (1977): Gene pool conservation and computer analysis. *Int. Zoo Yb.* 17: 77–81.

HAFEZ, E. S. E. (1968): Reproductive failure in females. In *Reproduction in farm animals*: 321–341. Hafez, E. S. E. (Ed.). Philadelphia: Lea & Febiger.

LASLEY, J. F. (1978): *Genetics of livestock improvement*. Englewood Cliffs, NJ: Prentice-Hall.

RALLS, K., BRUGGER, K. & BALLOU, J. (1979): Inbreeding and juvenile mortality in small populations of ungulates. *Science, Wash.* 206: 1101–1103.

SAUER, R. M. & Zook, B. C. (1972): Selenium-vitamin E deficiency at the National Zoological Park. *J. Zoo Anim. Med.* 3: 34–36.

SEAL, U. S. (1978): The Noah's Ark problem: multi-generation management of wild species in captivity. In *Endangered birds: management techniques for preserving threatened species*: 303–319. Temple, S. A. (Ed.). Madison: University of Wisconsin Press.

SEAL, U. S. (unpubl.): *Genetics and demography of studbook tigers in North American zoos with evidence for inbreeding depression.*

SENNER, J. (1980): Inbreeding depression and the survival of zoo populations. In *Conservation biology*: 209–224. Soulé, M. & Wilcox, B. (Eds). Sunderland, Mass: Sinauer Associates.

TREUS, V. D. & LOBANOV, N. V. (1971): Acclimatisation and domestication of the eland *Taurotragus oryx* at Askanya-Nova Zoo. *Int. Zoo Yb.* 11: 147–156.

WRIGHT, S. (1922): The effects of inbreeding and crossbreeding in guinea pigs. I. Decline in vigor. *Bull. U.S. Dept Agric.* 1090: 1–36.

WRIGHT, S. (1977): *Evolution and the genetics of populations 3. Experimental results and evolutionary deductions*: 44–96. Chicago: Univ. of Chicago Press.

POTENTIAL CONTRIBUTION OF CRYOPRESERVED GERM PLASM TO THE PRESERVATION OF GENETIC DIVERSITY AND CONSERVATION OF ENDANGERED SPECIES IN CAPTIVITY

JONATHAN D. BALLOU
DEPARTMENT OF ZOOLOGICAL RESEARCH
NATIONAL ZOOLOGICAL PARK
WASHINGTON, D.C. 20008

ABSTRACT

Demographic and genetic objectives of captive propagation programs for endangered species focus on establishing demographically secure populations that maintain adequate levels of genetic diversity. Long term storage and utilization of cryopreserved germ plasm could extend the population's generation length and allow higher levels of genetic variation to be maintained in smaller populations. Since fewer breeding animals would be needed, more species would be 'rescued' from extinction using the cage facilities currently available at existing institutions. Doubling generation lengths for callitrichid primates through use of cryopreservation could almost triple the number of species that could be rescued in world zoos. Additionally, long term cryopreservation would allow for a third population, that of the frozen zoo. Three-way exchange of germ plasm from germ plasm banks to captive and wild populations would increase genetic diversity at reduced risk and expense. Advances in reproductive technology and better understanding of the reproductive physiology of these animal populations are necessary to permit routine application of artificial insemination and embryo transfer using frozen-stored germ plasm.

more species could be maintained if cryopreservation and infusion of stored germ plasm could be utilized in captive propagation efforts.

The purpose of this paper is to outline strategies captive management programs can use to genetically and demographically manage captive populations for long-term conservation and to discuss the primary effect cryopreservation of germ plasm may have on the conservation of biological diversity.

CHALLENGES TO SMALL CAPTIVE POPULATIONS

Demographic instability, inbreeding problems and loss of genetic diversity are significant problems facing the continued survival of small captive populations. Captive populations of severely endangered species are often dispersed among different zoos. Conway (6) estimated that 76% of the 2750 mammal, bird and reptile species held in captivity had fewer than 25 individuals; 18% had only one or two. Their small numbers and wide distribution place these species at especially high risk of extinction (9). Very small populations are particularly vulnerable to demographic stochasticity. Random fluctuations in birth and death rates or sex ratio distortion, while insignificant in large populations, can drive small populations to extinction simply by reducing the population below numbers capable of recovery.

more species could be maintained if cryopreservation and infusion of stored germ plasm could be utilized in captive propagation efforts.

The purpose of this paper is to outline strategies captive management programs can use to genetically and demographically manage captive populations for long-term conservation and to discuss the primary effect cryopreservation of germ plasm may have on the conservation of biological diversity.

CHALLENGES TO SMALL CAPTIVE POPULATIONS

Demographic instability, inbreeding problems and loss of genetic diversity are significant problems facing the continued survival of small captive populations. Captive populations of severely endangered species are often dispersed among different zoos. Conway (6) estimated that 76% of the 2750 mammal, bird and reptile species held in captivity had fewer than 25 individuals; 18% had only one or two. Their small numbers and wide distribution place these species at especially high risk of extinction (9). Very small populations are particularly vulnerable to demographic stochasticity. Random fluctuations in birth and death rates or sex ratio distortion, while insignificant in large populations, can drive small populations to extinction simply by reducing the population below numbers capable of recovery.

Inbreeding depression can also adversely affect the viability of small populations. The deleterious effects of inbreeding are well known in domestic livestock and laboratory animals (27). Data on the deleterious effects of inbreeding in exotic wildlife are sparse (17) and most data come primarily from surveys of captive populations (18). In a survey of 45 captive mammals, mortality of inbred offspring was higher than non-inbred offspring in all but three populations (19)

Small populations also rapidly lose genetic diversity, Genetic diversity is lost each generation at a rate inversely proportional to the effective size of the population (Figure 1). Loss of genetic diversity adversely affects both the short and long-term fitness of the population. In the long-term, loss of diversity reduces the population's ability to evolve and adapt through natural selection. In the short-term, there is a general, but not universal, relationship between levels of genetic variation and various fitness components including disease resistance (1) and reproductive potential (26). Retention of this diversity maintains fitness in these populations and allows for future management options.

CAPTIVE PROPAGATION PROGRAMS

The goal of conservation oriented captive propagation programs is to maintain genetic diversity in a stable population (7). Soule et al. (22) recommend captive breeding programs attempt to maintain 90% of the population's genetic diversity of 200 years. Since retention of genetic diversity is dependent on population size, it is possible to calculate the number of animals required to achieve this objective. It is also a function of the generation length of the species, the number of individuals that founded the populations, and the populations's growth rate (3). Each population will require a unique size to achieve this recommended goal.

Demographic management objectives are to establish a stable population of this critical size and maintain the population at zero population growth. Population stability is achieved through monitoring the age distribution of the population and conducting life table analyses to determine age-specific survival and reproductive rates. From these analyses, it is possible to calculate the number and ages of animals to breed to achieve these objectives.

Genetic management objectives focus primarily on which individuals to breed to maximize retention of genetic diversity. Pedigree analyses determine how the founder's genes are distributed within the population's gene pool (13, 24). Often a small proportion of founders are responsible for most of the early breeding and these founders genes will be disproportionally represented in the current population. Breeding recommendations identify priority animals for reproduction to remedy this disproportionate distribution of founder genes.

Demographic and genetic recommendations are integrated into a management plan for the species. Currently, the American Association of Zoological Parks and Aquariums oversees 55 such Species Survival Plans and similar programs exist in the United Kingdom, Europe, Australia, New Zealand and Japan.

CONTRIBUTION OF CRYOPRESERVED GERM PLASM

Long-term storage of germ plasm through cryopreservation, followed by infusion of the germ plasm back into future generations could substantially increase generation lengths of populations. Cryopreservation of germ plasm extends the lifetime of an individual for as long as its stored germ plasm lasts. By periodically infusing genetic material back into the living population, either through stored semen, ova or embryos, the individual(s) contributing the germ plasm can continue to provide genetic material well into the future.

The generation length is defined as the average amount of time it takes an individual to replace itself in the population: the longer the animal reproduces, the larger its contribution to the population's generation length. Extending generation length decreases the number of generations occurring over a given time period. This provides fewer opportunities for losing genetic diversity. Figure 2 illustrates the effects of increasing generation length on maintaining levels of genetic diversity over a fixed time period (200 years). Populations with longer generation lengths can retain more of the population's original diversity than populations with shorter generation lengths. With cryopreservation, propagation goals could lengthen generation times and retrain higher levels of genetic diversity (e.g., 95% rather than 90% heterozygosity retained over 200 years.

Alternatively, captive propagation can benefit from the effect of lengthening generation time by establishing larger numbers of smaller populations. Extending generation times will allow smaller populations to achieve the same genetic goals as larger populations with shorter generations. Figure 3 illustrates the effect of generation length on population sizes required to maintain 90% of the genetic diversity for 200 years. Lengthening generation length can significantly reduce the population size required to achieve this goal. Facilities become available for other species with similar captive needs and the number of species benefiting from captive propagation can be increase.

The advantage of extending generation length can be illustrated using callitrichids (marmosets and tamarins) as an example. The current worldwide capacity of zoos to house callitrichids is approximately 2800 individuals (Table 1). Twenty-five of 35 known species (and subspecies) are currently kept in captivity. Ten are endangered. Generation length among the group varies, however, six years is probably a rough estimate for most callitrichids. Population sizes required to maintain 90% of the population's genetic diversity for 200 years for these species varies between 500 and 700 (depending on founder number and population growth rate). Division of available resources by need allows only 4 to 5 (11%) species of callitrichids to be preserved.

Figure 4 illustrates the increase in number of callitrichid species that zoos could preserve by increasing generation length through cryopreservation. Doubling the generation length (from 6 to 12 years) increases the number of species that can be preserved from five to 13 since population sizes need only be about 200 animals. Tripling the generation length to 18 years enables 22 species to be preserved with 125 individuals each. Reducing population sizes any further places the population at high demographic risk. Any additional increases in generation length resulting from cryopreservation should be used to retain more genetic diversity rather than reduce population size.

DISCUSSION

The reality of cryopreservation, with the concurrent necessary advances in reproductive technology, will clearly have a direct and critical impact on the contribution of captive management to single-species conservation efforts. A number of authors have discussed the potential contribution of cyrobiology to the maintenance of genetic diversity in captive gene pools (14, 22, 20). Ballou (2) discusses some of the genetic considerations involved in identifying individuals to contribute to germplasm banks. However, perhaps the most important application of cyropreservation is that it can substantially extend generation lengths of captive populations thereby allowing smaller populations to retain higher levels of genetic diversity. Smaller populations of each species permits more species to be included in the limited zoo "ark."

The effect of cryopreservation on generation length will depend directly on how much germ plasm can be preserved and how effectively it can be restored to the population. Taken to the (unrealistic) extreme, if unlimited amounts of cryopreserved germ plasm are available, generation length no longer becomes an issue in captive management programs and essentially 100% of a population's genetic diversity can be maintained indefinitely.

Additionally, the reality of long-term cryopreservation would allow a third 'population' to be considered - that of the frozen zoo (5). Three-way gene exchange between germplasm banks, wild and captive populations would increase the gene pool and effective size of the entire species. It would also facilitate two-way exchange of germplasm between wild and captive populations by reducing the logistics, expense and risk of capturing and transporting individuals between populations. In cases where concerns of disease transmission restrict movement of living individuals (wild cattle), transportation of cryopreserved germplasm may be the only way in which new genetic material is brought into the captive population.

Cryopreservation can only make a contribution if advances in reproductive technology would permit routine application of artificial insemination and embryo transfer of stored germplasm in a wide range of exotic species. Unfortunately, we are not yet at the stage where cryopreservation can be routinely applied in captive propagation programs. Fundamental understanding of the basic reproductive physiology does not exist for most exotic species and there is clearly a need to continue and increase basic research in this area in order for this biotechnology to be realistically and fully applied to conservation problems.

Current goals and management objectives already assume that cryopreservation for most captive exotic animals will be a reality in the future. The recommendation of Soule et al. (22) that 90% of a population's genetic diversity be maintained for 200 years is based on the assumption that reproductive technology should be available by that time. At that point, captive populations of reduced size can be managed with the aid of cryobiology. Without it, zoos will have insufficient resources to confront the pressing demand for captive propagation of species endangered in the wild.

REFERENCES

1. Allendorf, F. W. and Leary, R. F. 1986. Heterozygosity and fitness in natural populations of animals. pp. 57-76, in Conservation Biology: The Science of Scarcity and Diversity (M. E. Soule ed). Sinauer Assoc., Sunderland, Mass.

2. Ballou, J. D. 1984. Strategies for maintaining genetic diversity in captive populations through reproductive technology. Zoo Biology, 3:311-323.

3. Ballou, J. D. 1987. Small populations, genetic diversity and captive carrying capacities. Proceedings 1987 AAZPA Annual Conference, 33-47.

4. Ballou, J. D. 1988. 1987 Internation Golden-lion Tamarin Studbook. National Zoological Park, Washington, D.C.

5. Benirschke, K. 1984. The frozen zoo concept. Zoo Biology, 3:325- 328.

6. Conway, W. 1987. Species carrying capacity in the zoo alone. pp. 20-32, in Proceedings 1987 AAZPA Annual Conference. AAZPA, Wheeling, WV.

7. Foose, T. J., Lande, R., Flesness, N. R., Rabb, G. and Read, B. 1986. Propagation plans. Zoo Biology, 5:139-146.

8. Foose, T. J., Seal, U. S. and Flesness, N. R. 1987. Captive propagation as a component of conservation strategies for endangered primates. pp. 263-299, in Primate Conservation in the Tropical Rainforest (C. W. Marsh and R. A. Mittermier eds). A. R. Liss, New York, NY.

9. Gilpin, M. E. and Soule, M. E. 1986. Minimum viable populations: processes of species extinction. pp. 19-34, in Conservation Biology: The Science of Scarcity and Diversity (M. E. Soule ed). Sinauer Assoc., Sunderland, Mass.

10. ISIS. 1987. International Species Information System Database: 31 Dec. 1986 Distribution Report. Minneapolis, MN.

11. IUCN. 1986. 1986 IUCN Red List of Threatened Animals. IUCN Conservation Monitoring Center, Cambridge, U.K.

12. Larsson, H. 1984. International Studbook for Pygmy Marmoset, Cebuella pygmaea. Skansen-Akvariet, Stockholm.

13. MacCluer, J. W., VandeBerg, J. L., Read, B. and Ryder, O. A. 1986. Pedigree analysis by computer simulation. Zoo Biology, 5: 147-160.

14. Mace, G. M. 1989. The application of reproductive technology to endangered species breeding programmes. Zool. J. Linnean Society, 95:109-116.

15. Mallinson, J. J. C. 1987. International Studbook Golden-headed Lion tamarin Leontopithecus chrysomelas. Jersey Wildlife Preservation Trust, Jersey, Channel Islands.

16. Olney, P. J. S. 1984. Census of rare animals in captivity. Int. Zoo Yrbk. 24/25: 566-622.

17. Packer, C. 1979. Inter-troop transfer and inbreeding avoidance in Papio anubis. Anim. Behav. 27: 1-36.

18. Ralls, K. and Ballou, J. D. 1983. Extinction: lessons from zoos. pp. 164-184 in Genetics and Conservation (C. M. Schonewald- Cox, S. M. Chambers, B. MacBryde, and L. Thomas, ed). Benjamine/Cummings, Menlo Park, CA.

19. Ralls, K., Ballou, J. D. and Templeton, A. R. 1988. Estimates of lethal equivalents and the cost of inbreeding in mammals. Conservation Biology, 2:185-193.

20. Seager, S. W. J., Wildt, D. E. and Platz, C. C. 1980. Artificial breeding in captive wild mammals and its possible future use. pp. 1151-1153, in Current Therapy in Theriogenology (W. B. Saunders ed). Philadelphia Press, PA.

21. Simon, F. 1988. Black-lion Tamarin Studbook. Sao Paulo Zoological Park Foundation, Sao Paulo, Brazil.

22. Soule, M., Gilpin, M., Conway, W. and Foose, T. 1986. The Millenium Ark: how long a voyage, how many staterooms, how many passengers?. Zoo Biology 5:101-113.

23. Tardif, S. D and R. Colley. 1988. International Cotton-top Tamarin Studbook. Oak Ridge Assoc. Univ., Oak Ridge, TN.

24. Thompson, E. A. 1986. Ancestry of alleles and extinction of genes in populations with defindes pedigrees. Zoo Biology, 5:161- 170.

25. Warneke, M. 1988. Callimico goeldii. Chicago Zoological Society, Brookfield, Ill.

26. Wildt, D. E., M. Bush, K. L. Goodrowe, C. Packer, A. E. Pusey, J. L. Brown, P. Joslin, and S. J. O'Brien. 1987. Reproductive and genetic consequences of founding isolated lion populations. Nature 329: 328-331.

27. Wright, S. 1977. Evolution and the Genetics of Populations, Vol.3. Chicago, Ill., Univ. Chicago Press.

IMMUNOCONTRACEPTION IN ZOO ANIMALS: VACCINATING AGAINST PREGNANCY

J. F. Kirkpatrick, PhD*
ZooMontana, 2100 South Shiloh Road, Billings, MT 59106, USA

P. P. Calle, VMD, and P. Kalk, MS
New York Zoological Society, Bronx Zoo, Bronx, NY 10460, USA

L. Kolter, PhD, and W. Zimmermann, DVM
Zoologischer Garten Koln, Riehler Strasse 173, Koln, Germany

K. Goodrowe, PhD
Metropolitan Toronto Zoo, West Hill, Ontario, Canada

I.K.M. Liu, DVM, PhD, J.W. Turner, Jr., Ph.D. and M. Bernoco
Department of Reproduction, School of Veterinary Medicine, University of California, Davis, CA 95616, USA

A. T. Rutberg, PhD
Division of Wildlife and Habitat, The Humane Society of the U.S., Gaithersburg, MD 20879, USA

Three years of research with immunocontracpetion of captive female exotic species with a porcine zonae pellucidae (PZP) vaccine have been completed. As of June 1993, 17 zoos in 6 countries are participating in these studies. A total of 173 animals representing 35 different species have been immunized, including 24 species of ungulates, 8 carnivores and 3 species of bears (see below). As of June 1993 results are known for 11 of these species. Contraceptive efficacy ranged from a low of 77% for tur to a high of 100% for tahr, sika deer and Przewalski's horses. Based on the results of this research, as well as 6 years of PZP immunocontraceptive research with feral horses, 4 years with white-tailed deer and 15 years with nonhuman primates, the data indicate that (1) PZP immunocontraception is highly effective across a wide range of species, (2) there are differences in contraceptive effectiveness according to the type of adjuvant used, (3) no significant health problems result from PZP immunocontraception over 3 years in captive exotic species or in white-tailed deer or feral horses after 4 and 6 years respectively, (4) the vaccine is safe to give to pregnant animals, (5) the vaccine can be administered remotely, by dart, (6) a single annual booster inoculation is sufficient to extend contraception for a second year and (7) the contraceptive effect of PZP immunization is reversible after short-term use (up to 2-3 years).

Issues of concern include (1) the number of inoculations necessary for contraceptive antibody titers (2) the amount of PZP antigen necessary for contraception, (3) appropriate adjuvants, (4) the most effective delivery systems, (5) and long-term effects upon ovarian function, after 5-7 years of consecutive treatment, and research during the past year has focused on these potential problems. Species with well-defined seasonal breeding lasting 1-3 months can be treated successfully with a single inoculation and will produce contraceptive antibody titers for up to 200 days following administration. Species with longer breeding seasons can be treated with two inoculations given over 4-5 weeks. Preliminary evidence indicates that the "standard" dose of PZP antigen (65 μg of antigen or about 5,000 zonae) can be reduced to between 50%-90% and still generate contraceptive antibodies. From an economic viewpoint, this means that the cost of contraception can be reduced from the current $25/dose to somewhere between $2.50-$12.50/dose.

The concern over adjuvants arose primarily because of the possibility that Freund's Complete Adjuvant (FCA), which has previously been shown to be highly effective in generating high antibody titers, may lead to tuberculosis-positive test reactions in animals thus treated. Also, a small percentage of these animals produced small abscesses. A recent study of alternative adjuvants indicates that Freund's Incomplete Adjuvant (FIA), Carbopol® (Goodrich Co., Cleveland, OH), FIA = Quil-A (Superfos Specialty Chemicals, Vedback, Denmark) and DEAE-dextran (Sigma Chemical Co., St. Louis, MO) all produce contraceptive antibody titers when used with PZP vaccine. Muramyl dipeptide, and Ribi Adjuvant System did not produce contraceptive antibody titers.

Remote delivery is possible, but not all delivery systems are adequate because of the high viscosity of the antigen/adjuvant emulsion. The system which has provided the best results thus far is the Pneudart® 1.0 cc barbless dart (Pneudart, Inc., Williamsport, PA) fired from a Pneudart capture rifle, blowpipe or CO_2-powered pistol.

Long-term effects of the PZP vaccine upon ovarian function are not well understood and are the most important focus of the studies that are currently underway. While there is no evidence for debilitating side effects from PZP immunocontraception through 6 years of treatment, most available data indicate that developing ovarian follicles may also become the focus of action for anti-PZP antibodies, as well as ovulated ova, and that ovarian pools of oocytes may be depleted by prolonged use of the vaccine. Two species, rabbits and dogs, appear to have ovarian function disrupted even after short-term use; but there is no evidence of this in other species thus far. Reversibility of the contraceptive action of PZP after short-term use (1-2 years) has been documented in domestic mares. The majority of feral horses treated for 4 consecutive years demonstrated ovulatory cycles based on urinary estrone conjugates and behavior. At the Bronx Zoo a muntjac contracepted in 1991 produced a fawn in 1993, and at the Toronto Metropolitan Zoo, 3 of 6 tur contracepted in 1990 produced kids in 1993. At the Zoologischer Garten Koln, 3 banteng, which were contracepted in 1991 and which subsequently stopped demonstrating estrous cycles, were all cycling again in 1993. A protocol for the study of long-term effects of PZP contraception upon ovarian function and reproductive tract histopathology has now been developed and will be implemented in future studies. There can be no guarantee that unanticipated long-term effects will not appear, but annual updates of data will be provided to all participating zoos as this research progresses. We do not recommend that valuable animals in SSP breeding programs be treated with the PZP vaccine until the data base for long-term effects is broader.

Species treated as of June 1993 are given below. Those marked with asterisks have been treated successfully; for all others, data were not yet available at the time this abstract was prepared. These species included Przewalski's horse,* banteng,* sambar deer,* axis deer,* sika deer,* muntjac deer,* Himalayan tahr,* North American wapiti,* white-tailed deer,* West Caucasian tur,* African lion, tiger, black buck, Indian wolf, North American bison, pygmy hippo, addax, ibex, onager, river hippo, impala, kudu, giraffe, waterbuck, fallow deer, aoudad, mouflon sheep, cougar, jaguar, bobcat, leopard, European brown bear, Kodiak bear, Asiatic black bear, Asian small-clawed otter. Contraception failed to be achieved in the river hippo but may have been the result of a lack of adjuvant or poor injection. Although contraceptive effectiveness has not yet been assessed, very high antibody titers have been achieved in the Indian wolf, African lion and tiger.

ADVERSE EFFECTS OF CONTRACEPTIVES IN CARNIVORES, PRIMATES AND UNGULATES

Linda Munson, DVM, PhD
Dept. of Pathobiology, College of Veterinary Medicine, University of Tennessee, Knoxville, TN 37901 USA

Contraceptive use in zoos has evolved with the increasing commitment of zoological parks to conservation programs. The immediate need to prevent reproduction of surplus animals and to postpone pregnancy in some individuals, as part of single species conservation plans, required using available contraceptives in species for whom these contraceptives had not been safety tested. Consequently, our understanding of the effects of these contraceptives on zoo species are only now gradually emerging from the large clinical trial we are conducting.

It should be remembered that no medical procedure or pharmaceutical is completely without risks. Our goal should be to use existing knowledge to choose contraceptives that have minimal detrimental effects on the health of the animals. This report summarizes current available information on the adverse effects of contraceptives on zoo species. Adverse effects of contraceptives in free-ranging wildlife are included in the review by Kirkpatrick and Turner.[2]

Steroid contraceptives

The most widely used contraceptives in all zoo species are the progestins, melengestrol acetate (MGA), megestrol acetate (MA), and medroxyprogesterone (MPA). Combined estrogen-progestin contraceptives (birth control pills) also have been used in primates. All steroid hormones exert their contraceptive effects by disrupting the normal cyclical hormonal levels of the hypothalamic-pituitary-gonadal axis. Tissue sensitivity to steroids depends on the presence of specific receptors, and receptor numbers in turn are modulated by exogenous and endogenous steroids. The response to receptor binding also depends on the species and tissue. All progestins are presumed to exert their action by binding to the progesterone receptors in tissues. Progesterone receptor numbers usually are up-regulated by estrogen and down-regulated by progesterone. For zoo species, the regulation of progesterone receptor numbers and responses to receptor binding are not known, but are assumed to be analogous to those of similar domestic and laboratory species.

The response of the endometrium and mammary gland to sex steroids varies among taxa and has only been studied in domestic and laboratory animals and women. For most species, estrogens promote hyperplasia and hypertrophy of the uterus, whereas progesterone antagonizes the estrogen effects, promotes secretory differentiation of the endometrium, and causes uterine atony. In canids and felids, however, progesterone also promotes endometrial proliferation. Mammary gland growth in all species requires estrogen, progesterone, and the pituitary hormones, prolactin and growth hormone.

Adverse effects of progestin contraceptives in carnivores

Our ongoing reproductive pathology surveillance of MGA-contracepted zoo felids at the time of this writing includes 137 felids representing 22 species (MGA-contracepted = 64; non-contracepted = 73). Our data to date indicate that MGA is highly associated with more severe forms of endometrial hyperplasia and development of endometrial hyperplasia at earlier ages than non-contracepted felids. All ten felids with uterine cancer from this survey had been contracepted with progestins, as had 22 of 25 felids with mammary gland cancer. Our data also suggest that more advanced endometrial hyperplasia and cancer are associated with lower doses of and prolonged exposure to MGA (5.5 or more years). These findings confirm the predicted pathologic effects of progestins on felid reproductive organs and indicate that progestins should not be used as permanent contraceptives for felids. Minimal endometrial lesions were noted in felids contracepted with MGA for less than 3 years, and these lesions most likely would resolve with withdrawal of MGA and resumption of estrous cycles. Thus MGA may cause acceptable levels of changes that pose a minimal health risk, when used as a temporary contraceptive.

Diabetes mellitus also has been reported in MGA and MA contracepted felids, and has been presumed to be due to the potential of progestins to promote insulin resistance and aggravate latent diabetes. However, a case-control study has not been conducted to confirm this correlation.

Cystic endometrial hyperplasia, pyometra, and mammary cancer have been noted in progestin-contracepted canids and other carnivores (eg. binturong, civet, and fox), but extensive epidemiologic studies have not been conducted to confirm the association of these lesions with progestin exposure. However, in canids particularly, progestins would be expected to be a major risk factor for these diseases. Delineation of the role of progestins in disease development in other carnivores awaits further studies.

Adverse effects of mibolerone in canids and felids

The androgenic steroid, mibolerone, has been used as an effective contraceptive in wolves, jaguars, leopards, and lions.[1] Anorexia, masculinization of lions, and increased aggression among wolves were notable side effects in this study.

Adverse effects of progestins in ungulates

Insufficient information on the effects of contraceptive doses of MGA in zoo ungulates is available, because use has been limited to a few zoos. In domestic cattle, prolonged exposure to progestins can result in accumulation of endometrial secretions (mucometra or hydrometra) and secondary endometrial atrophy. Two cases of mucometra/hydrometra have in fact been reported in zoo ungulates ingesting MGA. This condition may be reversible if atony and atrophy are not prolonged and if secondary infection does not occur. Male barasingha ingesting MGA have been reported to have abnormal horn growth (B.Raphael, personal communication).

Adverse effects of progestins in primates

Progestin-only contraceptives, such as levonorgestrel and medroxyprogesterone, have been extensively tested in laboratory primates and are currently approved for use in women. Adverse affects have been minor, such as amenorrhea and weight gain. However, some investigators are concerned that progestins may increase the risk of breast cancer when used in young women. The effects of long-term exposure of primates to MGA are not known, but would be predicted to be similar to other progestins.

Reproductive pathology surveillance of zoo primates on either progestin-only or combined progestin-estrogen contraceptives has only recently been initiated, so data is limited. Notable adverse effects of progestin-only contraceptives in lemurs have been weight gain and color changes (I. Porton, personal communication). MGA implant removal by primates (self-removal or by cagemates) has been common and has resulted in superficial wounds. One case of retained placenta and endometritis was noted in an MGA-contracepted tamarin that was (or became) pregnant while exposed to MGA. The fate of the fetus was unknown. One orangutan with an MGA implant had profound endometrial atrophy and an intraluminal endometrial "cast", but had no clinical signs associated with these findings. These are presumed to be rare events, and progestin-only contraceptives are expected to be acceptable contraceptives for zoo primates.

Vas deferens plugs

Surgically-placed silicone vas deferens plugs have been tested extensively as reversible contraceptives in humans with no adverse reactions. Knowledge of pathologic effects in other species are very limited, because clinical trials with formed-in-place soft silicone plugs have just been initiated at zoos. However, no serious adverse reactions are anticipated. In preliminary tests on impala and horses, small granulomas and mild inflammatory reactions were noted near the site of insertion and minimal tissue changes associated with healing were present. None of these lesions impinged on the lumen of the vas, nor were any pathologic changes within the vas containing the plugs. These preliminary findings suggest that this method will be safe for temporary or permanent contraception of males.

Surgical contraception

The most prevalent methods of permanent contraception are surgical ovariohysterectomy or vasectomy. Male gonadectomy (castration) is usually not chosen because social hierarchies can be disrupted and secondary sexual characteristics will be lost. Female gonadectomy without removal of the uterus also is not optimal for some species, because of the potential for developing infections in the post-pubertal, atonic uterus. The risks involved in any of these surgical procedures are minimal because current anesthetics are safe, and the procedures are relatively simple. The risks would be the same as for any surgical minor procedure.

Other contraceptives

Clinical trials with the anti-spermatogenic contraceptive bisdiamine and immunocontraception with zona pellucida vaccines in zoo species are in initial stages, and pathology surveillance for adverse effects has just been enacted. Therefore at the time of this writing, no information is available on their systemic or gonadal effects in zoo species. Because drug metabolism differs among species, extrapolation of bisdiamine safety data to zoo species may be inappropriate. The same is true for species variation in response to zona pellucida (ZP) vaccines. In laboratory dogs, mice, and primates, the ovarian effects of ZP immunization depended on the species, origin and purity of the immunogen, dose, and type of adjuvant. In some cases, permanent destruction of the ovary occurred. Information gained from these studies should be used to chose the best system for temporary or permanent immunocontraception in zoo species. The variation in ovarian response noted in these laboratory animal studies also confirm the importance of conducting carefully controlled clinical trials that include histopathological analysis of gonads to determine the species-specific effects of ZP vaccines.

AAZPA contraceptive committee adverse reaction reporting system

To address the critical need for more information on the safety of contraceptives in zoo species, the AAZPA Contraceptive Committee has established a system for reporting adverse reactions. Any reproductive problems or unexplained diseases in contracepted animals should be reported to this center by completing the enclosed form. Each contribution to this database increases our collective understanding of the risks of using certain contraceptive methods. Information from this databank will be reported annually at the AAZPA meeting.

Ongoing safety assessment trials

The optimal method to assess the safety of contraceptive methods in new species is to conduct controlled prospective clinical trials, rather than retrospective epidemiological analyses. Toward this aim, we have proposed that safety trials be conducted for the following contraceptives:

1. Zona pellucida vaccines from native or recombinant proteins with various adjuvants.
2. Vas deferens plugs
3. High dose melengestrol acetate in a 24-month trial
4. Bisdiamines and indenopyridine
5. Medroxyprogesterone in primates and seasonal carnivores
6. LHRH vaccines

These trials need surplus animal volunteers that are targeted for permanent contraception. If you are interested in contributing your animals to these trials, contact Dr. Cheri Asa, St. Louis Zoological Park, Forest Park, St. Louis, MO 63110 (314-781-0900 X 488) or Dr. Linda Munson, Dept Pathobiology, CVM, University of Tennessee, P.O. Box 1071, Knoxville, TN 37901 (615-974-8235).

SECTION - IV

RE - INTRODUCTION

REFERENCES

1. Gardner, H.M., W. D. Hueston and E.F. Donovan. 1985. Use of mibolerone in wolves and three *Panthera* species. J.Am. Vet. Med. Assn. 187:1193-1194.

2. Kirkpatrick, J.F. and Turner, J.W. 1991. Reversible contraception in nondomestic animals. J. Zoo Wildf. Med. 22:392-408.

3. Munson L. and Mason R. 1991. Pathological findings in the uteri of progestogen-implanted exotic felids. Proc. Amer Assoc Zoo Vet, Calgary, Canada. p 311.

DRAFT GUIDELINES FOR RE-INTRODUCTIONS

INTRODUCTION

These policy guidelines have been drafted by the Re-introduction Specialist Group of the IUCN's Species Survival Commission[1], in response to the increasing occurrence of re-introduction projects world-wide, and consequently, to the growing need for specific policy guidelines to help ensure that the re-introductions achieve their intended conservation benefit, and do not cause adverse side-effects of greater impact. Although the IUCN developed a Position Statement on the Translocation of Living Organisms in 1987, more detailed guidelines were felt to be essential in providing more comprehensive coverage of the various factors involved in re-introduction exercises.

These guidelines are intended to act as a guide for procedures useful to re-introduction programmes and do not represent an inflexible code of conduct. Many of the points are more relevant to re-introductions using captive-bred individuals than to translocations of wild species. Others are especially relevant to globally endangered species with limited numbers of founders. Each re-introduction proposal should be rigorously reviewed on its individual merits. On the whole, it should be noted that re-introduction is a very lengthy and complex process.

This document is very general, and worded so that it covers the full range of plant and animal taxa. It will be regularly revised. Handbooks for re-introducing individual groups of animals and plants will be developed in future.

1. DEFINITION OF TERMS

a. "Re-introduction": an attempt to establish a species[2] in an area which was once part of its historical range, but from which it has become extinct[3]. ("Re-establishment" is a synonym, but implies that the re-introduction has been successful).

b. "Translocation": deliberate and mediated movement of wild individuals or populations from one part of their range to another.

c. "Re-inforcement/Supplementation": addition of individuals to an existing population

---

[1] Guidelines for determining procedures for disposal of species confiscated in trade are being developed separately by IUCN for CITES.

[2] The taxonomic unit referred to throughout the document is species: it may be a lower taxonomic unit (e.g. sub-species or race) as long as it can be unambiguously defined.

[3] CITES criterion of "extinct": species not definitely located in the wild during the past 50 years.

of conspecifics.

d. "Conservation/Benign Introductions": an attempt to establish a species, for the purpose of conservation, outside its recorded distribution but within an appropriate habitat and eco-geographical area.

2. AIMS AND OBJECTIVES OF THE RE-INTRODUCTION

a. Aims:

A re-introduction should aim to establish a viable, free-ranging population in the wild, of a species or subspecies which was formerly globally or locally extinct (extirpated). In some circumstances, a re-introduction may have to be made into an area which is fenced or otherwise delimited, but it should be within the species' former natural habitat and range, and require minimal long-term management.

b. Objectives:

The objectives of a re-introduction will include: to enhance the long-term survival of a species; to re-establish a keystone species (in the ecological or cultural sense) in an ecosystem; to maintain natural biodiversity; to provide long-term economic benefits to the local and/or national economy; to promote conservation awareness; or a combination of these.

Re-introductions or translocations of species for short-term, sporting or commercial purposes - where there is no intention to establish a viable population - are a different issue, beyond the scope of these guidelines. These include fishing and hunting activities.

3. MULTIDISCIPLINARY APPROACH

A re-introduction requires a multidisciplinary approach involving a team of persons drawn from a variety of backgrounds. They may include persons from: governmental natural resource management agencies; non-governmental organisations; funding bodies; universities; veterinary institutions; zoos (and private animal breeders) and/or botanic gardens, with a full range of suitable expertise. Team leaders should be responsible for coordination between the various bodies and provision should be made for publicity and public education about the project.

4. PRE-PROJECT ACTIVITIES

4a. BIOLOGICAL

(i) Feasibility study and background research

- An assessment should be made of the taxonomic status of individuals to be re-introduced. They must be of the same subspecies as those which were extirpated, unless adequate numbers are not available. An investigation of historical information about the loss and fate of individuals from the re-introduction area, as well as molecular genetic studies, should be undertaken in case of doubt. A study of genetic variation within and between populations of this and related taxa can also be helpful. Special care is needed when the population has long been extinct.

- Detailed studies should be made of the status and biology of wild populations (if they exist) to determine the species' critical needs; for animals, this would include descriptions of habitat preferences, intraspecific variation and adaptations to local ecological conditions, social behaviour, group composition, home range size, shelter and food requirements, foraging and feeding behaviour, predators and diseases. For plants it would include biotic and abiotic habitat requirements, dispersal mechanisms, reproductive biology, symbiotic relationships (e.g. with mycorrhizae, pollinators), insect pests and diseases. Overall, a firm knowledge of the natural history of the species in question is crucial to the entire re-introduction scheme.

- The build-up of the released population should be modelled under various sets of conditions, in order to specify the optimal number and composition of individuals to be released per year and the numbers of years necessary to promote establishment of a viable population.

- A Population and Habitat Viability Analysis will aid in identifying significant environmental and population variables and assessing their potential interactions, which would guide long-term population management.

(ii) Previous Re-introductions

- Thorough research into previous re-introductions of the same or similar species and wide-ranging contacts with persons having relevant expertise should be conducted prior to and while developing re-introduction protocol.

(iii) Choice of release site

- Site should be within the historic range of species and for an initial re-inforcement or re-introduction have very few, or no, remnant wild individuals (to prevent disease spread, social disruption and introduction of alien genes). A conservation/ benign introduction should be undertaken only as a last resort when no opportunities for re-introduction into the original site or range exist.

- The re-introduction area should have assured, long-term protection (whether formal or otherwise).

(iv) Evaluation of re-introduction site

- Availability of suitable habitat: re-introductions should only take place where the habitat and landscape requirements of the species are satisfied, and likely to be sustained for the for-seeable future. The possibility of natural habitat change since extirpation must be considered. The area should have sufficient carrying capacity to sustain growth of the re-introduced population and support a viable (self-sustaining) population in the long run.

- Identification and elimination of previous causes of decline: could include disease; over-hunting; over-collection; pollution; poisoning; competition with or predation by introduced species; habitat loss; adverse effects of earlier research or management programmes; competition with domestic livestock, which may be seasonal.

- Where the release site has undergone substantial degradation caused by human activity, a habitat restoration programme should be initiated before the re-introduction is carried out.

(v) Availability of suitable release stock

- Release stock should be ideally closely-related genetically to the original native stock.

- If captive or artificially propagated stock is to be used, it must be from a population which has been soundly managed both demographically and genetically, according to the principles of contemporary conservation biology.

- Re-introductions should not be carried out merely because captive stocks exist, nor should they be a means of disposing of surplus stock.

- Removal of individuals for re-introduction must not endanger the captive stock population or the wild source population. Stock must be guaranteed available on a regular and predictable basis, meeting specifications of the project protocol.

- Prospective release stock must be subjected to a thorough veterinary screening process <u>before</u> shipment from original source. Any animals found to be infected or which test positive for selected pathogens must be removed from the consignment, and the uninfected, negative remainder must be placed in strict quarantine for a suitable period before retest. If clear after retesting, the animals may be placed for shipment.

- Since infection with serious disease can be acquired <u>during</u> shipment, especially if this is intercontinental, great care must be taken to minimize this risk.

- Stock must meet all health regulations prescribed by the veterinary authorities of the recipient country and adequate provisions must be made for quarantine if necessary.

- Individuals should only be removed from a wild population after the effects of translocation on the donor population have been assessed, and after it is guaranteed that these effects will not be negative.

4b. SOCIO-ECONOMIC AND LEGAL ACTIVITIES

- Re-introductions are generally long-term projects that require the commitment of long-term financial and political support.

- Socio-economic studies should be made to assess costs and benefits of the re-introduction programme to local human populations.

- A thorough assessment of attitudes of local people to the proposed project is necessary to ensure long term protection of the re-introduced population, especially if the cause of species' decline was due to human factors (e.g. over-hunting, over-collection, loss of habitat). The programme should be fully understood, accepted and supported by local communities.

- Where the security of the re-introduced population is at risk from human activities, measures should be taken to minimise these in the re-introduction area. If these measures are inadequate, the re-introduction should be abandoned or alternative release areas sought.

- The policy of the country to re-introductions and to the species concerned should be assessed. This might include checking existing national and international legislation and regulations, and provision of new measures as necessary. Re-introduction must take place with the full permission and involvement of all relevant government agencies of the recipient or host country. This is particularly important in re-introductions in border areas, or involving more than one state.

- If the species poses potential risk to life or property, these risks should be minimised and adequate provision made for compensation where necessary; where all other solutions fail, removal or destruction of the released individual should be considered. In the case of migratory/mobile species, provisions should be made for crossing of international/state boundaries.

5. PLANNING, PREPARATION AND RELEASE STAGES

- Construction of a multidisciplinary team with access to expert technical advice for all phases of the programme.

- Approval of all relevant government agencies and land owners, and coordination with national and international conservation organizations.

- Development of transport plans for delivery of stock to the country and site of re-introduction, with special emphasis on ways to minimize stress on the individuals during transport.

- Identification of short-and long-term success indicators and prediction of programme duration, in context of agreed aims and objectives.

- Securing adequate funding for all programme phases.
- Design of pre- and post- release monitoring programme so that each re-introduction is a carefully designed experiment, with the capability to test methodology with scientifically collected data.
- Appropriate health and genetic screening of release stock. Health screening of closely related species in re-introduction area.
- If release stock is wild-caught, care must be taken to ensure that: a) the stock is free from infectious or contagious pathogens and parasites before shipment and b) the stock will not be exposed to vectors of disease agents which may be present at the release site (and absent at the source site) and to which it may have no acquired immunity.
- If vaccination prior to release, against local endemic or epidemic diseases of wild stock or domestic livestock at the release site, is deemed appropriate, this must be carried out during the "Preparation Stage" so as to allow sufficient time for the development of the required immunity.
- Appropriate veterinary or horticultural measures to ensure health of released stock throughout programme. This is to include adequate quarantine arrangements, especially where founder stock travels far or crosses international boundaries to release site.
- Determination of release strategy (acclimatization of release stock to release area; behavioural training - including hunting and feeding; group composition, number, release patterns and techniques; timing).
- Establishment of policies on interventions (see below).
- Development of conservation education for long-term support; professional training of individuals involved in long-term programme; public relations through the mass media and in local community; involvement where possible of local people in the programme.
- The welfare of animals for release is of paramount concern through all these stages.

6. POST-RELEASE ACTIVITIES

- Post release monitoring of all (or sample of) individuals. This most vital aspect may be by direct (e.g. tagging, telemetry) or indirect (e.g. spoor, informants) methods as suitable.
- Demographic, ecological and behavioural studies of released stock.

- Study of processes of long-term adaptation by individuals and the population.
- Collection and investigation of mortalities.
- Interventions (e.g. supplemental feeding; veterinary aid; horticultural aid) when necessary.
- Decisions for revision, rescheduling, or discontinuation of programme where necessary.
- Habitat protection or restoration to continue where necessary.
- Continuing public relations activities, including education and mass media coverage.
- Evaluation of cost-effectiveness and success of re- introduction techniques.
- Regular publications in scientific and popular literature.

WELFARE GUIDELINES FOR THE RE-INTRODUCTION OF CAPTIVE BRED MAMMALS TO THE WILD

151

INTERNATIONAL ACADEMY OF ANIMAL WELFARE SCIENCES

CONTENTS

Acknowledgements

The International Academy of Animal Welfare Sciences is grateful to Ms Janis Carter, Mr Eddie Brewer, Dr Anna Feistner, Dr James Mahoney and Dr Brian Miller for their detailed comments and advice in the preparation of these guidelines. Thanks are also due to the Primate Society of Great Britain for agreeing to the publication of its guidelines in the appendix.

from normal physical contact with other members of their species, or denied the opportunity to manipulate natural materials which would be used for such activities as nest building or foraging. Individuals should also be rejected which have been exposed to recurrent disease, such as TB, or are likely to carry deleterious genetic traits. Inbred groups should not be used for re-introduction.

Age. Younger individuals may be more flexible in their behaviour but, if they are too young, are likely to be incautious and overconfident.

Sex. One sex may be less competitive and more willing, in a social context, to cooperate with and promote the survival of conspecifics. Thus the sex ratio in the group could be an important factor in the successful re-introduction of social mammals.

Character. Mammals vary greatly as individuals so that their success in adapting to the wild will depend not only on the attributes of the individual but also, where there is a group re-introduction, on the interaction of the different personalities involved. Factors of relevance are likely to be attributes such as assertiveness, intelligence, ability to imitate and friendliness.

Social group. Where mammals are sociable it is advantageous that they should be re-introduced to the wild as a stable social group and this may take a considerable time to achieve. The aim should be to set up a group of compatible individuals with an appropriate age/sex structure prior to release.

Health. Animals should be immunised against human diseases to which they may be susceptible and diseases endemic to the wild population against which they would normally have acquired immunity through the placenta and/or colostrum. An epidemiological survey of the diseases and parasites present at the release site should be made prior to re-introduction. Where there is an indigenous population of the same species, it is vitally important that diseases should not be carried into the wild by the re-introduced individuals. Regular health checks should also be carried out on human caretakers. All individuals intended for re-introduction should be certified by a veterinary surgeon with specialist knowledge of the species as being in good health both prior to and at every stage of training and acclimatisation. Veterinary advice should also be taken with regard to health monitoring and prophylaxis for the particular species.

Developing the skills of the animal

This stage of training should take place in a protected and restricted area in the country where the release is to take place. Training will enable the animal to identify and experiment with the properties of naturally occurring objects of relevance to the species. Aversion therapy can be provided where necessary, for example by the use of stimuli such as loud noises or species specific alarm calls, to condition the animal to avoid strange human beings, predators or poisonous snakes and to discourage arboreal species from sleeping on the ground. A comprehensive list should be drawn up of the items of knowledge and skills which the individual animal will require for survival when released into the natural environment. The acquisition of each item of knowledge and particular skill should be recorded for each individual. When the individual has acquired an adequate range of skills and operating level of efficiency, it can be entered into the second phase of the training programme.

Where it is impossible, for some reason, to train the animals in the country of release, training in other countries can be considered bearing in mind the points already raised. For this procedure to succeed, however, much more effort will be required.

Responsibilities of the trainer

These can be summarised as:

- control of animals including on-site caging to allow isolation or mixing of animals for short periods, ensuring that monitoring staff are able to reach the site without being exposed to attack etc;
- training and re-education programmes to ensure that the individual animal has established a natural time budget, developed appropriate skills, can recognise food plants and hazards and is able to build a refuge and interact amicably with others;
- assessment of the skills acquired by each individual;
- protection of animals from unfamiliar hazards, poaching and human interference;
- maintaining good personal relations with the animals under training;
- establishing a routine for inspecting individuals to monitor their health, for example, chimpanzees in The Gambia programme were trained to open their mouths for dental examinations. Monitoring should be carried out regularly, for example, starting on a quarterly basis and subsequently reducing in time to annual visits.

WELFARE GUIDELINES FOR THE RE-INTRODUCTION OF CAPTIVE BRED MAMMALS TO THE WILD

151

INTERNATIONAL ACADEMY OF
ANIMAL WELFARE SCIENCES

CONTENTS

Acknowledgements

The International Academy of Animal Welfare Sciences is grateful to Ms Janis Carter, Mr Eddie Brewer, Dr Anna Feistner, Dr James Mahoney and Dr Brian Miller for their detailed comments and advice in the preparation of these guidelines. Thanks are also due to the Primate Society of Great Britain for agreeing to the publication of its guidelines in the appendix.

INTRODUCTION

The need for welfare guidelines became apparent at a symposium in 1989 on the re-introducion of captive bred animals into the wild, organised jointly by the Zoological Society of London, the Mammal Society and the Primate Society of Great Britain (PSGB)[1]. It appeared that few re-introductions had been an unqualified success and that the whole procedure of re-introducing animals into their natural habitat was still at an experimental stage.

The term **re-introduction** is defined as the release of animals into areas in their historical ranges where they have become extinct in the wild.

The term **rehabilitation** is used to refer to the process whereby an individual is trained to adapt successfully to life in the wild.

To date, the most successful re-introductions of captive bred mammals include the Arabian oryx in Oman[2] and the golden lion tamarin in Brazil[3]. In both cases, the scientists involved accepted that the procedure for re-introduction was still developing and they assumed responsibility for the animals' welfare both before and after release. They were also meticulous in maintaining contact with the captive bred individuals and monitoring their success and survival.

Useful discussions of the problems and appropriate techniques for re-introducing species into the wild have been provided by Kleiman[4] and Hannah and McGrew[5].

It is clear that the well-being of an individual mammal may be compromised by releasing it into the wild, because it will be exposed to risks which are absent in captivity. The procedure of re-introduction, however, must be viewed in the broad context of the overall value of the operation. If there are good reasons for believing that a viable wild population can be established from the re-introduced animals then the risk to an individual may be compensated for by the gain for conservation.

These welfare guidelines therefore should be used in combination with existing conservation guidelines issued by IUCN[6]. It should not be expected that the released individuals would survive more successfully than normal wild ones, rather that their chances of survival should be equivalent to those of wild bred animals of similar age, sex and status in the natural habitat.

An important objective in modern zoos is to breed endangered species so that a viable population is preserved and, as appropriate, available for re-introduction, should environmental conditions become suitable in the future[6]. Ultimately, the value of sustaining a breeding population of an endangered species rests on the ability of zoos to release individuals into the wild. If the welfare of these individuals is to be assured, it is essential that they should be competent to survive under natural conditions and this means that, where necessary, they should have received adequate training prior to and immediately after release.

Also reported, but not published in the proceedings of the London symposium, were instances of re-introductions with insufficient preparation for life in the natural habitat and inadequate post-release monitoring, for example, the re-introduction of captive bred Barbary macaques in Morocco. In this case there was pressure from some members of the public to release the surplus monkeys in a natural habitat rather than the owners disposing of them for research or euthanasia.

Another recent example of a re-introduction which caused some concern was the release of 850 ranch bred coypus to the wild at seven sites in Uruguay. As far as can be ascertained, no prior check was made to determine whether the animals possessed suitable skills to survive in the wild and there was no effective post-release monitoring.

As PSGB was directly involved in the London symposium, it has since produced a policy statement on the treatment of surplus captive bred members of endangered species, see Appendix. The need to be concerned about the welfare implications of re-introductions was also raised at the International Primatological Society (IPS) meeting in 1990 and its views were conveyed to the Re-introductions Specialist Group, IUCN/Species Survival Commission (SSC).

Through its involvement with zoos worldwide[7,8], UFAW and its International Academy of Animal Welfare Sciences is in a position to influence the conduct of re-introductions from the viewpoint of welfare. Accordingly it has decided, with the advice of specialists in the field, to publish these welfare guidelines firstly, to provide practical advice on animal welfare and, secondly, to encourage zoos and other organisations holding specimens of endangered species of mammal to fully consider the commitment in time and money that will be required if re-introductions are to succeed.

The chimpanzees in The Gambia[9] provide a good example of the time and effort which may be required to achieve a successful rehabilitation of a higher primate to enable it to survive in the wild. The majority of these animals were wild born with minimum periods of time in captivity, but three were captive born. One of them, a twenty year old female born in the Yerkes laboratory and released at the age of seven, is not only alive and well, but has a four year old daughter. In all, five groups of chimpanzees are now living on four islands in the River Gambia. They are provisioned at intervals to allow for censuses and health checks, but are not dependent on supplementary feeding for their survival. One of the practical problems recognised, however, is that the rehabilitated animals have lost their natural fear of man so that they may approach humans too closely. This could create conflict situations resulting in aggressive behaviour and thus would have represented a hazard, had the chimpanzees been released into an area with a human population. There could also be similar problems should rehabilitated individuals be placed in areas where they might come into contact with indigenous wild chimpanzees.

It is appreciated that the higher primates may be among the most difficult mammals to adapt to life in the wild in comparison with herbivores, such as cattle and antelopes; the problem, however, is essentially one of degree. Carnivores, omnivores such as bears and, among herbivores the elephants, all are long lived and have complex requirements and probably need more 'hard-wired', so that re-introduction should be easier but, in any event, careful post-release monitoring is essential.

These guidelines are confined to mammals, because there is more knowledge of their needs, however, it is appreciated that similar problems may arise with other vertebrates.

AIM OF RE-INTRODUCTION

The aim in re-introducing captive reared mammals into the wild is *to establish a viable population of the species in an area in a way that does not constitute a physical or health hazard to local human or animal populations.*

Rehabilitation should seek *to ensure that individuals to be released are as capable of survival in the wild as those of similar age, sex and status in a natural population.*

SELECTION FOR RE-INTRODUCTION TO THE WILD

Species of Mammal

The differences in skills required to survive in captivity and the wild vary from species to species. Some mammals, such as large grazers, have relatively simple dietary requirements in nature whereas omnivores and carnivores need to acquire complex foraging skills[2]. Wild mammals must also recognise and know how to avoid hazards, develop topographical knowledge and acquire complex social techniques in order to survive and reproduce. Species which are highly adaptable, and therefore relatively easy to re-introduce, are unlikely to be endangered. It is essential to have a full understanding of the biology of the species before re-introducing captive bred individuals to the wild.

Discrepancy between captive and wild conditions

If they are to maintain the adaptive responses necessary for survival, animals in captivity must be exposed to the stimuli which produce those responses in the wild. To maximise the likelihood of success in adaptation to the wild, the discrepancy between the captive and wild conditions should be minimal in terms of climate, food availability, natural vegetation and hazards, such as diseases and parasites. Climatic factors, such as temperature range, rainfall and humidity, and also day length should be adjusted to resemble those of the wild habitat. All re-introductions should follow the IUCN Guidelines[6] with regard to the suitability of the area and carrying capacity of the environment[2].

Mammals kept for re-introduction should, wherever practicable, be held in captivity in the country in which they have their natural habitat and maintained in conditions which simulate, as far as possible, those which they will experience in nature. This represents a half way house between the typical zoo and the wild habitat. Clearly this will only be practicable in countries whose governments are firmly committed to rehabilitation and re-introduction programmes.

Suitability for training

Individuals which are intended for re-introduction should be carefully selected, taking into account the following factors:

Previous history. Not all individuals of a particular species will be suitable for release and, where a choice exists, some animals should not be selected; for example, those that have been kept in a highly artificial environment, isolated from normal physical contact with other members of their species, or denied the opportunity to manipulate natural materials which would be used for such activities as nest building or foraging. Individuals should also be rejected which have been exposed to recurrent disease, such as TB, or are likely to carry deleterious genetic traits. Inbred groups should not be used for re-introduction.

Age. Younger individuals may be more flexible in their behaviour but, if they are too young, are likely to be incautious and overconfident.

Sex. One sex may be less competitive and more willing, in a social context, to cooperate with and promote the survival of conspecifics. Thus the sex ratio in the group could be an important factor in the successful re-introduction of social mammals.

Character. Mammals vary greatly as individuals so that their success in adapting to the wild will depend not only on the attributes of the individual but also, where there is a group re-introduction, on the interaction of the different personalities involved. Factors of relevance are likely to be attributes such as assertiveness, intelligence, ability to imitate and friendliness.

Social group. Where mammals are sociable it is advantageous that they should be re-introduced to the wild as a stable social group and this may take a considerable time to achieve. The aim should be to set up a group of compatible individuals with an appropriate age/sex structure prior to release.

Health. Animals should be immunised against human diseases to which they may be susceptible and diseases endemic to the wild population against which they would normally have acquired immunity through the placenta and/or colostrum. An epidemiological survey of the diseases and parasites present at the release site should be made prior to re-introduction. Where there is an indigenous population of the same species, it is vitally important that diseases should not be carried into the wild by the re-introduced individuals. Regular health checks should also be carried out on human caretakers. All individuals intended for re-introduction should be certified by a veterinary surgeon with specialist knowledge of the species as being in good health both prior to and at every stage of training and acclimatisation. Veterinary advice should also be taken with regard to health monitoring and prophylaxis for the particular species.

Developing the skills of the animal

This stage of training should take place in a protected and restricted area in the country where the release is to take place. Training will enable the animal to identify and experiment with the properties of naturally occurring objects of relevance to the species. Aversion therapy can be provided where necessary, for example by the use of stimuli such as loud noises or species specific alarm calls, to condition the animal to avoid strange human beings, predators or poisonous snakes and to discourage arboreal species from sleeping on the ground. A comprehensive list should be drawn up of the items of knowledge and skills which the individual animal will require for survival when released into the natural environment. The acquisition of each item of knowledge and particular skill should be recorded for each individual. When the individual has acquired an adequate range of skills and operating level of efficiency, it can be entered into the second phase of the training programme.

Where it is impossible, for some reason, to train the animals in the country of release, training in other countries can be considered bearing in mind the points already raised. For this procedure to succeed, however, much more effort will be required.

Responsibilities of the trainer

These can be summarised as:

- control of the animals including on-site caging to allow isolation or mixing of animals for short periods, ensuring that monitoring staff are able to reach the site without being exposed to attack etc;
- training and re-education programmes to ensure that the individual animal has established a natural time budget, developed appropriate skills, can recognise food plants and hazards and is able to build a refuge and interact amicably with others;
- assessment of the skills acquired by each individual;
- protection of animals from unfamiliar hazards, poaching and human interference;
- maintaining good personal relations with the animals under training;
- establishing a routine for inspecting individuals to monitor their health, for example, chimpanzees in The Gambia programme were trained to open their mouths for dental examinations. Monitoring should be carried out regularly, for example, starting on a quarterly basis and subsequently reducing in time to annual visits.

TRAINING IN HABITAT

Relocation

At this stage the trainees should be moved either to a protected area of natural habitat, such as an island in a river for species which are non-swimmers, or to a fully fenced large enclosure. If such an area is not available the animals may have to be re-introduced directly to the final site, although such a procedure does incur serious risks. They should be accompanied by their trainer who will also be responsible for the implementation of further training, which may last for as long as a year.

Further developing the animals' skills

This phase should aim to ensure that the individual animals are able to apply their knowledge and skills in the natural situation, for example, natural foraging techniques may be encouraged by incrementally decreasing the amount of provisioning until full independence is achieved. There should be a minimum of interference by the trainers, who should gradually distance themselves from the trainees as they become more capable.

The goals for the animals at this stage of training should be the following:

- establishment of an independent home base;
- development of natural behavioural repertoires;
- appropriate responses to potential predators;
- ability to recognise food sources and acquire a balanced diet;
- establishment of safe travel routes;
- topographical awareness, ie a cognitive map;
- making appropriate responses to unfamiliar conspecifics where there are other individuals or groups in the area.

The responsibilities of the trainer during this time include:

- monitoring activity and progress by observing and tracking;
- reassessment of habitat suitability;
- routine periodic health checks, eg by use of a baiting technique, and medication where necessary;
- emergency procedures, eg techniques for recapture or isolation of an individual;
- phasing out human contact to encourage the animals to become completely independent.

Release to the wild habitat

Whenever possible, the protected area should be sited alongside the final release point, so that there is easy access to the wild habitat. In some instances, however, this may be impracticable and the animals will have to be caught and transported there for release. A cage or compound for health monitoring should be sited in the core area and all individuals should be familiar with it and enter freely. The aim of the release is to establish a viable, healthy population in an area.

The responsibilities of the trainer after animals have been released into the wild habitat should be to confirm that:

- their survival skills are equivalent to those of wild counterparts of similar age and sex;
- they are completely independent of human intervention;
- they do not constitute a physical or health hazard to the local human or animal populations;
- the threat from poaching is minimised.

Semi-natural environments

It may not always be practicable to re-introduce surplus animals into the wild, for example, lack of natural habitat, or the animals have been in captivity for so long that they would be incapable of acquiring the necessary skills to survive, as is likely to be the case of many individuals retired from biomedical research laboratories. In such cases owners should be encouraged to release the animals into safe and sustainable semi-natural environments, providing that the necessary level of continued human support can be guaranteed. The levels of training and the responsibilities of the trainers will be similar to those for release of animals into the wild.

CONCLUSIONS

Those intending to re-introduce captive bred mammals into the wild should accept responsibility for their welfare both before and after their release.

Many species of mammal rely heavily on experience and learning during their development, when they acquire skills which are essential for survival. Thus, captive bred mammals will have developed behaviours which are relevant to confinement, but they may lack the experience to survive in the wild.

Individuals to be released should be trained until they have the necessary skills to survive in the wild. This is particularly important if they have been kept in conditions which differ considerably from those in nature.

It is essential to ensure that individuals to be re-introduced are healthy. This will avoid the danger of carrying disease into the habitat and infecting the wild population.

When planning re-introductions, conservationists should be prepared to make the necessary commitment in time and resources to ensure the welfare of the animals to be released.

These guidelines provide information on procedures which may be adopted to facilitate successful re-introduction, taking into account the well-being of the individuals to be released. They are intended to complement the recommendations of the IUCN position statement[6].

Literature cited

1 Gipps J H W (ed) 1991 *Beyond Captive Breeding: Re-introducing Endangered Species to the Wild. Symposium of the Zoological Society of London No. 62* Clarendon Press: Oxford

2 Stanley Price M R 1989 *Animal Re-introductions: the Arabian Oryx in Oman.* Cambridge University Press: Cambridge

3 Kleiman D G, Beck B B, Dietz J M, Dietz L A, Ballou J D, Coimbra-Filho A F 1986 Conservation programme for the golden lion tamarin: captive research and management, ecological studies, educational strategies and re-introduction. In Benirschke K (ed) *Primates: the road to self-sustaining populations.* pp 959-980. Springer-Verlag: New York

4 Kleiman D G 1990 Re-introduction of captive mammals for conservation: guidelines for re-introducing endangered species into the wild. *Bioscience 39:* 152-161

5 Hannah A C, McGrew W C 1991 Rehabilitation of captive chimpanzees. In Box H O (ed) *Primate Responses to Environmental Change*, pp 167-186. Chapman and Hall: London

6 IUCN 1987 *The IUCN position statement on translocation of living organisms: introductions, re-introductions and re-stocking.* International Union for Conservation of Nature: Gland, Switzerland

7 UFAW 1988 *Why Zoos?* Universities Federation for Animal Welfare: Potters Bar

8 Roe D 1990 The UFAW Zoo Animal Welfare Award 1987-1989. *International Zoo Yearbook 29:* 220-240

9 Carter J 1988 Survival training for chimps. *Smithsonian 19, 3:* 36-48

APPENDIX

PRIMATE SOCIETY OF GREAT BRITAIN
Policy on Surplus Individuals of Endangered Species of Primates in Captivity

Statement prepared by the Conservation and Captive Care Working Parties and adopted as the official policy of the Primate Society of Great Britain by Council at its meeting of September 8 1988 and published in *Primate Eye 36:* pp17-18, October 1988.

1. The Primate Society of Great Britain supports the captive breeding of endangered species (the term 'endangered' will be used to refer to any animal in the Red Data book, rather than a category defined therein).
2. Wherever possible these primates should be re-introduced to the wild providing:
   a. The individuals in question have been prepared to cope with life in the wild and their subsequent survival is monitored.
   b. The environmental carrying capacity is adequate and the factors which led to local extinction of the species have been eliminated or ameliorated.
   c. Re-introduction is undertaken as part of an efficiently co-ordinated programme.
3. When re-introduction to the wild is at present impractical:
   a. Every effort should be made to ensure that the global population in captivity forms a viable base for further re-introduction or continued captive breeding.
   b. If the captive global population is adequate, the following actions should be taken to deal with surpluses in the population:
      i. The animals may be used for humane research which increases our knowledge of the biology of the species.
      ii. Fertility control should be applied to a portion of the population.
      iii. Euthanasia should only be used as a final resort. Where this is practised, due consideration must be given to the genetic and demographic character of the population. Maximum use should be made of the carcase of the animal in appropriate research laboratories.
   c. Individuals of an endangered species bred in colonies or zoos, as part of a conservation programme, which are surplus, should not be used as a model for humans in any form of biomedical research or for any other purpose which might create a demand for wild caught specimens.
4. Where existing laboratory populations of an endangered species are currently used as a model for humans in biomedical research, there is no objection, providing these colonies are self-maintaining and do not create a demand for wild caught specimens. At the end of any such research programme every effort should be made to conserve their breeding potential.

INTERNATIONAL ACADEMY OF ANIMAL WELFARE SCIENCES

Object and purposes

The object for which the Academy is established is to promote humane behaviour towards animals on an international basis and in furtherance of this object its purposes are:

★ To coordinate and develop activities relating to the welfare of animals, in particular the activities of scientists and technologists.

★ To liaise with and offer advice to the regulatory and legislative authorities.

★ To act as a focal point for the collection, dissemination and exchange of information and views relating to animal welfare and the humane treatment and use of animals.

★ To maintain a register of individuals and organisations relevant to animal welfare science and technology.

★ To receive donations, subscriptions, endowments, bequests and legacies for the purposes of the Academy.

★ To do all such other lawful things that are incidental or conducive to the attainment of the object of the Academy.

The Academy is established and supported by resolution of the Council of the Universities Federation for Animal Welfare (UFAW), a company limited by guarantee (No 579991) and registered as a charity (No 207996).

Disease risks associated with wildlife translocation projects

M.H. Woodford
IUCN/SSC Veterinary Specialist Group, Washington, DC, USA
and
P.B. Rossiter
Kenya Agricultural Research Institute, Kikuy, Kenya.

9.1 INTRODUCTION

The translocation of wild animals by man for the establishment of new populations is a very ancient practice. There is evidence in the writings of Pliny that the Romans artificially extended the natural range of the rabbit (*Oryctolagus cuniculus*) from southern Spain to most of western Europe (although the Normans are credited with the introduction of the species into Britain). The Romans, too, are said to have moved the fallow deer (*Dama dama*) from its ancestral range in the Mediterranean forests to the newly conquered territories of Gaul and Britannia. The motive for most of these artificial animal movements was then, as now, to establish an easily accessible supply of food 'on the hoof' and to provide a suitable quarry for hunting. Rarely was the motive anything other than practical, although Pliny does mention the translocation of a species of croaking frogs from the Continent to Cyrene to liven up the local frogs which were said to be dumb. Translocation of wild animals as a wildlife management tool thus has many precedents, and the vast

Creative Conservation: Interactive management of wild and captive animals.
Edited by P.J.S. Olney, G.M. Mace and A.T.C. Feistner.
Published in 1994 by Chapman & Hall, London.
ISBN 0 412 49570 8

majority of movements of wild animals whether they are introductions, reintroductions or reinforcements are still made for sporting purposes.

A recent survey (1973–1986) of **intentional** releases of indigenous birds and mammals into the wild in Australia, Canada, Hawaii, New Zealand and the United States shows that on average nearly 700 translocations were conducted each year. Native game species, many of them birds, comprised 90% of these movements (Griffith *et al.*, 1989). Many similar releases, usually for sporting purposes, are made each year in Europe and on a smaller scale elsewhere in the world.

The translocation of rare and endangered species has become an important conservation technique, especially for those species which possess limited dispersal ability – since these often find themselves confined in shrinking and disconnected habitat fragments where early extinction can be predicted (Wilson and MacArthur, 1967).

Translocations of rare species can be expensive (Cade, 1988; Kleiman, 1989) and often attract great public attention (Booth, 1988). Several factors have been associated with the outcome of such enterprises. These have been discussed and evaluated by Griffith *et al.* (1989), but surprisingly the possibility that disease might present a negative influence on the efforts of founder animals to establish themselves was not considered. However, other authors (Aveling and Mitchell, 1982; Brambell, 1977; Caldecott and Kavanagh, 1983) have drawn attention to the problem.

9.2 TYPES OF DISEASE RISK

Most of the diseases likely to be of importance in translocation projects are infectious, and the risks, whatever the objective of these operations may be, will depend on a variety of factors. Amongst these are the epidemiological situations at the source from which the animals derive and those at their destination or release site.

The source is often a zoo, a ranch or an extensive captive breeding establishment, and it is sometimes located on a distant continent. Occasionally, however, a supply of suitable wild animals for translocation can be found in another area within the country where the release is planned.

The release site may be a national park or other protected area where contact with other wild species may occur, or it may be an undesignated area of suitable habitat where contact with domestic livestock and humans is an added hazard.

Animals born and bred in a zoo or in a captive breeding facility in a distant country will acquire local infections, and in some cases will become symptomless carriers of disease agents. Zoo-bred stock is often exposed to exotic pathogens brought in from foreign countries and to infections transmitted to them by their attendants and visitors. Furthermore, captivity subjects some species to continuous stress resulting in immunodepression and increased susceptibility to infection. Tuberculosis, usually of the bovine type in ungulates and of human origin in primates, is common in zoological collections, and unfortunately, at least for wild ungulates, the current diagnostic tests for this disease are unreliable and difficult to interpret (Philip, 1989; Flamand, 1990).

Ranch-raised animals, usually herding ungulates, are often exposed to the common pathogens of local domestic animals. Brucellosis, bluetongue and various tick-borne haemoparasites are likely examples, while equids will be exposed to the endemic diseases of horses and donkeys in the country where they are raised.

9.3 DISEASES INTRODUCED BY TRANSLOCATED ANIMALS

There is a risk, therefore, that both zoo-bred and ranch-raised animals, as well as wild-caught stock, may bring new pathogens into a release area and that these may cause disease amongst coexisting immunologically naïve wild and domestic animals. As has been aptly remarked, each translocated animal is not a representative of a single species but is rather a biological package containing a selection of viruses, bacteria, protozoa, helminths and arthropods (Nettles, 1988).

There have been many instances in which captive-bred (and sometimes wild-caught) animals have brought with them pathogens which have had a severe impact on wild and domestic stock in and around the release site (Table .1). Some of these cases, like the introduction of African horse sickness into Spain by two zebra (*Equus burchelli*) from Namibia in 1987 are well documented (OIE, 1987). Unfortunately others are only anecdotal or described in rudimentary and unconfirmed detail.

It should be borne in mind that capture and quarantine themselves may both place a high level of stress on wild animals, especially those caught in the wild, and that there is a great deal of variation in the response of species and age classes. Stress can lead to the clinical recrudescence of latent infectious diseases. For example, Cape buffaloes (*Syncerus caffer*) transported a long distance by lorry have excreted foot and mouth disease virus in sufficient quantities to infect nearby cattle (Hedger and Condy, 1985) and fatal cases of trypanosomiasis have arisen in black rhinoceros (*Diceros bicornis*) captured and translocated while harbouring inapparent trypanosome infections (McCulloch and Achard, 1969).

A classic case has been the outbreak of tuberculosis in Arabian oryx (*Oryx leucoryx*) in Saudi Arabia (Heuschele, 1990; Asmode and Khoja, 1989; Kock and Woodford, 1988). The late King Khaled of Saudi Arabia was in the habit of turning loose in a large, fenced enclosure outside

Table 1 Diseases introduced into release areas by translocated wildlife[a]

Species translocated	*Source*	*Disease introduced*	*Release area*	*Species affected*	*Reference*
Zebra	Namibia, w/c	African horse sickness	Spain	Domestic equids	OIE, 1987
Arabian oryx	Riyadh, Saudi Arabia, c/b	Tuberculosis	Taif, Saudi Arabia	Translocates	Heuschele, 1990; Asmode and Khoji, 1989; Kock and Woodford, 1988
Raccoon	Texas, w/c	Parvoviral enteritis	West Virginia	Local raccoons	Allen, 1986
Raccoon	Florida, w/c	Rabies	West Virginia	Skunks, local raccoons	Anon, 1990
Reindeer	Norway, c/b	Warble flies, nostril flies	Greenland	Caribou	Rosen, 1955; Rosen, 1958; Thing and Thing, 1983
Mojave desert tortoise	Petshops in California	'Respiratory disease'	Mojave Desert	Wild tortoises	Jacobsen *et al.*, 1991
Bighorn sheep	Arizona, w/c	'Viral pneumonia'	New Mexico	Local bighorns	–
Plains bison	Montana, c/b	Tuberculosis, Brucellosis	Canada	Wood bison	Environmental Assessment Panel, 1990
Hares	Hungary, Czechoslovakia, w/c	Brucellosis	Switzerland; Italy	Domestic animals, people	Pastoret *et al.*, 1988
Rainbow trout	USA, c/b	'Whirling disease'	UK	Trout	Trust, 1986

[a]w/c = wild caught; c/b = captive bred

Riyadh, all the herbivorous diplomatic gifts that he received. Amongst these assorted animals, most of which had been zoo-bred in the country of their donors, must have been some carrying sub-clinical tuberculosis. When later it was decided to prepare a herd of Arabian oryx for release into the wild in Saudi Arabia, 57 of these desert antelopes were separated out from the mixed herd of herbivores and relocated by air to the National Wildlife Research Centre at Taif, some 400 miles away. Within a few weeks of this translocation, some of the oryx became sick and died of acute tuberculosis, a disease of which there had been no signs in the mixed antelope herd at Riyadh. It was considered likely that the stresses of capture, crating and translocation probably played a part in precipitating the clinical disease. Plains bison (*Bison bison*), translocated in 1907 from Montana to Canada brought with them tuberculosis and brucellosis, two infections which have resulted in a recent decision to slaughter 3200 infected animals in an attempt to eliminate the diseases from the Wood Buffalo National Park in Canada, where they threaten the relict herd of wood bison (*Bison bison athabascae*). However, public pressure has now caused the slaughter decision to be rescinded.

In 1985, raccoons (*Procyon lotor*), translocated from Texas to West Virginia to augment the local raccoon stock for hunting purposes are believed to have brought with them parvoviral enteritis, a serious disease previously not present in West Virginia and now enzootic in the local raccoon population (Allen, 1986). A similar case occurred when 'a few thousand' raccoons were translocated from Florida to West Virginia in 1977, again for hunting purposes. This particular relocation is still blamed for the current rabies epizootic in raccoons and skunks (*Mephitis mephitis*) in Pennsylvania, Virginia and Maryland (Anon, 1990). Rabies is said to have been far less common in these states before the raccoon translocation from Florida took place. It is, of course, possible that the ongoing rabies outbreak may be a reflection of the increase in the local raccoon population in the area.

In September 1952, 225 domestic reindeer (*Rangifer tarandus*) were translocated by ship from northern Norway to western Greenland. The object of this introduction was to provide a new livelihood for the local Inuit (Rosen, 1955). Unfortunately the reindeer brought with them a warble fly (*Oedemagna tarandi*) and a nostril fly (*Cephenemyia trompe*), both of which at that time did not occur in Greenland (Rosen, 1958). In due course these parasites transferred their attention to the indigenous wild Greenland caribou (*Rangifer tarandus groenlandicus*). Both these flies severely harass the caribou throughout the relatively warm long summer days to the extent that they are unable to feed sufficiently to build up the fat stores upon which they depend to survive the Arctic winter. This translocation was a disaster for the Greenland caribou, which are now greatly reduced in numbers due to severe winter mortality. All the caribou in western Greenland are now infested with both parasites (Thing and Thing, 1983).

Sick specimens of the endangered Mojave Desert tortoise (*Xerobates agassizii*), unwanted by their owners, have been released back into the desert and are believed to have infected the wild tortoises with a fatal upper respiratory tract infection, probably acquired on pet shop premises (Jacobsen *et al.*, 1991).

Large numbers of hares (*Lepus europaeus*) are imported annually from Hungary and Czechoslovakia into Switzerland and Italy for sporting purposes. Some of these animals are infected with *Brucella suis*, an important pathogen which can seriously affect domestic livestock (Pastoret *et al.*, 1988).

9.4 DISEASES ENCOUNTERED BY TRANSLOCATED ANIMALS AT THE RELEASE SITE

Animals born and bred on a distant continent in a very different epidemiological environment, may have encountered diseases endemic in that area (and may sometimes have become symptomless carriers of the pathogens), but will also inevitably lack acquired immunity or resistance to infections that are equally exotic (to them) which will challenge them at the release site. Many diseases and parasites are very local in their distribution as a result of the highly specific ecological requirements of the pathogens and their vectors, and even a short translocation of wild-caught animals from one ecozone to another can result in their exposure to unsuspected disease problems. Some examples are given in Table 9.2.

About half of 50 koalas (*Phascolartos cinereus*) translocated from a tick-free area in Victoria, Australia to a nearby range infested with the Ixodid vector of tick paralysis, rapidly succumbed, (S. McOrist, pers. comm.). Adult Kafue Flats lechwe (*Kobus leche*) – a large Zambian antelope – were translocated into an area infested with the tick vector of heartwater and where this disease was enzootic in nearby domestic stock. Within two months 56 lechwe had died; autopsies revealed heavy tick infestations (*Amblyomma variegatum*) and characteristic lesions of heartwater (Pandey, 1991). Had either of these two diverse species been born in the areas infested by the tick vectors they would probably have acquired resistance to the respective diseases and the translocations would have been a success. Caribou and moose (*Alces americana*) are seriously affected by the 'meningeal worm' (*Pneumostrongylus tenuis*) of white tailed deer (*Odocoileus virginianus*), and attempts to translocate these ungulates into the white-tailed deer range in north-eastern America have been frustrated by cerebrospinal nematodiasis acquired by the

Table .2 Diseases encountered at release areas by translocated wildlife[a]

Species translocated	*Source*	*Disease encountered at release site*	*Release area*	*Source of pathogen*	*References*
Koala	Victoria, Australia, w/c Tick paralysis, vector: *Ixodes* spp.		Victoria, Australia	Toxic agent in tick saliva	–
Lechwe	Zambia, w/c	Heartwater, vector: *Amblyomma* spp.	Zambia	Enzootic in local wild ruminants	Pandey, 1991
Caribou	Eastern USA, w/c	Cerebrospinal nematodiasis	Ontario	White-tailed deer	Anderson, 1971
Caribou	Quebec, w/c	Cerebrospinal nematodiasis	Nova Scotia	White-tailed deer	Anderson, 1971

Arabian oryx	USA, c/b	Botulism	Oman	Enzootic in Oman	Stanley Price, 1989
Muskrat	Canada, w/c	Tularaemia	USSR	Water voles	Pavlovsky, 1966
Golden lion tamarin	USA, c/b	'Disease'	S.E. Brazil	?	May and Lyles, 1987
Hawaiian goose	UK, c/b	Avian pox vector: mosquitoes	Hawaii	Local birds	Kear, 1977; Kear and Berger, 1980; Berger, 1978
Brush-tailed possum	Tasmania, w/c	Bovine tuberculosis	New Zealand	Domestic cattle	Hickling, 1991
Black rhinoceros	Highland Kenya, w/c	Trypanosomiasis	Lowland Kenya	Tsetse flies, local wildlife and domestic stock	Mihok *et al.*, 1992

*w.c = wild caught; c/b = captive bred.

after stringent quarantine has been undergone in the country of origin. In other cases the DVSs may not only require that the quarantine premises be approved by their departments but that any biological samples shall be collected under the supervision of their officers, and that subsequent diagnostic tests shall be conducted at their departments' laboratories. Furthermore it is becoming a common practice for the DVS to require a further period of quarantine, during which some of the diagnostic tests may be repeated, after the imported animals arrive in the destination country.

These regulations and requirements are likely to become more stringent as international animal disease control policies develop. Their impact on the future prospects for intercontinental animal movements will be considerable. Even within countries, the distribution of disease agents is irregular and the local movement of animals, both wild and domestic, is often subject to strict veterinary regulation.

The criteria for the selection of founders for a reintroduction attempt have been discussed by Stanley Price (1989). In this review, disease risk is considered to be a major factor in assessing the wisdom of population reinforcements and the case is cited where at least one release of rehabilitated orang utans (*Pongo pygmaeus*) in Indonesia was cancelled because some were found to be infected with human tuberculosis (Jones, 1982). Tuberculosis and human herpesvirus have recently been found to infect orang utans translocated from Taiwan, where they had been held captive, to Malaysia, where it was planned to release them back into the wild. These animals are now (1992) being held in isolation until an appropriate solution is found.

After selection of the founders has taken place, the group must be placed in quarantine for a minimum of 30 days (some countries may require 60 days). The site of the quarantine station may be at the zoo, wild animal park or ranch where the animals were raised, or it can be at a distance if animals from several separate sources are to be combined to make up the herd or group. The main requirement is that the group should be completely isolated from its own and related species (if possible from all species), with the necessary exception of a limited number of human attendants.

The veterinary import requirements of the receiving country should be known so as to ensure that the period of quarantine and any special screening requirements can be met.

The quarantine premises must be appropriate for the species concerned and for the epidemiological situation, e.g. mosquito-netted enclosures will need to be provided where vector-borne diseases are to be excluded. The facilities must allow adequate visual access and permit clinical examination, sampling and, if necessary, chemical immobilization. Isolation from all possible sources of infection must be absolute and human attendants must be screened for transmissible diseases, e.g. tuberculosis. Early in the quarantine period disease screening procedures such as the following must be instituted.

(a) The breeding history and clinical records of the founder stock (if available) will be examined. Since founders gathered at a quarantine station may have their origins in several zoos or captive breeding establishments this may be a tedious process, but it is important because some zoos have a poor health record, especially for some infectious diseases such as tuberculosis, and this will influence the interpretation of subsequent tests.
(b) The stock should be given a thorough visual clinical examination during which the veterinarian will look for aberrant behavioural traits as well as clinical signs. When the animals are released and exposed to the selective forces of their wild environment any physical or behavioural abnormality will reduce their chances of survival. This is particularly important when the founders are derived from captive-bred stock. Only very rarely are animals that are habituated to humans suitable for a reintroduction project.
(c) Local and regional disease patterns in the source area must be assessed, if necessary referring to the Office International des Epizooties (OIE), and the Food and Agriculture Organization (FAO)'s *Animal Health Yearbook*, and for Europe, *Faune Sauvage d'Europe, Informations Techniques des Services Veterinaires*, for details of disease occurrence in the country concerned. The advice of the national DVS and of local veterinarians, wildlife biologists and livestock farmers should also be actively sought. On the basis of these enquiries and on a knowledge of the common pathogens of the founder species, the veterinarian will prepare a screening protocol that will also take into account any disease problems which may have been associated with previous translocation of the taxon and any special pathogens stipulated by the international or national veterinary authorities in the release country.
(d) Before undertaking the screening procedures all founder animals should be permanently marked by ear tag, tattoo and/or electronic micro-chip.
(e) The collection of biological samples from the founder animals is best carried out early in the day so as to allow for same-day processing and swift dispatch to the laboratory.
(f) The samples should be sent to internationally recognized reference laboratories. These institutions have the requisite expertise and will be using the most up-to-date tests. It may be an advantage to send replicate samples to different laboratories and to ask the laboratories for their interpretation of the results.

(g) Laboratory procedures for the direct detection of evidence of infection will include:
- clinical haematology;
- blood smears for haemoparasites (for trypanosomes the buffy coat of a microhaematocrit tube may be examined);
- bacterial cultures;
- viral cultures;
- faecal egg counts;
- faecal larval culture (especially for lungworm);
- urinalysis (and examination of urine for kidney worm eggs);
- molecular biological techniques, especially nucleic acid hybridization with specific probes, are robust, highly sensitive and increasingly available.

(h) Laboratory procedures for the indirect detection of evidence of infection will include demonstration of antibodies. The presence of antibodies to a specific pathogen in a single serum sample at a determined level of dilution (titre) reveals that the animal has been exposed to infection by that pathogen. This indicates either natural infection or, in the case of zoo or captive-bred stock, the possibility of prior vaccination. Serial serum samples showing an active rising antibody titre are required to determine whether an animal is incubating or recovering from an infection. Depending on the pathogen concerned, further tests may be needed to differentiate whether an animal whose serum contains specific antibodies is likely to be an infectious carrier of the disease.

In some cases it may be desirable to recommend a total ban on the importation (into a 'clean' country) of certain species. For example, Greenwood and Cooper (1982) drew attention to the likely danger presented by prairie falcons (*Falco mexicanus*) and great horned owls (*Bubo virginianus*), both of which are commonly infected with falcon herpesvirus and suggested that the importation of these species from the USA into the UK should be restricted or banned.

9.5.2 Veterinary intervention at the proposed release site

Where possible, the veterinarian should visit the proposed release site during the planning phase (and well in advance of the translocation) to carry out the following.

(a) Consult with the directors of veterinary and wildlife services of the recipient country. This is important to avoid misunderstandings and to find out whether there are any special tests or certifications required by these directorates.

(b) Determine which diseases of wild and domestic animals and what vectors and reservoirs are enzootic in contiguous territories. A study of local seasonal wildlife migrations and domestic livestock trade routes is also relevant.

(c) Consult with regional veterinary authorities about the prevalence and incidence of local diseases.

(d) Check with the local diagnostic laboratory on the results of recent domestic animal disease surveys.

(e) Ascertain the degree of contact likely between the translocated animals and domestic stock, wildlife and humans.

(f) Decide if vaccination programmes of the national veterinary department are adequate to provide a protective immune barrier for susceptible wildlife against such diseases as rinderpest and foot and mouth disease for ungulates, and rabies for carnivores.

(g) Survey the proposed release site and assess the likely presence of disease vectors and disease foci. The overall suitability of the release site may be greatly influenced by these factors.

(h) If possible, survey and sample selected wild species and domestic stock at the release site and screen for appropriate suspected pathogens.

(i) Investigate availability of suitable vaccines to protect founder stock against local diseases identified during these investigations.

(j) Check if any mineral or trace element deficiencies or excesses occur in the release area. If supplementary feeding is planned, foodstuffs, especially hay, may have to be transported over long distances from a different ecozone and should be checked for toxic substances (e.g. selenium), for ticks and other parasites and for agricultural pesticides.

(k) Check the release area for the presence of poisonous plants which may be unfamiliar to translocated animals, especially in the dry season.

(l) Find out why the species to be translocated is absent from the area. Have previous translocations failed? If so, was disease a reason?

(m) Prepare a report and send copies to the directors of veterinary and wildlife services of the recipient country.

9.5.3 Pre-release planning

The well-tried strategy of confining an integrated social group in a large open enclosure near or actually in the release area for a considerable period before release has a number of advantages (Stanley Price, 1989).

(a) Social groupings can be adjusted and become established.

(b) The period of confinement acts as an extended quarantine during which the clinical signs of infectious or contagious disease may be detected.

(c) Contact with domestic stock and other wildlife can be excluded, thus reducing the chance of disease transmission.
(d) The foundation stock can become acclimatized to local conditions.
(e) Handling can be minimized but if necessary can be achieved with little stress if the enclosure is equipped with well-designed facilities for restraint.

Once the founder stock is released there will be little chance of protecting them against the challenge of disease agents. Nevertheless, successful attempts have been made in the Kruger National Park to vaccinate valuable roan antelope (*Hippotragus equinus*) against anthrax by darting them from a helicopter (de Vos, Van Rooyen and Kloppers, 1973), and the success of oral rabies vaccine baits for foxes (*Vulpes vulpes*) in Europe is now well known (Blancou *et al.*, 1988; Pastoret *et al.*, 1988).

9.6 INTERPRETATION OF SURVEY AND SCREENING RESULTS

The results of the investigation of the disease history of the source of the animals will help in deciding if any biological tests should be given priority. The finding that zoo-bred animals have been vaccinated against a certain disease, for example, leptospirosis, may be evidence that this disease is a problem in the zoo supplying the animals. Tuberculin tests for animals originating in a zoo where tuberculosis is enzootic need to be interpreted more carefully than where the disease is unknown. Bluetongue and epizootic haemorrhagic disease sera may cross-react, and virus isolation tests may be necessary to determine whether positive serology indicates carrier status for either virus. Zebra and wild African suids are symptomless carriers of African horse sickness and African swine fever viruses, respectively, and are therefore subject to strict international movement regulations. Elephants (*Loxodonta africana*) and aardvarks (*Orycteropus afer*) may have antibodies to these respective disease agents but their significance is unclear.

So great is the variety of mammals, birds, reptiles, amphibians and even invertebrates which may in future become the subject of translocation projects, that specialist advice will almost certainly be required for the interpretation of results of the investigations carried out at both the source of the founder species and the release site. International disease monitoring organizations such as the International Office of Epizootics (OIE); the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) may all be consulted, as may the Veterinary Group (VG) of the Species Survival Commission (SSC) of the World Conservation Union (IUCN) and the veterinary services of the countries concerned.

9.7 VACCINATION OF FOUNDERS

The decision to vaccinate and the choice of vaccines will depend on the interpretation of the results of the surveys and investigations described in sections 9.5.1 and 9.5.2.

If there is a significant risk of founder stock being infected by serious pathogens at the release site then it may be advisable to vaccinate them. Two main types of vaccines are available: modified live vaccines which have reduced virulence for one or more species, and a range of 'inactive' vaccines which contain no viable organisms. The advantages of the live vaccines are that they grow in the host after inoculation, and usually induce a solid immunity similar to that found in animals which have recovered from the particular pathogen – if such an immunity occurs. Consequently vaccination with a live vaccine usually requires only one inoculation, which is a great advantage when dealing with wildlife, especially those that need restraint.

The disadvantage of live vaccines is that whilst they may have reduced virulence for some species they may remain pathogenic for others. For instance, live canine distemper virus vaccines have induced disease in susceptible mustelids, including the endangered black-footed ferret (*Mustela nigripes*). Live feline parvovirus vaccine (feline enteritis or panleucopaenia), which is innocuous for domestic cats, is thought to have caused disease in other felines. Although safe in most breeds of cattle, a live rinderpest vaccine prepared in rabbits caused significant mortality when tested in a variety of African artiodactyls (Brown and Scott, 1960). Fortunately the current cell-culture-derived rinderpest vaccine has proved both safe and efficacious in the wild species tested to date, including buffalo, eland and warthog, which are highly susceptible, and impala and oryx, which are less so (Rossiter, unpublished findings; Plowright, 1982; Bengis and Erasmus, 1988). The control of rabies in western Europe and elsewhere has been radically improved through the use of live vaccines administered orally to foxes and other wildlife in 'baits'. There is considerable variation in the susceptibility of different species to live rabies virus and an important concern was the risk that live vaccines, although innocuous for the fox or other target species, could prove virulent for other species which might incidentally scavenge the baits.

Thus for vaccination of founder stock live vaccines offer several advantages so long as they have been proven to be safe in the chosen species. Care should be taken to use the same strain of a particular vaccine that has been successfully tested in the species, since different manufacturers may use different strains. Unless they have been tested with the vaccine, it is best to avoid vaccinating pregnant females as some live vaccines, especially viral, can cause foetal death and/or abortion. Similarly some live vaccines may cause disease in very young animals and the manufacturer's instructions should be sought on this matter. If females have been vaccinated previously, then maternal immunity may reduce the immunogenicity of live vaccines administered to young animals (carnivores less than three to four months old, herbivores less than six months old).

Inactive vaccines carry little risk of infecting the host, although some toxoids can induce local reactions at the site of inoculation. However, since they do not replicate in the host, these vaccines usually require more than one initial application and may require frequent boosting. Whether this will prove to be the case with the inactivated canine distemper virus vaccines currently being investigated for the protection of harbour seals (*Phoca vitulina*) against phocid distemper remains to be seen (Visser *et al.*, 1989). These vaccines are often incorporated into alum or other 'adjuvants', which help stimulate the immune response but can also cause significant local reaction at the inoculation site.

A good example of the use of an inactivated viral vaccine to protect a captive-bred species prior to exposure to infection in the wild is afforded by the case of the whooping crane (*Grus americana*). The whooping crane, although never abundant in North America, became endangered largely because of habitat modification and destruction. To help recovery, a captive propagation and reintroduction program was initiated in 1966 at the Paluxent Wildlife Research Centre (PWRC) at Laurel, Maryland. However, in 1984, seven of 39 whooping cranes at PWRC died from infection by eastern equine encephalitis virus (EEE), an arbovirus that infects a wide variety of indigenous bird species, although mortality is generally restricted to introduced birds. Following identification of the causal agent, surveillance and control measures were implemented, including serological monitoring of both wild and captive birds for EEE viral antibody and assay of locally trapped mosquitoes for the virus. In addition, an inactivated EEE virus vaccine developed for use in humans was evaluated in the captive whooping cranes. Results so far suggest that the vaccine will afford protection to susceptible birds.

As part of the effort to restore whooping crane populations in the wild, three geographically isolated areas in the eastern USA are being considered as possible reintroduction sites. Since EEE viral transmission occurs annually in parts of eastern USA it will be important to survey for EEE virus and its mosquito vectors before selecting the release sites.

Although the die-off of whooping crane due to EEE virus was a set back for the captive breeding programme, it is now known that this disease must also be considered in establishing wild crane populations (Carpenter, Clark and Watts, 1989).

If there is an urgent need to vaccinate stock of unknown susceptibility to a live vaccine then an inactive vaccine should be used, if available. Failing this, the live vaccine could be tested in one or two founder stock, so long as these are isolated from the rest of the group.

Protective immunity may take from a few days to several weeks to develop, so immunization schedules should be carried out well in advance of translocation. This has the added benefit of acting as a further quarantine period lest the animals be incubating a field infection or be excreting the live vaccinal agent administered to them. It should be remembered that some live vaccines induce persistent infections, the vaccinates in effect becoming carrier animals which may pass on infection to vectors or susceptibles, although fortunately this is rare.

9.8 POST-RELEASE HEALTH MONITORING

Regular, systematic monitoring of the health and reproductive performance of translocated animals may provide an early warning of incipient disease problems. If the causes of disease or reduced productivity can be determined, a change in management may be indicated for the current or future translocations.

Provision for long-term monitoring is often included in translocation project plans but is seldom carried out once the released animals appear to be surviving in the wild. Post-release monitoring of the Hawaiian goose was recommended during the project design (Kear and Berger, 1980) but little took place. After the release of 1244 birds over 16 years on Hawaii and a further 391 on Maui Island, the status of the reintroduced population was unknown and the reasons for its limited success (believed to be associated with avian pox virus infection) could only be guessed (Berger, 1978).

9.9 DISEASE TRANSMISSION HAZARDS WITH CRYOPRESERVED GERMPLASM

In the not-too-distant future, translocation of wild animal gametes and embryos may become an accepted technique for minimizing the effects of inbreeding in small isolated populations. When genetic resource banking programmes become established, the disease implications of these activities will have to be addressed.

The diseases of domestic stock transmissible by semen and embryo transfer have been reviewed by Hare (1985) and Singh (1988). Disease transmission between different populations can be greatly reduced by embryo transfer, because an intact embryo collected from a diseased mother is often free from the bacterial and viral disease agent and so does not transmit the disease to the foster mother. The surrogate mother, too, may confer passive immunity to the offspring which develops from a transferred embryo. This passive immunity may be transplacental or via the colostrum, and can prove of value in producing offspring passively immune to local enzootic diseases.

If the results of research on domestic embryos can be extrapolated to wild animals, it would seem that the potential of embryos to transmit infectious disease is considerably less than that of semen or live animals. In fact, it remains to be established whether under field conditions disease transmission will ever occur via embryo transfer. Sufficient research has been carried out with embryos from bovine leukaemia virus-infected donors and foot and mouth disease virus donors to determine that these viruses will not be transmitted via embryos, provided they are handled properly (Singh, 1988). Research is at present in progress to determine whether similar conclusions can be reached for other pathogens.

Little, if any, research has been done on the disease transmission potential of cryopreserved germplasm derived specifically from wild animals. Semen clearly has great potential for the spread of infectious disease, but semen also provides an excellent means of disease control when it is collected and transferred artificially using strict aseptic techniques, because direct animal contact is avoided, the health status of the donor can be predetermined and, if the semen is frozen, aliquots can be tested for the presence of microorganisms.

Embryos have less potential for the transmission of disease than does semen. At the developmental stage at which they are usually transferred embryos are protected by a relatively thick capsule, the zona pellucida. For the embryo to transmit infectious disease it has either to be infected with a minimum infective dose or to act as a carrier through association of the disease agent with the zona pellucida. Preliminary evidence suggests that while many disease agents are removed or inactivated by washing or other treatments, a few are not. Current regulations to control disease transmission by embryos of domestic animals are based largely on the philosophy that if the donors are free from specified diseases, their embryos will be similarly free. Evidence to date suggests that this approach may be unnecessarily restrictive with regard to a number of diseases (Hare, 1985).

It is expected that the principles summarized here will be applicable to cryopreserved wildlife germplasm, but that while the results of current research on diseases of domestic animals transmissible by semen and embryo transfer techniques can probably be extrapolated to include cryopreserved wildlife genetic material, care will be needed to ensure that specific wildlife diseases are not transferred.

9.10 DISCUSSION

Many endangered species have been reintroduced into the wild after captive propagation. In at least six cases – Père David's Deer, Przewalski's horse (*Equus przewalski*), red wolf (*Canis rufus*), Arabian oryx, Guam kingfisher (*Halcyon cinnamomina*) and Guam rail (*Rallus owstoni*) – these species were extinct in the wild at the time of the reintroduction: in the case of Père David's deer, extinct for 800 years! A number of other species, notably the California condor (*Gymnogyps californianus*) and the black-footed ferret, are likely to be reintroduced into their native habitat as soon as captive numbers are considered adequate.

In the majority of translocation projects few systematic attempts are made to quantify and minimize the veterinary risks attending the translocation of the founder animals. Notable exceptions to this generalization have been the careful screening and preparation of the black-footed ferret for return to the wild, and the development of stringent veterinary protocols for the Arabian oryx destined for release in the deserts of Oman. The latter have now become so strict that the captive source (a zoological collection in the USA), from which founder and reinforcement stock have been obtained, is no longer able to comply.

The 'rescue', rehabilitation and return to the wild of sick and injured wild animals and birds is an activity which attracts the attention and money of the general public. These activities are often carried out by enthusiastic amateurs and can, in some cases, be hazardous. Animals which are sick may wander long distances from their home range, and birds on migration may alight many miles from their destination. If such specimens, when apparently restored to health, are released back into the wild, they may become serious foci of infection for local animals. Even more dangerous is the return of sick strays to their distant natural habitat after a period in captivity during which they may have been in contact with diseased animals of the same or related species from other sources.

Members of the veterinary profession with experience and expertise in wildlife disease need to be involved in the timely planning of translocation projects to ensure that appropriate quarantine and screening are carried out. In special cases the quarantine period may need to be extended, e.g. if tuberculosis is perceived as a special hazard. The disease conditions affecting the great range of taxa which may be the subject of future translocation projects are so varied that no simple guidelines can be drawn to cover all exigencies. Each case must be separately evaluated, taking into account all biological, ecological, geographical and epidemiological circumstances. Only then will the inherent risks in moving potential 'disease packages' across the world be minimized, and the chances of failing to establish a healthy new wild population significantly reduced.

In the longer term, the establishment of a database on infectious agents and diseases of wildlife would be a very important supporting activity. An expanding source of information, publishing bulletins of wildlife disease occurrence on a global scale, will assist veterinarians to evaluate the disease risks which may attend a translocation proposal.

ACKNOWLEDGEMENTS

Permission to reproduce this paper is given by the Director General of OTE.

REFERENCES

Allen, T.J. (1986) Evaluation of movements, harvest rate, vulnerability and survival of translocated raccoons in southern West Virginia. *Trans. Northeast. Sect. Wildl. Soc.*, 43, 64.

Anderson, R.C. (1971) Lungworms, in *Parasitic Diseases of Wild Animals* (Eds J.W. Davis and R.C. Anderson), Iowa State University Press, Ames, Iowa, pp. 81–126.

Anon (1990) A bridge too far. *The Economist*, May 12, 1990, 48–9.

Aveling, R. and Mitchell, A. (1982) Is rehabilitating orang utans worthwhile? *Oryx*, 16, 263–71.

Asmode, J.F. and Khoja, A.R. (1989) Arabian oryx captive breeding and re-introduction in Saudi Arabia, in *Proc. Captive Breeding Specialist Group Aridland-Antelope Workshop, San Antonio, Texas* (eds U.S. Seal, K. Sausman and J. Mikolai), pp. 109–25.

Bengis, R.G. and Erasmus, J.M. (1988) Wildlife diseases in South Africa: a review. *Rev. Sci. Tech. Off. Int. Epiz*, 7 (4), 807–21.

Berger, A.J. (1978) Reintroduction of Hawaiian geese, in *Endangered Birds: Management Techniques for Preserving Threatened Species* (ed. S.S. Temple), Univ. of Wisconsin Press, London, pp. 339–44.

Blancou, J., Pastoret, P.-P., Brochier, B., Thomas, I and Bogel, K. (1988) Vaccinating wild animals against rabies. *Rev. Sci. Tech. Off. Int. Epiz.*, 7, (4), 989–1003.

Booth, W. (1988) Reintroducing a political animal. *Science*, 24, 156–9.

Brambell, M.R. (1977) Reintroductions. *Int. Zoo. Ybk*, 17, 112–16.

Brown, R.H. and Scott, G.R. (1960) Vaccination of game with lapinised rinderpest virus. *Vet. Rec.*, 72, 1232.

Cade, T.J. (1988) Using science and technology to reestablish species lost in nature, in *Biodiversity* (eds E.O. Wilson and F.M. Peter), National Academy Press, Washington, DC, pp. 279–88.

Caldecott, J.O. and Kavanagh, M. (1983) Can translocation help wild primates? *Oryx*, 17, 135–9.

Carpenter, J.W., Clark, G.G. and Watts, D.M. (1989) The impact of Eastern equine encephalitis on efforts to recover the endangered whooping crane, in *Disease and Threatened Birds* (ed. J.F. Cooper), ICBP Technical Publications No. 10, pp. 115–20.

de Vos, V., Van Rooyen, G.L. and Kloppers, J.J. (1973) Anthrax immunisation of free-living roan antelope (*Hippotragus equinus*) in the Kruger National Park. *Koedoe*, 16, 11–25.

Flamand, J. (1990) An outbreak of tuberculosis in a herd of Arabian oryx. Diagnosis and management, in *Abstracts: VI Int. Conf. on Wildl. Dis.*, Berlin, p. 21.

Greenwood, A.G. and Cooper, J.E. (1982) Herpes virus infections in falcons. *Vet. Rec.*, 11, 514.

Griffith, B., Scott, J.M., Carpenter, J.W. and Read, C. (1989) Translocation as a species conservation tool: status and strategy. *Science*, **245**, 477–80.

Hare, W.C.D. (1985) Diseases transmissible by semen and embryo transfer. OIE Tech. Series No. 4, Office International des Epizooties, Paris.

Hedger, R.S. and Condy, J.B. (1985) Transmission of foot and mouth disease from African buffalo virus carriers to bovines. *Vet. Rec.*, **117**, 205.

Heuschele, W.P. (1990) Tuberculosis in captive Arabian oryx, in *Abstracts: VI Int. Conf. on Wildl. Dis.*, Berlin, p 31.

Hickling, G.J. (1991) The ecology of brush-tailed possum populations infected with tuberculosis, in *Proc. Symp. Tuberculosis. Publication 132* (ed. R. Jackson), Massey Univ., Palmerston North, New Zealand.

Jacobsen, E.R., Gaskin, J.M., Brown, M.B. *et al.* (1991) Chronic upper respiratory tract disease of free-ranging desert tortoises (*Xerobates agassizii*). *J. Wild. Dis.*, **27** (2), 296–316.

Jones, D.M. (1982) Conservation in relation to animal disease in Africa and Asia. *Symp. Zoo. Soc. Lond.*, **50**, 271–85

Kear, J. (1977) The problems of breeding endangered species in captivity. *Int. Zoo Ybk.*, **17**, 5–14.

Kear, J. and Berger, A.J. (1980) *The Hawaiian Goose: An Experiment in Conservation.* T. & A.D. Poyser, Calton.

Kleiman, D.G. (1989) Reintroduction of captive mammals for conservation. *Bioscience*, **39**, 152–69.

Kock, R.A. and Woodford, M.H. (1988) Reintroduction of Père David's deer (*Elaphurus davidianus*), scimitar-horned oryx (*Oryx dammah*) and the Arabian oryx (*Oryx leucoryx*) to their native habitats – a veterinary perspective, in *Proc. Joint Conf. Amer. Assoc. Zoo Vets and Amer. Assoc. Wildl. Vets*, Toronto, Ontario, pp. 143–4.

May, R.M. and Lyles, A.M. (1987) Living Latin binomials. *Nature*, **334**, 642–3.

McCulloch, B and Achard, P.L. (1969) Mortalities associated with capture, translocation, trade and exhibition of black rhinos. *Int. Zoo. Ybk.*, **9**, 184–91.

Mhok, S., Munyoki E., Brett R.A. *et al.* (1992) Trypanosomiasis and the conservation of black rhinoceros (*Diceros bicornis*) at Ngulia Rhino Sanctuary, Tsavo West National Park, Kenya. *Afr. J. Ecol.*.

Nettles, V.F. (1988) Wildlife relocation: disease implications and regulations. *Proc. 37th Ann. Conf. Wildl. Dis. Assoc. Athens*, Georgia, p. 52.

Environmental Assessment Panel (1990) Northern Diseased Bison, Report of the Environmental Assessment Panel, 510–750 Cambie St, Vancouver, B.C. V6B 2P2, Canada.

OIE (1987) Epizootiological Information, Nos. ESP/87/1/117, ESP/87/2/119, ESP/87/3/121, ESP/87/4/127, ESP/87/5/142 and ESP/87/6/145, Office International des Epizooties, Paris.

Pastoret P.-P., Thiry E., Brochier B. *et al.* (1988) Diseases of wild animals transmissible to domestic animals. *Rev. Sci. Tech. Off. Int. Epiz.*, 7, (4), 705–36.

Pandey, G.S. (1991) Heartwater (*Cowdria ruminantium*) with special reference to its occurrence in Zambian wildlife. *Newsletter of the Centre for Tropical Veterinary Medicine (Edinburgh)*, **52**, 6.

Pavlovsky, E.N. (1966) The natural nidus of a disease as a pathobiocenose, in *Natural Nidality of Transmissible Diseases*, Univ. of Illinois Press, Urbana, pp. 13–15.

Philip, P. (1989) Tuberculosis in deer in Great Britain. *State Vet. J.*, **43**, 125.

Plowright, W. (1982) The effects of rinderpest and rinderpest control on wildlife in Africa. *Symp. Zool. Soc. Lond.*, 50, 1–28.
Rosen, J. (1955) Norwegian domesticated reindeer in Greenland, In *Polarboken*, Norwegian Polar Institute, Oslo, pp. 147–59.
Rosen, J. (1958) Reindeer flies and reindeer lice. *Gronlandsposten*, 26, 24.
Singh, E. (1988) Potential of embryos to control transmission of disease: a review of current research. Animal Disease Research Inst., Nepean, Ontario, Canada.
Stanley Price, M.R. (1989) *Animal Re-introductions: The Arabian Oryx in Oman*. Cambridge Univ. Press, Cambridge, UK, pp. 188, 119–201, 222–38.
Thing, E.M. and Thing, H. (1983) Cow–calf behaviour in West Greenland caribou on Sdr. Stromfjord summer range. *Acta Zoologica Fennica*, 175, 113–15.
Trust, T.J. (1986) Pathogenesis of infectious diseases of fish. *Ann. Rev. Microbiol*, 40, 479–502.
Visser, I.K.G., van der Bildt, M.W.G., Brugge H.N. *et al.* (1989) Vaccination of harbour seals (*Phoca vitulina*) against phocid distemper with two different inactivated canine distemper virus (CDV) vaccines. *Vaccine*, 7, 521–6.
Wilson, E.O. and MacArthur, R.H. (1967) *The Theory of Island Biogeography* (ed. E.O. Wilson), Princeton Univ. Press, Princeton, NJ, pp. 203.

PREVENTIVE MEDICINE PROTOCOLS FOR REINTRODUCTION PROGRAMS

Terry M. Norton, DVM* Dipl. ACZM
Riverbanks Zoological Park, PO Box 1060, Columbia, SC 29202 USA

Reintroduction of captive animals to the wild is currently receiving considerable attention.[1,2,4-7,9,11-15] Several species reared in captivity have been or are currently being reintroduced to the wild including the golden lion tamarin (*Leontopithecus rosalia*),[7] black-footed ferret (*Mustela nigripes*),[13,15] red wolf (*Canis rufus*), Arabian oryx (*Oryx leucoryx*),[14] scimitar-horned oryx (*Oryx dammah*),[14] Pere David's deer (*Elaphurus davidianus*),[14] whooping crane (*Grus americana*),[6] Bali mynah (*Leucopsar rothschildi*), California condor (*Gymnogyps californianus*),[11] Andean condor (*Vultur gryphus*),[11] thick billed parrot (*Rhynchopsitta pachyrhyncha*),[12] Virgin Island boa (*Epicrates monensis granti*),[9] and many others. Preventive medicine has become a vital part of reintroduction programs.[1,3,5-7,11,13-15] The goal of a good preventive medicine program should be to prevent the introduced species from contracting disease from animals indigenous to the reintroduction area and prevent the introduction of diseases into the area's indigenous animal or human population.[14] This discussion will outline preventive medicine issues that should be developed and tailored to the specific species considered for reintroduction. The author has served as veterinary advisor for the Bali mynah (*Leucopsar rothschildi*) Species Survival Plan (SSP) for the past 3 years and many examples utilized in this discussion come from this experience.

In the initial planning stages of a reintroduction project, a disease and medical problem preventive medicine program should be developed.[1] Protocols should be continually re-evaluated and updated as more information becomes available. The Bali mynah reintroduction program has been ongoing since 1985. Minimal medical screening was performed prior to the Bali mynah releases in 1988 and 1990. Shortly after the first release, all the birds died or could not be located. These disappointing results were attributed to releasing the birds during the dry season, releasing the birds too far from any existing roost sites, and releasing too few birds (three). The second release was much more successful, because the birds were released during the wet season, the locality of the release was very near the only remaining regular Bali mynah roosting site, and a greater number of birds (thirteen) were released(Pers. Comm., Seibels). At the time of this writing a third release is being planned on a small island off the coast of Bali. It is unknown whether the birds will fly to Bali and join the current wild flock or stay on the island. There have been no Bali mynahs sighted on this island to date. In 1990, the wild Bali mynah population was estimated in the range of 12 to 18 birds. Most recent estimates are in the range of 55 to 61 (Pers. Comm., Seibels).

The first step in developing a preventive medicine program for a reintroduction project is to define the diseases in captivity of the species to be reintroduced.[8] Veterinary assistance is critical in defining medical problems in captivity. Many SSPs have recently added veterinary medical advisors to assist the propagation group in the overall management of SSP animals. The veterinary advisor can act to coordinate other specialists to assist in medical evaluation and management. The cheetah SSP is an excellent model to use when developing a team of health and husbandry specialists to evaluate a captive population of a particular species.[8] The Florida panther project is likewise an excellent model for disease evaluation of a wild population of a particular species.[10] A pathologist should be consulted in the development of a necropsy protocol and assisting in the evaluation of health problems of a particular species. Dr. Kenneth Latimer, a pathologist at the University of Georgia, assisted in the preparation of the US Bali mynah necropsy protocol, and performs the histopathology on all Bali mynah deaths at no charge. This provides more uniform necropsies and has been the most useful diagnostic tool in defining diseases in the US Bali mynah population. A necropsy protocol was developed for Indonesian zoos and the Pre-release Training Center (PTC) in Bali and was translated into the local Indonesian language (Bahasa). Vials of 10% formalin were given to each Indonesian zoo housing Bali mynahs along with the protocol. Permits have been obtained to bring formalinized tissues to the US for histopathology. At the time of this writing, it is too early to assess the effectiveness of this effort.

The Bali mynah SSP has also received considerable assistance from Dr. Ellis Greiner, a parasitologist from the University of Florida. Atoxoplasmosis is now known to be widespread throughout the US and Indonesian captive Bali mynah populations. It is currently thought to be the most serious infectious disease in captive Bali mynahs. Dr. Greiner's expertise has been utilized to define the extent of the atoxoplasmosis problem and evaluate the effectiveness of therapy. There are other infectious diseases which impact the captive and wild Bali mynah populations, but these are less common than atoxoplasmosis and have not been well documented. These include chlamydiosis, newcastles disease virus (endemic to Indonesia), toxoplasmosis and salmonellosis. Some examples of infectious diseases and medical problems that have been of concern to some other reintroduction programs include eastern equine encephalitis, *Mycobacterium avium*, disseminated visceral coccidiosis, inclusion body disease, and mycotoxicosis in the whooping crane[2,6]; callitrichid hepatitis virus, *Pterygodermatitesnyciticebi*, intestinal campylobacteriosis, and a familial defect of the diaphragm in golden lion tamarins[7]; bovine tuberculosis in Arabian oryx[14]; malignant catarrhal fever in Pere David's deer[5,14]; canine distemper in the black-footed ferret[13,15] to name a few. Recommendations for infectious disease screening in the various animal groups are listed in Table 1.[5]

Surveys can be developed to define past and present medical problems. They should be written so that the data can be easily utilized and computerized.[8]

The whooping crane recovery program recently held a health management workshop in Madison, Wisconsin in March of 1992 to develop standardized management protocols and to define and prioritize disease research needs. Participants included researchers and clinical veterinarians involved with the whooping crane.[6] A protocol manual entitled "Whooping Crane Health Management Workshop" was developed from the meeting and is an excellent model to be utilized when considering reintroduction for other avian species.

Assessing the impact of a particular medical problem on the wild population is essential. However, this can be very difficult when the release program is in an underdeveloped country and deals with an endangered species. With only 50 Bali mynahs remaining in the wild, it will be very difficult to define diseases in wild Bali mynahs and the impact of disease (such as atoxoplasmosis) on the wild population.

It is extremely important to carry out regular disease monitoring of a population after a release. A disease surveillance protocol should be tailored for the reintroduced species.[14] If possible, selected animals should be physically restrained or immobilized at regular intervals and appropriate samples taken for analysis.[14] Appropriate physical restraint and/or anesthetic protocols should be developed.[14] Facilities should be available for field storage of biomedical samples. Field necropsies are often not feasible due to inability to locate the carcass, rapid autolysis of the carcass, and lack of medical expertise in the field.[8,14] If telemetry is utilized in the reintroduced animals, carcasses may be recovered in a more timely manner. A good example of this is the documentation of a panleukopenia epizootic in wild bobcats (*Felis rufus*) in Southern Florida, where 11 of 18 radio-collared animals died in a 3 month period. Furthermore, over a 10 year period, 16 radio-collared Florida panther (*Felis concolor coryi*) carcasses were recovered and received a thorough postmortem revealing the cause of death of each animal. Without radiotelemetric technology the carcasses would not have been recovered.[10] In future Bali mynah releases, telemetry will be utilized to monitor the released birds. Field biologists should be trained on gross necropsy techniques and sample collection. Permanent records (preferably computerized) should be developed for all aspects of the reintroduction project.

Evaluating the diseases of other species in the release area may also be of benefit to the overall knowledge of infectious disease exposure to the released species. Researchers involved with the black-footed ferret reintroduction project have surveyed for diseases in the release area concentrating on the primary predator species, coyotes (*Canis latrans*) and badgers (*Taxidea taxus*), because of their presumed importance to the epizootiology of canine distemper. The black-footed ferret's primary prey species, the white-tailed prairie dog (*Cynomys leucerus*), were also studied because they are the major host of sylvatic plague (*Yersinia pestis*).[13,15] Eastern Equine Encephalitis (EEE) virus is of major concern to the whooping crane, which is being reintroduced into Florida. The sandhill crane (*Grus canadensis*) is abundant in Florida and is susceptible to similar diseases to the whooping crane, thus it is being used as the animal model for the whooping cranes.[6] The black-winged starling (*Sturnus melanopterus*) is an abundant species closely related to the Bali mynah with an overlapping range, and thus may be a good model for diseases that occur in the wild Bali mynah population. The feasibility of utilizing this species is currently under investigation.

Domestic animals in the release area are another potential source of infectious disease to the reintroduced species.[14] A small village currently resides in the Bali Barat National Park very close to the Pre-release Training Center. Back yard chickens are abundant in this village and a serious threat to the Bali mynahs at the PTC and the wild population of Bali mynahs. Efforts are being made to relocate this village, but this is obviously a very politically sensitive issue. The threat of the released species transferring diseases to domestic stock is often a concern and may be politically detrimental to a release project.

The potential diagnostic laboratories to be used for screening animals in a reintroduction project for infectious diseases and general health should be visited and evaluated by the veterinary advisor.[14] Simply sending samples to a laboratory which claims to test for a particular disease may prove to be a waste of finances, because the results may be misleading, difficult to interpret, or unreliable.[14] The lack of veterinary medical expertise on Bali and throughout Indonesia has made the development of a disease screening protocol for the Bali mynah very difficult. There are very few veterinary or medical laboratories capable of performing the necessary screening tests. The author visited all the zoos in Indonesia housing Bali mynahs in an effort to define the diseases in captivity, train veterinarians and other staff members on basic principles of avian medicine, and develop relationships with Indonesian researchers and laboratories. Involving the native people in reintroduction projects enhance local support and awareness and is essential for a successful program.

When accurate diagnostic testing is unavailable, treatment of certain diseases may be an alternative. For example, a 45 day doxycycline therapy can be utilized to treat chlamydiosis and potentially substitute for screening tests. Immunizations have been used in selected reintroduction programs, usually against pathogens that the species is susceptible to and that are endemic or epidemic in the release area. A few examples include vaccination of the whooping crane against EEE virus[2,6], the black-footed ferret against canine distemper virus[15], and the Florida panther (vaccinated the wild population) against rabies virus, upper respiratory virus, and feline distemper virus.[10]

Another important aspect of developing a reintroduction preventive medicine program (especially in underdeveloped countries) is being familiar with the captive breeding facilities. The animal health history of the supplying institution or individual owner's premises should be studied, together with the incidence and prevalence of local and regional enzootic animal diseases.[14] This has become quite complex when dealing with Bali mynahs. Most Bali mynahs released back to the wild thus far have been born in Indonesia at the Surabaya Zoo in Java. A separate breeding facility, partially funded by the AAZPA, at the Surabaya Zoo was built in 1987. There is no public access to this facility. The birds are housed as individual pairs and egg production has been excellent. Unfortunately, there has been a very high chick and fledgling mortality rate. Atoxoplasmosis is suspected to be the cause of the high mortality, because *Isospora* spp. oocysts (consistent with atoxoplasmosis) were found in the feces of a very high percentage of Bali mynahs at this facility. The preventive medical care and husbandry at the zoo are in need of improvement. In the past, the birds to be released have gone directly to the Pre-release Training Center (PTC) from the Surabaya Zoo without being quarantined. The PTC is designed to provide natural vegetation and diet with minimal human contact. A quarantine facility is currently being constructed on Bali in the Bali Barat National Park. This facility will be utilized to quarantine all birds prior to entry into the PTC. The design of a quarantine facility and procedures should be effective from a medical standpoint, but also designed to minimize injury to the animal (i.e. broken flight or tail feathers in a bird may significantly delay the timing of the release). Obviously, it is recommended to build quarantine facilities prior to the start of the reintroduction project. The length and conditions of the quarantine period will depend on the species to be released and the specific local disease risks which the quarantine is designed to eliminate (i.e. if *Mycobacterium tuberculosis* or *M. bovis* are deemed a hazard then appropriate testing protocols and isolation should be developed, if bluetongue virus is of concern then the quarantine facility should be mosquito proof).[14]

Eight birds from the Surabaya Zoo are currently being housed at the PTC and have been there for well over a year. Physical examinations and diagnostic samples were collected from these birds by the author. The birds were in excellent health except they were all shedding Isospora spp. oocysts consistent with atoxoplasmosis in their feces. A researcher has received funding to place radiotelemetry devices on these birds and monitor them post-release. He is scheduled to start his project in April of 1993, thus it is important that the release take place in a timely manner. A pre-release treatment and diagnostic protocol has been developed for these 8 birds (Table 2). Confining integrated social groups of animals to be reintroduced in a large enclosure in the area near or within the release site for several weeks to months before a release is a very important part of any release program.[14] These birds will be taken to an island off the coast of Bali and placed in a large pre-release enclosure for an acclimation period and then released. Following this release, another group of birds from the Surabaya Zoo will be sent to Bali. A separate quarantine protocol has been developed for these birds (Table 2).

A source of birds for both captive breeding and potential release is the Amnesty Campaign. This program, administered by the Indonesian government, allows citizens who are illegally holding wild-caught Bali mynahs to register them without fear of retribution. The Bali mynah is a status symbol in Bali and throughout Indonesia and is kept in captivity for its beauty and unusual vocalizations. All of these birds are wild caught and very valuable from a genetic standpoint. Genetically unimportant birds from the US have been shipped to Indonesia to be exchanged for the privately-owned wild caught birds. Pre-shipment screening protocols have been developed for US zoos (Table 5). The birds come from a variety of US zoos and are held at the Los Angeles Zoo prior to shipment to Indonesia. Approximately 80 wild caught Bali mynahs currently kept as pets have been identified for exchange. Most of these birds will be used for captive breeding and their offspring will be released. The birds will be distributed to various Indonesian Zoos and to the PTC. The author examined several of these birds at the owner's homes in Denpasar, Bali. A high percentage of them had *Isospora* spp. oocysts in their feces consistent with atoxoplasmosis. Atoxoplasmosis organisms were also found in the monocytes from a plain blood smear from 1 young bird. Unfortunately, most of these birds are housed under suboptimal conditions and have been exposed to a variety of pathogens. Many of them were probably in the bird market at one time during their stay in captivity. These markets are stressful and overcrowded, with a variety of avian and mammalian wildlife. Because of the additional disease risks, a separate quarantine protocol has been developed for these birds (Table 2). Quarantine and preventive medicine guidelines have been distributed to all the zoos in Indonesia housing Bali mynahs. It is very important that all protocols are presented in the native language.

The animals to be released must be identified in some manner (i.e. ear tags, tattoos, bands, or transponders) so that individual recognition and recording are possible.[14] Transponders have been placed in all released Bali mynahs. A Bali mynah recovered from poachers was identified to be a released bird by reading its transponder.

Communication is not only one of the most important parts of developing preventive medicine protocols for a reintroduction program, but for the success of the entire program. The California and Andean condor projects have had extensive veterinary input from multiple individuals and have been successful primarily because of good communication between veterinarians, field biologists, curators, etc.[4] The medical aspects of the Bali mynah reintroduction project are still evolving. It is becoming apparent that communication at all levels is crucial to the success of the medical portion of the program.

The initial drafts for preventive medicine protocols for the Bali mynah release program were ideal protocols which did not take into account limitations in funding, facility space, lack of diagnostic laboratories, educational background of personnel involved with the project, and politics. Hopefully using examples of the successes and the failures of the Bali mynah reintroduction project have given some insight into the development of a preventive medicine program for a release project. Future reintroduction programs should develop medical management strategies prior to releasing captive animals to the wild.

LITERATURE CITED

1. Beck, B. B. 1992. Guidelines for reintroduction of animals born or held in captivity. AAZPA Reintroduction Advisory Group.

2. Carpenter, J. W., G.G. Clark, and D. M. Watts. 1989. The impact of eastern equine encephalitis virus on efforts to recover the endangered whooping crane. ICBP Technical Publication No. 10. Pp. 115-120.

3. Cooper, J. E. 1989. The role of pathogens in threatened populations: an historical review. ICBP Technical Publication No. 10. Pp. 51-59.

4. Hacbler, R. 1992. Disease risk to wildlife following reintroduction. Proc. Joint Meet. AAZV/AAWV. p. 12.

5. Heuschele, W. D. 1991. The importance of infectious disease concerns in wildlife reintroductions. AAZPA Annual Conference Proceedings. Pp 143-146.

6. Langenberg, J. 1992. Health management for the whooping crane captive propagation and reintroduction program. Proc. Joint Meeting AAZV/AAWV. Pp. 2-9.

7. Montali, R. J., and M. Bush. 1992. Some diseases of golden lion tamarins acquired in captivity and their impact on reintroduction. Proc. Joint Meeting AAZV/AAWV. Pp. 14-16.

8. Munson, L. 1991. Strategies for integrating pathology into single species conservation programs. J. Zoo Wildl. Med. 22(2): 165-168.

9. Reichard, T. A. and P. J. Tolson. 1991. Cooperative recovery efforts for the Virgin Island boa (*Epicrates monensis granti*), at the Toledo Zoological Gardens. Proc. Amer. Assoc. Zoo Vet. Ann. Conf. Pp. 98-99.

10. Roelke, R. E., D. J. Forrester, E. R. Jacobson, and G. V. Kollias. 1991. Rationale for surveillance and prevention of infectious and parasitic disease transmission among free-ranging and captive Florida panthers (*Felis concolor coryi*). Proc. Amer. Assoc. Zoo Vet. Pp. 185-190.

11. Shima, A. L. and B. Gonzales. 1991. Veterinary involvement in the California and Andean condor recovery and release projects. Proc. Amer. Assoc. Zoo Vet. Ann. Conf. Pp. 90-97.

12. Snyder, N. F. R., H. A. Snyder, and T. B. Johnson. 1989. Thick-billed parrots, released and raised in the wilds of Arizona. afa Watchbird, Pp. 38-45.

13. Thorne, E. T. and E. W. Williams. 1988. Diseases and endangered species: the black-footed ferret as a recent example. Conserv. Biol. 2(1): 66-74.

14. Woodford, M. H., and R. A. Kock. 1991. Veterinary considerations in re-introduction and translocation projects. Symp. Zool. Soc. Lond. 62: 101-110.

15. Williams, E. S., E. T. Thorne, D. R. Kwiatkowski, and B. Oakleaf. 1992. Disease management in the black-footed ferret (*Mustela nigripes*) reintroduction program in Wyoming. Proc. Joint Meeting AAZV/AAWV. Pp. 10-11.

(i.e. if *Mycobacterium tuberculosis* or *M. bovis* are deemed a hazard then appropriate testing protocols and isolation should be developed, if bluetongue virus is of concern then the quarantine facility should be mosquito proof).[14]

Eight birds from the Surabaya Zoo are currently being housed at the PTC and have been there for well over a year. Physical examinations and diagnostic samples were collected from these birds by the author. The birds were in excellent health except they were all shedding Isospora spp. oocysts consistent with atoxoplasmosis in their feces. A researcher has received funding to place radiotelemetry devices on these birds and monitor them post-release. He is scheduled to start his project in April of 1993, thus it is important that the release take place in a timely manner. A pre-release treatment and diagnostic protocol has been developed for these 8 birds (Table 2). Confining integrated social groups of animals to be reintroduced in a large enclosure in the area near or within the release site for several weeks to months before a release is a very important part of any release program.[14] These birds will be taken to an island off the coast of Bali and placed in a large pre-release enclosure for an acclimation period and then released. Following this release, another group of birds from the Surabaya Zoo will be sent to Bali. A separate quarantine protocol has been developed for these birds (Table 2).

A source of birds for both captive breeding and potential release is the Amnesty Campaign. This program, administered by the Indonesian government, allows citizens who are illegally holding wild-caught Bali mynahs to register them without fear of retribution. The Bali mynah is a status symbol in Bali and throughout Indonesia and is kept in captivity for its beauty and unusual vocalizations. All of these birds are wild caught and very valuable from a genetic standpoint. Genetically unimportant birds from the US have been shipped to Indonesia to be exchanged for the privately-owned wild caught birds. Pre-shipment screening protocols have been developed for US zoos (Table 5). The birds come from a variety of US zoos and are held at the Los Angeles Zoo prior to shipment to Indonesia. Approximately 80 wild caught Bali mynahs currently kept as pets have been identified for exchange. Most of these birds will be used for captive breeding and their offspring will be released. The birds will be distributed to various Indonesian Zoos and to the PTC. The author examined several of these birds at the owner's homes in Denpasar, Bali. A high percentage of them had *Isospora* spp. oocysts in their feces consistent with atoxoplasmosis. Atoxoplasmosis organisms were also found in the monocytes from a plain blood smear from 1 young bird. Unfortunately, most of these birds are housed under suboptimal conditions and have been exposed to a variety of pathogens. Many of them were probably in the bird market at one time during their stay in captivity. These markets are stressful and overcrowded, with a variety of avian and mammalian wildlife. Because of the additional disease risks, a separate quarantine protocol has been developed for these birds (Table 2). Quarantine and preventive medicine guidelines have been distributed to all the zoos in Indonesia housing Bali mynahs. It is very important that all protocols are presented in the native language.

The animals to be released must be identified in some manner (i.e. ear tags, tattoos, bands, or transponders) so that individual recognition and recording are possible.[14] Transponders have been placed in all released Bali mynahs. A Bali mynah recovered from poachers was identified to be a released bird by reading its transponder.

Communication is not only one of the most important parts of developing preventive medicine protocols for a reintroduction program, but for the success of the entire program. The California and Andean condor projects have had extensive veterinary input from multiple individuals and have been successful primarily because of good communication between veterinarians, field biologists, curators, etc.[4] The medical aspects of the Bali mynah reintroduction project are still evolving. It is becoming apparent that communication at all levels is crucial to the success of the medical portion of the program.

The initial drafts for preventive medicine protocols for the Bali mynah release program were ideal protocols which did not take into account limitations in funding, facility space, lack of diagnostic laboratories, educational background of personnel involved with the project, and politics. Hopefully using examples of the successes and the failures of the Bali mynah reintroduction project have given some insight into the development of a preventive medicine program for a release project. Future reintroduction programs should develop medical management strategies prior to releasing captive animals to the wild.

LITERATURE CITED

1. Beck, B. B. 1992. Guidelines for reintroduction of animals born or held in captivity. AAZPA Reintroduction Advisory Group.
2. Carpenter, J. W., G.G. Clark, and D. M. Watts. 1989. The impact of eastern equine encephalitis virus on efforts to recover the endangered whooping crane. ICBP Technical Publication No. 10. Pp. 115-120.
3. Cooper, J. E. 1989. The role of pathogens in threatened populations: an historical review. ICBP Technical Publication No. 10. Pp. 51-59.
4. Haebler, R. 1992. Disease risk to wildlife following reintroduction. Proc. Joint Meet. AAZV/AAWV. p. 12.
5. Heuschele, W. D. 1991. The importance of infectious disease concerns in wildlife reintroductions. AAZPA Annual Conference Proceedings. Pp 143-146.
6. Langenberg, J. 1992. Health management for the whooping crane captive propagation and reintroduction program. Proc. Joint Meeting AAZV/AAWV. Pp. 2-9.
7. Montali, R. J., and M. Bush. 1992. Some diseases of golden lion tamarins acquired in captivity and their impact on reintroduction. Proc. Joint Meeting AAZV/AAWV. Pp. 14-16.
8. Munson, L. 1991. Strategies for integrating pathology into single species conservation programs. J. Zoo Wildl. Med. 22(2): 165-168.
9. Reichard, T. A. and P. J. Tolson. 1991. Cooperative recovery efforts for the Virgin Island boa (*Epicrates monensis granti*), at the Toledo Zoological Gardens. Proc. Amer. Assoc. Zoo Vet. Ann. Conf. Pp. 98-99.
10. Roelke, R. E., D. J. Forrester, E. R. Jacobson, and G. V. Kollias. 1991. Rationale for surveillance and prevention of infectious and parasitic disease transmission among free-ranging and captive Florida panthers (*Felis concolor coryi*). Proc. Amer. Assoc. Zoo Vet. Pp. 185-190.
11. Shima, A. L. and B. Gonzales. 1991. Veterinary involvement in the California and Andean condor recovery and release projects. Proc. Amer. Assoc. Zoo Vet. Ann. Conf. Pp. 90-97.
12. Snyder, N. F. R., H. A. Snyder, and T. B. Johnson. 1989. Thick-billed parrots, released and raised in the wilds of Arizona. afa Watchbird, Pp. 38-45.
13. Thorne, E. T. and E. W. Williams. 1988. Diseases and endangered species: the black-footed ferret as a recent example. Conserv. Biol. 2(1): 66-74.
14. Woodford, M. H., and R. A. Kock. 1991. Veterinary considerations in re-introduction and translocation projects. Symp. Zool. Soc. Lond. 62: 101-110.
15. Williams, E. S., E. T. Thorne, D. R. Kwiatkowski, and B. Oakleaf. 1992. Disease management in the black-footed ferret (*Mustela nigripes*) reintroduction program in Wyoming. Proc. Joint Meeting AAZV/AAWV. Pp. 10-11.

Table 1. General recommendations for infectious disease screening in the various animal groups.

Ruminants	Tuberculosis, brucellosis, bovine viral diarrhea, epizootic hemorrhagic disease, and bluetongue virus, rinderpest, salmonellosis.
Equids	African horse sickness, *Babesia equi* and *caballi*, dourine, glanders, equine infectious anemia, equine herpesviruses and equine viral arteritis, salmonellosis.
Suids	Swine fever, African swine fever, vesicular diseases, pseudorabies, Erysipelas, salmonellosis.
Canids, Mustelids, Procyonids, Viverrids	Rabies, canine distemper, parvoviruses, salmonellosis.
Felids	Rabies, parvovirus, Feline immunodeficiency virus (FIV), Feline leukemia (FeLV), salmonellosis.
Primates	*Salmonella, Shigella, Campylobacter, Mycobacterium* spp., variety of viral and parasitic organisms depending on the primate species.
Avian	Newcastles disease virus, avian influenza, herpesviruses, *Salmonella, Chlamydia psittaci*, psittacine beak and feather disease.

Table 2. Bali starling (Leucopsar rothschildi) Quarantine at Pre-release Training Center (PTC)

1) Birds currently in PTC

a) Body weight and physical exam (preferably by a veterinarian, otherwise Bas or Mark)

b) The bird must be eating well, have no noticeable abnormalities, normal feces and urates

c) Screen for Newcastles Disease Virus

d) Screen for salmonella (3 samples at least 1 week apart preferred, minimum of 2 samples, can use fresh feces, culture center of fecal sample to avoid contamination).

e) Treat with Ivermectin and Droncit, use dosages on treatment sheet.

f) Treat birds for atoxoplasmosis as previously described.

g) Place birds out on Island 20 days into atoxoplasmosis treatment.
h) Collect fresh fecal samples in Potassium dichromate as previously described.

i) Send samples by express mail service or identify person to hand carry into US. If prior to July 1, the current permit is sufficient, otherwise it will need to be renewed.

2) White Wash Campaign birds

a) If possible screen for newcastles disease virus prior to acceptance into release program.

b) These birds must be quarantined in new quarantine building.

c) Upon arrival, obtain a weight, perform a physical exam (Mark or Bas), if obviously unthrifty the bird should not be placed at the PTC, send to Taman Safari for more strict quarantine.

d) Give ivermectin and droncit using doses on treatment sheet at the beginning of quarantine.

e) Acclimate for a few days, then start on atoxoplasmosis treatment protocol. Start feeding food item to be used for medication upon arrival (ie grapes, mealworms).

f) Enclosures should be cleaned daily utilizing an appropriate disinfectant (ie chlorox diluted 1:40 with water), the disinfectant should be rinsed with fresh water.

g) If animals are being kept in the PTC, the quarantine animals should be cleaned and fed after the PTC. Gloves should be worn (or at least handwashing with an antiseptic soap between each exhibit), a pair of rubber boots should be designated for quarantine, a foot bath with a disinfectant should be present in entry into quarantine (do not walk in quarantine with bare feet).

h) Samples should be collected for newcastles disease virus, *Chlamydia psittaci*, and 3 salmonella fecal cultures during the first 30 days of quarantine.

i) After the 30 day treatment for atoxoplasmosis, rest 1 week (during this time give a second dose of ivermectin and droncit).

j) If Chlamydia psittaci diagnostic tests are unavailable, the birds should be treated with a 45 day course of doxycycline at 50 mg/kg (approximately 5 mg) once daily in a preferred food item. Nystatin (100,000 units/ml) should be utilized at this time to prevent secondary yeast overgrowth at a dose of 30,000 units (or 0.3 ml) once daily.

k) During the *Chlamydia psittaci* treatment, 3 negative fecal direct and flotations should be performed (these samples should be collected 1 week apart), also samples should be collected for atoxoplasmosis screening using the previous protocol.

l) Birds should be brought into quarantine at approximately the same time period. If a new bird comes into quarantine, all other birds in quarantine will start over again. All birds should be released from quarantine at approximately the same time.

m) A prerelease physical exam and weight should be performed (preferably by Dr. Norton during his trip in late August).

n) Birds will then be placed either in the PTC for breeding and/or designated for eventual release.

o) Birds must be eating well, have no noticeable abnormalities, normal feces and urates prior to release from quarantine.

3) Surabaya Zoo (KBS) birds

a) Select only thrifty birds, preferably birds examined previously by Dr. Norton.

b) If possible perform weight and physical examination prior to leaving the Surabaya Zoo. Ivermectin and droncit can be given at this time (it would be nice if Bas or Mark could be present for the exam).

c) Test birds for newcastles disease virus preferably prior to leaving the Surabaya Zoo; also 3 negative salmonella cultures (at least 1 culture).

d) It is preferable that these birds go into quarantine rather than the PTC, this will depend on the time frame-no exposure should occur between current PTC birds, WW birds, and Surabaya birds. If housed at the same time, the keeper must be trained on appropriate disinfection, hand washing, foot bath use, cleaning feed bowls, tools and net cleaning (separate tools and nets should be used for PTC and Quarantine), food preparation, etc.

e) Screening for salmonella (3 cultures from fresh feces), newcastles disease virus (not necessary if done at Surabaya).

f) Repeat ivermectin and droncit upon arrival (must be a minimum of 10 days from last dose), this must be repeated as with WW birds if not performed at Surabaya.

g) Treat for atoxoplasmosis as previously described.

h) Collect feces 1 week after 2 doses of ivermectin and droncit, must have 3 negative fecal samples, these should be collected no less than 1 week apart.

i) Screen for *Chlamydia psittaci* or treat as described for WW birds.

j) Collect feces for atoxoplasmosis screening as previously described (possibly Dr. Norton to transport back to US).

k) If quarantined in PTC, it will need to be completely stripped, this must take place before the atoxoplasmosis treatment is complete, otherwise the birds will become reinfected.

l) Birds must be eating normally, have no noticeable abnormalities, normal feces and urates prior to release from quarantine or the PTC.

Table 3. Preshipment workup for Bali Mynahs going to Indonesia in August

1) Physical examination and body weight

2) Fecal direct and flotation, and appropriate deworming

3) Cloacal or fresh fecal culture for *Salmonella*

4) Complete blood count

5) Serum biochemical profile (SGOT, LDH most important)

6) Chlamydial latex agglutination

   c/o Dr. James Grimes
   Texas Veterinary Medical Diagnostic Laboratory
   #1 Sippel Road
   College Station, Texas 77841-3040

7) Whole body radiographs

8) Follow atoxoplasmosis diagnostic protocol

9) Treat any positive birds for atoxoplasmosis

10) Please submit a summary of the results to:

   Dr. Terry M. Norton
   Riverbanks Zoological Park
   PO Box 1060
   Columbia, SC 29202
   Phone 803-779-8717

Int. Zoo Yb. (1986) 24/25: 200–205

Irresponsible introductions and reintroductions of animals into Europe with particular reference to Britain

SIMON J. BAKER
Coypu Research Laboratory, Jupiter Road, Norwich NR6 6SP, Great Britain

Over the centuries a great many animal species have been translocated by man and introduced successfully into areas of Europe where they never previously occurred. This is especially true for Britain and Ireland where such events need to be considered in relation to the influence of the Pleistocene ice ages which left these regions isolated, with a relatively impoverished flora and fauna, as the ice finally retreated and the sea level rose. The living systems that subsequently developed have been largely shaped by man's activities, particularly agriculture, forestry and industry; the resulting vacant niches and new habitats have provided many opportunities for colonisation by exotic species. This potential has already been partially realised on mainland Britain where 14 of the 56 species of mammal were introduced by man (Corbet, 1974). Some species, like the rabbit *Oryctolagus cuniculus*, were introduced deliberately to provide a resource to be cropped (Sheail, 1984); others, such as the Brown rat *Rattus norvegicus*, have extended their range with the inadvertent help of man. This latter species spread from Asia as world trade expanded, reaching Europe early in the 18th century and the USA shortly afterwards (Lever, 1977). In this paper man's role in such translocations, especially with reference to irresponsible action, will be discussed.

REASONS FOR ANIMAL RELEASES

The reasons behind deliberate releases in Europe over the last century have been as varied as the governments, organisations and individuals that have carried them out but the prime motives can be classified as economic, sporting or aesthetic. The economic incentive of enhanced hunting led to attempts to acclimatise 26 species of mammal to areas in the USSR between 1925 and 1944 (Naumov, 1972), including *c.* 4000 Russian desmans *Desmana moschata*, 3200 Racoons *Procyon lotor* and more than 500 Sable *Martes zibellina*. Lavrov & Pokrovsky (1967) recorded that by 1963 attempts had been made to acclimatise a further six species of mammal and nearly 50 species of fish. Amongst the mammals released were some 250 000 Muskrats *Ondatra zibethicus* and several thousand Coypus *Myocastor coypus*. Animals have also been translocated for use in field sports; Hungary, for instance, exported an average of 40 000 live Brown hares *Lepus capensis*, 50 000 Grey partridges *Perdix perdix* and 35 000 Pheasants *Phasianus colchicus* annually between 1930 and 1940 (Niethammer, 1963).

The desire to be reminded of their homelands led European colonists to take common birds, like the Starling *Sturnus vulgaris* and House sparrow *Passer domesticus*, with them when they emigrated. At the beginning of the 19th century the House sparrow, for example, was confined to the western palaearctic but today, with man's help, its range covers much of North and South America, South Africa, New Zealand and some of Australia (Jarvis, 1980). Recently attempts to return both bird and mammal species to parts of Europe in which they no longer occur have become more frequent. These include projects to reintroduce species such as the White-tailed sea eagle *Haliaeetus albicilla* onto the island of Rhum off the west coast of Scotland (Love & Ball, 1979) and into Czechoslovakia (Fentzloff, 1984), the Bearded vulture *Gypaetus barbatus aureus* to the Alps (Anderegg *et al.*, 1984), the European eagle owl *Bubo b. bubo* into Germany (Von Frankenberg und Ludwigsdorf *et al.*, 1984), the Great bustard *Otis tarda* into England (Collar & Goriup, 1980), the Eurasian beaver *Castor fiber* into Germany (Reichholf, 1976) and France (Richard, 1967; Hesse & Jollivet, 1978) and the Ibex *Capra i. ibex* into Italy (Framarin, 1976).

WHAT IS IRRESPONSIBLE?

Amongst all these movements of animals how can we decide what constitutes irresponsible introduction or reintroduction? With the benefit of hindsight it is often easy to identify problems but the actions may not have been irresponsible in the light of contemporary thinking. Was the release of domestic pigs and goats onto uninhabited islands in the Pacific and South Atlantic Oceans to feed passing or shipwrecked mariners irresponsible? Even though it is now clear that the consequences for the native fauna and flora have often proved catastrophic these introductions appeared to be valid when first carried out. In the light of current knowledge, guidelines for the future may be easier to establish. Any animals that escape from captivity as a result of negligence on the part of their keepers or that are accidentally transported around the world, without reasonable efforts being taken to prevent this, must be deemed to have been released irresponsibly. More generally, responsible action must be legal and should take account of scientific opinion on the likely result.

The European Economic Community currently recognises four international conventions concerned with flora and fauna (Haigh, 1984), the Berne Convention (EEC, 1982) on the conservation of European wildlife and natural habitats being that which is relevant to the translocation of species. This 'seeks to encourage the reintroduction of native species of wild flora and fauna when this would contribute to the conservation of an endangered species provided that a study is first made in the light of the experiences of other Contracting Parties to establish that such reintroduction would be effective and acceptable'. A further provision requires that the Contracting Parties 'strictly control the introduction of non-native species'. Britain has ratified this convention and its obligations are being fulfilled under the Wildlife and Countryside Act of 1981 which makes it an offence to release species which do not already have established populations in the wild unless licensed authorisation is granted by the Nature Conservancy Council.

A number of guidelines that reflect scientific opinion on release programmes have been suggested at meetings held under the auspices of the International Union for the Conservation of Nature and Natural Resources (IUCN) (Anon, 1967) and the World Wildlife Fund (WWF) (Boitani, 1976). From the detailed proposals put forward a consensus has emerged on a number of basic issues:

1. There must be a valid motive behind the release and local people must not suffer serious negative economic or aesthetic consequences;
2. the release must not threaten the existing ecosystem or the existence of any of its components, other than if the motive is biological control;
3. subsequent acclimatisation of the species should be monitored;
4. it must be possible to control the population should this become necessary.

To provide the information required to fulfil these requirements any responsible programme needs to be supported by competent scientific research. A proposal for an introduction will always be more difficult to assess than that for a reintroduction, which is one reason why the latter is widely considered to be more acceptable. Despite this it has been argued that the same criteria should be used to judge both types of release (Boitani, 1976; Green, unpubl.).

IMPACT OF INTRODUCED SPECIES

The quality of life enjoyed in many countries depends to a great extent on introduced plant and animal species, particularly vegetables, cereals and livestock. Not all introduced species have been of benefit, however, and various attempts have been made to view the introduction to an ecosystem of new species in the context of ecological theory. The instability of simple systems has been used by Elton (1963) to explain the susceptibility of impoverished island flora and fauna to disruption by exotic species. Reichholf (1976) suggested that introduced species could often be regarded as newcomers to a man-made ecosystem and, in such cases, the idea of an interaction with an established 'fauna' would not be relevant. More recently, Jarvis (1980) has suggested that the niche concept is useful for the understanding of how an introduced species can establish itself in an area. Three broad options are outlined:

1. it can occupy a niche that does not notably infringe upon the resource requirements of other species;
2. it can overlap with the niches of other species, in which case its niche is restricted by competition;
3. it can effectively match the resources required by another species so that competitive exclusion would lead to the displacement of one of the species.

Lavrov & Pokrovsky (1967) recorded that in some parts of the USSR European water voles *Arvicola terrestris* were being displaced by muskrats, and noted incidentally that this appeared to have led to a decrease in the incidence of tularaemia infection for which the water vole was the main vector. Several examples of competition between native and introduced species are given by De Vos & Petrides (1967) including competition between Brown and Alpine hares *L. timidus* in Sweden. Competition may also be indirectly responsible for species decline as suggested in the case of the Red squirrel *Sciurus vulgaris* in Britain. Here the initial decline was probably caused by widespread habitat destruction together with epidemic disease but the subsequent return is apparently being prevented by the presence of the introduced Grey squirrel *S. carolinensis* (Tittensor, 1977). A project to reintroduce the Red squirrel to parts of London, and to examine the factors which may have caused its previous decline, is currently being conducted by The Zoological Society of London (Bertram & Moltu, in press).

Successful introduced species may have a considerable effect on the trophic level below their own. An example is the change caused to the vegetation of the Norfolk Broads in England by the selective feeding of a dense population of Coypus (Ellis, 1963); in particular the amount of the *Phragmites australis* reed fringing the open water has been reduced (Boorman & Fuller, 1981). The impact of carnivores has been more difficult to assess, the effect of escaped mink *Mustela* spp on native animals in Britain being a case in point. Lever (1978) has concluded that mink will severely depress populations of the species upon which they prey, although Linn & Chanin (1978) and Chanin & Linn (1980) have argued that they will not normally have an impact on native wildlife. There is little doubt that, at least under certain circumstances, the activities of mink do affect the surrounding wildlife; colonies of seabirds or dense populations of waterfowl, for example, are known to have suffered from their predation (Gudmundsson, 1952).

The introduction of new individuals or species may also have important genetic consequences for an existing fauna. This is a particular problem in waterfowl, since they have shown a greater potential for hybridisation than any other group of birds (Weller, 1969). Scott (1967) noted that the Northern hemisphere Mallard *Anas platyrhynchos* has crossed extensively with the New Zealand grey duck *A. poecilorhyncha superciliosa* to produce a widespread hybrid. The Mallard has also hybridised with numerous forms of domestic duck at many sites within its original range in Europe. An example of such genetic effects in mammals is possibly the introduction of Red foxes *Vulpes vulpes* into Sweden from Britain; these may have been responsible for the appearance of 'Samson foxes' which have an inherited deficiency of guard hairs (De Vos & Petrides, 1967).

The population control of introduced species that have become pests can be an extremely expensive operation. In Britain the Coypu, originally brought into the country from South America for the fur trade, causes much damage to drainage systems by its burrowing activities; it also depletes crops and alters the composition of natural plant communities by its selective feeding. As a result, in 1978 it was suggested to the British Ministry of Agriculture, Fisheries and Food that a campaign should be started to eradicate the species within ten years (MAFF, 1978);

in 1981 such a project was undertaken at an estimated cost of £1.75 million. A species which causes similar problems in many parts of Europe is the Muskrat, a native of North America. Expensive campaigns to control both this species and the Coypu have been carried out in countries such as Belgium, France, West Germany and the Netherlands.

SOURCES OF RECENT INTRODUCTIONS INTO BRITAIN

The origin and status of the established populations of introduced mammals in Britain have been reviewed by Fitter (1959) and by Lever (1977). The parks of large country houses have supplied most of our introduced deer populations; Woburn Park, the seat of the Dukes of Bedford, has been responsible for the release of groups of Reeves' muntjac *Muntiacus reevesi* and Chinese water deer *Hydropotes inermis*. In Victorian times a number of successful attempts were made to introduce new species, including the Grey squirrel and Fat dormouse *Glis glis*. A number of Red-necked wallabies *Macropus rufogriseus* were released from a private collection in Staffordshire in about 1940 and acted as founders for the group which now lives in the Peak District of Cheshire. Fur farms have been another major source of mammals; Coypus were reported to have escaped from over half of the farms in the country by the middle of the 1940's (Laurie, 1946) and from these a population eventually became established in East Anglia (Gosling *et al.*, 1981). The Muskrat (Warwick, 1934) and American mink *Mustela vison* (Thompson, 1962) populations have been similarly established, although the Muskrat was later exterminated by controlled trapping (Warwick, 1940). A recent disturbing trend has been for 'animal liberation' groups to release animals bred for the fur trade. A recent case involved 40 Arctic foxes *Alopex lagopus*; as well as being traumatic for the released individuals this could potentially pose the kind of ecological problems seen for the Mink, Muskrat and Coypu.

A variety of exotic species have, on occasion, been released accidentally from zoos and private collections although it is rare for established feral populations to arise from such escapes. This did happen, however, in the case of the Himalayan porcupine *Hystrix hodgsoni* (Gosling, 1980). Records held at the MAFF show 27 exotic mammal species to have been out of captivity in Britain since 1969. This list excludes animals commonly held as household pets, such as the Golden hamster *Mesocricetus auratus*, and those with an established feral population such as the Red-necked wallaby. On the 38 occasions where the origin of the escapees was known, 68% were from animal collections open to the public and a further 24% from private collections. The range of species includes Hamadryas baboons *Papio hamadryas*, American beaver *Castor canadensis*, various species of porcupine *Hystrix* spp, Wolves *Canis lupus*, Racoons, large cats, Wild boar *Sus scrofa* and Père David's deer *Elaphurus davidianus* to name but a few. Some, including the large cats, were at liberty for only a few hours; others, like the porcupines, for some years.

A number of mammals have also been found living free in cargos that arrive at air and sea ports from other countries. Records are by no means comprehensive but there have been five occurrences reported to the MAFF from aeroplanes and a further 12 from ships. The animals were generally unidentified rodents but they did include a birch mouse *Sicista* sp, a Garden dormouse *Eliomys quercinus* and a Racoon. Many of the others could have been species with populations already well established in Britain such as the House mouse *Mus musculus* and the Black rat *Rattus rattus*. Fitter (1959) records five other species of small mammals that have entered Britain in a similar way.

Introduced bird species have been reviewed by Lever (1977) and more recently by Long (1981) in his extensive work on introductions throughout the world. The origins of feral bird populations are similar to those of the mammals. Since the early 1900's a number of duck species have become established in Britain because groups were kept in private collections unpinioned (Lever, 1977); these include the Carolina duck *Aix sponsa*, Mandarin duck *A. galericulata* and

CORBET, G. B. (1974): The distribution of mammals in historic times. In *The changing flora and fauna of Britain:* 179–202. Hawksworth, D. L. (Ed.). London: Academic Press.

DE VOS, A. & PETRIDES, G. A. (1967): Biological effects caused by terrestrial vertebrates introduced into non-native environments. In *Proceedings and papers. Towards a new relationship of man and nature in temperate lands.* Part 3: 113–119. IUCN Publs (N.S.) No. 9.

EEC (1982): *Council decision concerning the conclusion of the convention on the conservation of European wildlife and natural habitats.* 82/72/EEC (O.J.L. 38 10.2.82).

ELLIS, E. A. (1963): Some effects of selective feeding by the coypu (*Myocastor coypus*) on the vegetation of Broadland. *Trans Norfolk Norw. Nats Soc.* 20: 32–35.

ELTON, C. S. (1963): *The ecology of invasions by animals and plants.* London: Methuen.

FENTZLOFF, C. (1984): Breeding, artificial incubation and release of white-tailed sea eagles *Haliaeetus albicilla. Int. Zoo Yb.* 23: 18–35.

FITTER, R. S. R. (1959): *The ark in our midst.* London: Collins.

FRAMARIN, F. (1976): Alcune considerazione sulla cessione di stambecchi del Gran Paradiso per formare altrove nuove colonie. *Serie Atti Studi WWF* No. 2: 17–19.

GOSLING, L. M. (1980): Reproduction of the Himalayan porcupine (*Hystrix hodgsoni*) in captivity. *J. Zool., Lond.* 192: 546–549.

GOSLING, L. M., WATT, A. D. & BAKER, S. J. (1981): Continuous retrospective census of the East Anglian coypu population between 1970 and 1979. *J. Anim. Ecol.* 50: 855–901.

GREEN, G. H. (unpublished): *Wildlife introductions to Great Britain.* Report by the working group on introductions of the UK Committee for International Nature Conservation to the Nature Conservancy Council, London, 1979.

GUDMUNDSSON, F. (1952): Bird protection in Iceland. *Bull. int. Comm. Bird Prot.* 6: 153–160.

HAIGH, N. (1984): *Environmental policy and Britain.* London: Environmental Data Services Ltd.

HESSE, J. & JOLLIVET, J. P. (1978): Reintroduction de castors sur la Loire. *Courrier Nat.* No. 54: 1–8.

JARVIS, P. J. (1980): The biogeography and ecology of introduced species. *Dept Geog., Univ. Birmingham, Working Pap. Ser.* No. 1.

LAURIE, E. M. O. (1946): The coypu (*Myocastor coypus*) in Great Britain. *J. Anim. Ecol.* 15: 22–34.

LAVROV, N. P. & POKROVSKY, V. S. (1967): Ecological relationships between local fauna and species commercially introduced into the USSR. In *Proceedings and papers. Towards a new relationship of man and nature in temperate lands.* Part 3: 181–193. IUCN Publs (N.S.) No. 9.

LEVER, C. (1977): *The naturalized animals of the British Isles.* London: Hutchinson Benham Ltd.

LEVER, C. (1978): The not so innocuous mink? *New Sci.* 78: 812–814.

LINN, I. & CHANIN, P. (1978): Are mink really pests in Britain? *New Sci.* 77: 560–562.

LONG, J. L. (1981): *Introduced birds of the world.* Newton Abbot & London: David & Charles.

LOVE, J. A. & BALL, M. E. (1979): White-tailed sea eagle *Haliaeetus albicilla* reintroduction to the Isle of Rhum, Scotland, 1975–1977. *Biol. Conserv.* 16: 23–30.

MAFF (1978): *Coypu: report of the coypu strategy group.* London: HMSO.

NAUMOV, N. P. (1972): In *The ecology of animals:* Levine, N. D. (Ed.), Plous, F. K., Jr (Trans.). Urbana, IL: University of Illinois Press.

NIETHAMMER, G. (1963): *Die Einbürgerung von Saügetieren und Vögeln in Europe.* Hamburg: Paul Parey.

REICHHOLF, J. (1976): The reintroduction of the beaver (*Castor fiber L.*) In Bavaria: some preliminary results. *Serie Atti Studie WWF* No. 2: 49–53.

RICHARD, B. (1967): La reintroduction du castor (*Castor fiber*) en Bretagne. *Penn ar bed* 49: 45–52.

SCOTT, P. (1967): Cause and effect in the introduction of exotic species. In *Proceedings and papers. Towards a new relationship of man and nature in temperate lands* Part 3: 120–123. IUCN Publs (N.S.) No. 9.

SHEAIL, J. (1984): The rabbit. *Biologist* 31: 135–140.

THOMPSON, H. V. (1962): Wild mink in Britain. *New Sci.* 13: 130–132.

TITTENSOR, A. M. (1977): Red squirrel. In *The handbook of British mammals* (2nd edn): 153–164. Corbet, G. B. & Southern, H. N. (Eds). Oxford: Blackwell Scientific Publications.

VAN DEN BRINK, F. H. (1967): *A field guide to the mammals of Britain and Europe.* London: Collins.

VON FRANKENBERG UND LUDWIGSDORF, O., HERRLINGER, E. & BERGERHAUSEN, W. (1984): Reintroduction of the European eagle owl *Bubo b. bubo* in the Federal Republic of Germany. *Int. Zoo Yb.* 23: 95–100.

WARWICK, T. (1934): The distribution of the muskrat (*Fiber zibethicus*) in the British Isles. *J. Anim. Ecol.* 3: 250–267.

WARWICK, T. (1940): A contribution to the ecology of the musk-rat (*Ondatra zibethica*) in the British Isles. *Proc. zool. Soc. Lond.* 110A: 165–201.

WELLER, M. V. (1969): Potential dangers of exotic wildfowl introductions. *Wildfowl* 20: 55–58.

the Ruddy duck *Oxyura jamaicensis*. The Little owl *Athene noctua* is now an acknowledged part of the English fauna after having been released deliberately in the late 1800's, while the Rose-ringed parakeet *Psittacula krameri* has settled in parts of England as a result of escapes over the past century (Lever, 1977). The group of Black-crowned night herons *Nycticorax nycticorax* now living and breeding near Edinburgh in Scotland is an example of a recently established population since its founder members escaped or were released from Edinburgh Zoo in the 1950's; the group, which originally numbered 18, now consists of 30–40 birds (Long, 1981).

SPECULATION ON THE FUTURE

What species will be most likely to develop established populations in Britain as a result of irresponsible action in the future? Necessary qualifications are: the opportunity to become established, which will favour species that frequently escape from captivity; the ability to survive and reproduce in the British climate. As examples porcupines of the genus *Hystrix* and the Racoon have been chosen from several possible candidates. Details are from MAFF records unless other sources are given.

A pair of Himalayan porcupines escaped from a wildlife park in Devon in 1969 (Gosling, 1980) and a group derived from these animals persisted in the wild until at least 1979 by which time a total of six had been accounted for by trapping and accidents. They lived mainly in Badger *Meles meles* setts; the damage they caused to a number of conifer plantations by removing bark from trees provides some indication of the kind of pest that the species might have developed into had it become established. The African crested porcupine *H. cristata* is also known to be able to survive well in the British countryside; for example, a pair lived free in Staffordshire for at least two years after escaping in 1972 (Lever, 1977). More recently a single animal escaped from a collection in County Durham and was recaptured 20 months later, close to where it had escaped, despite having been hit by a car in the interim. In all the MAFF has recorded *Hystrix* spp out of captivity on six occasions over the past 15 years, with ten different individuals being involved in the escapes.

The Racoon is another species where the ability of feral individuals to survive is not in doubt since one of the ten escaped animals reported to the MAFF was at liberty for four years before being recaptured. Although they have not, to my knowledge, bred outside captivity in Britain their wide distribution in North America indicates that this could occur if they were presented with the opportunity. The presence of feral populations in Hessen and Eifel in Germany (van den Brink, 1967) and the success of the introductions into the USSR (Naumov, 1972) makes it extremely likely that the species could become established.

It can only be hoped that these speculations are not fulfilled and that any new species added to Britain's fauna by man will be the result of responsible actions and prove an advantage to the species and to ourselves. Whilst the benefits from introductions, particularly domesticated plants and animals, have been enormous so the costs of irresponsible actions can be high.

ACKNOWLEDGEMENTS

I would like to thank my colleagues in the MAFF who have provided reports of exotic mammal releases, and Morris Gosling of the Coypu Research Laboratory for his helpful comments on this paper.

REFERENCES

ANDEREGG, R., FREY, H. & MÜLLER, H. U. (1984): Reintroduction of the bearded vulture or lammergeier *Gypaetus barbatus aureus* to the Alps. *Int. Zoo Yb.* 23: 35–41.

ANON (1967): *Proceedings and papers. Towards a new relationship of man and nature in temperate lands.* Part 3. IUCN Publs (N.S.) No. 9.

BOITANI, L. (Ed.) (1976): Reintroductions: techniques and ethics. *Serie Atti Studi WWF* No. 2: 1–303.

BOORMAN, L. A. & FULLER, R. M. (1981): The changing status of reedswamp in the Norfolk Broads. *J. Anim. Ecol.* 50: 241–269.

BERTRAM, B. C. R. & MOLTU, D.-P. (in press): Reintroducing the red squirrel into Regent's Park. *Mamm. Rev.*

CHANIN, P. R. F. & LINN, I. (1980): The diet of the feral mink (*Mustela vison*) in southwest Britain. *J. Zool., Lond.* 192: 205–223.

COLLAR, N. J. & GORIUP, P. D. (1980): Problems and progress in the captive breeding of great bustards (*Otis tarda*) in quasi-natural conditions. *Avicult. Mag.* 86: 131–140.

SECTION - V

EDUCATION

Environmental education programmes for out-of-school youth

David K. J. Withrington
Adviser, Working Group on Education
London (United Kingdom)
International Youth Federation for Environmental Studies and Conservation

Introduction

The purpose of this paper is to examine the role which out-of-school youth activities play in environmental education, to describe the activities and organizational structures involved, and to determine problems and constraints facing the development of environmental education programmes for young people. The author has attempted to present a world review of out-of-school environmental youth activities, based on his own experience in this field and upon input from some twenty-five environmental youth leaders and educators in Africa, Asia, Australasia, Europe, Latin America, North America and international youth organizations.

Youth is usually defined as being under 28 years old—though this concept differs from one part of the world to another. The effective age range for members of most environmental youth organizations is from 11 to 25 years. Young people comprise more than half the world's population; their education presents a great challenge and also an opportunity to achieve social change and environmental improvement.

Environmental education is essentially a practical process for equipping people with the knowledge, skills and commitment to protect or improve their environment. It is important as part of this process that students come to understand not only what the environmental problems are—e.g. pollution, shortages of food and other natural resources, degradation of soils and ecosystems—but why they have arisen.

In recent years, concern for the environment has become fashionable and environmental organizations have proliferated; but the environment has continued to deteriorate at an alarming rate. One reason for this may be that much environmental education has remained at a superficial level, and in many instances has not addressed itself to the economic, social and political pressures affecting the environment.

Out-of-school environmental youth activities are not exempt from this indictment; but they do provide involvement in society and with actual environmental problems. Out-of-school environmental activities are a valuable extension to formal education at all age levels, and are of special importance for those who have limited access to school education. These activities can provide enjoyment and recreation for young people in their natural environment, while achieving educational objectives and contributing to community involvement. Participation in such activities can also lead to an understanding of some of the root causes of the environmental crisis, such as those which have been identified by several youth organizations: overpopulation; economic systems aimed at growth through induced consumption of natural resources; the unequal distribution of wealth between industrialized and less-developed nations, and between different sectors of the community within each country; and a senseless drain on resources in wasteful technology.

including armaments.'[1]

Educators have recognized that young people are more motivated to environmental awareness by out-of-school activities than by classroom experiences. It is therefore essential that, since environmental education is encouraged in all school and university curricula, field work be integrated with problem-solving activities in the classroom, so that in-school and out-of-school environmental education activities can begin to strengthen and reinforce each other. Environmental activities undertaken by young people on their own initiative, particularly within environmental youth organizations, can be instrumental in developing an individual and collective commitment and sense of responsibility towards the environment.

In a recent survey of environmental youth leaders[2] 'practical knowledge of ecological principles' was considered the most essential element of out-of-school environmental education programmes, for many developments in the modern world are undertaken without any regard for ecological principles, and mankind is suffering the inevitable consequences. Other important elements were 'the study of nature', 'the improvement of the local urban and rural environment', 'the knowledge of agriculture', and 'action campaigns against environmental threats'. The main objective of environmental education for young people as expressed by the youth leaders was to stimulate meaningful environmental action. The kinds of environmental action often thought up for young people by adults, 'beautification campaigns and litter clearance', were considered the least relevant.

Those groups working to structure sound out-of-school environmental activities face challenges from both the youth and adults involved. Many young people are disenchanted with the apparent corruption and inertia in adult affairs, and may be resistant to adult interference in their own plans and activities. Often adults find it difficult to accept that young people can achieve anything worth while on their own initiative. The most successful adult environmental educators see their role as that of resource persons, available to give advice and assistance. These educators recognize the ability of young people to act as propagators of environmental education and action in the community; and further recognize that the energy and free time of young people can make a major contribution to environmental improvement.

Activities and structures

Although environmental youth organizations are established in over forty countries, their membership is relatively small. Fortunately, environmental education is beginning to reach a larger section of young people through the programmes of several youth, student and outdoor organizations, a few government departments and educational institutions.

In most countries environmental education is not compulsory and few if any facilities are provided. Out-of-school informal activities may offer the only means of introducing environmental education. An important contribution in this area has been made by enthusiastic teachers, students and youth leaders, working independently of any organization, who have started up environmental programmes for young people.

The types of organizations providing out-of-school environmental education for young people are: self-governing environmental youth organizations; conservation work camp organizations; university and college student environmental societies; school clubs; environmental action groups, ecology and recycling centres; museums, zoo clubs, young naturalists' clubs; nature and field study centres, and centres for young naturalists and scientists; non-specialist organizations such as Scouts, Pioneers, young farmers, and civic, religious and political youth groups.

A brief outline of the activities and development of each type of organization is given below:

1. 'Statement of Eleven International Youth Organisations to the U.N. Conference on the Human Environment', *Environment Stockholm*, p. 19, Geneva, CESI, 1972.
2. David Withrington, *Questionnaire on Out-of-school Environmental Activities by Youth for Unesco/UNEP Environment Education Programme*, April 1975.

Self-governing environmental youth organizations

These are the traditional pioneers of out-of-school environmental education for young people; the first was founded in the Netherlands in 1923 Nederlandse Jeugdbond voor Naturrstudie. By the late 1950s, organizations of this type were established in most European countries and were developing camps and projects with the emphasis on study and conservation of nature. Now they have spread to countries in Asia and other parts of the world, and their programmes have evolved to embrace a more total concept of environmental conservation, concentrating on ecological surveys and environmental action campaigns, with the understanding that environmental problems require social and political solutions. These organizations have a strong democratic tradition; the members gather at a national congress to elect officers and discuss the year's programme. Working groups co-ordinate environmental action, educational activities, and the study of plants and animals. Action guides and identification keys are published, as well as a regular magazine or newsletter. Often based in a clubhouse, local group activities include weekly excursions, ecological surveys, study camps, demonstrations against environmental threats, and social gatherings. Membership over an average period of eight years can turn into a way of life, a symbiotic relationship with human companions and nature.

Environmental youth organizations undertake projects in almost every sphere—for instance, studies of seasonal activities in plants and birds, of amphibian mortality due to motor traffic, of endangered landscapes, of water pollution, enforcement of legislation on hunting, trapping and trade in protected animals, educational displays and exhibitions, campaigns for energy conservation, protests against nuclear power stations, consumer information on the level of phosphates in washing powders, and action against commercial exploitation of national parks.

Camps under canvas or in huts are regularly held to enable members to study different habitats; foreign participants are invited in the summer months. Training courses are organized in field study techniques. Leader training is given in administration of local clubs, finance, public relations, and camp organization. Some countries have special courses for teachers, and members give lectures and guided field trips at schools. Booklets on environmental topics for use in schools have been produced by Sveriges Fältbiologiske Ungdomsforening (Sweden) and Jeunes et Environnement (Luxembourg). Other active organizations include Osterreichische Naturschutzjugend (Austria), Belgische Jeugdbond voor Naturrstudie and Natuur 2000 (Belgium), Natur og Ungdom (Denmark and Norway), Luonto Liitto (Finland), Jeunes et Nature (France), Christelijke Jeugdbond van Natuurvrienden (Netherlands), Deutscher Jugenbund für Naturbeobachtung (Federal Republic of Germany) and, more recently formed, the Mauritius Youth Council for Environmental Studies and Nature Conservation, the Indian Environmental Society and the Indian Youth Association for Environmental Studies and Conservation.

This type of organization probably gives the most comprehensive environmental education to young people, but memberships of these groups throughout the world at any one time may not be more than 75,000. The expansion of this type of organization, run by youth, has been limited chiefly by relative lack of financial and material support as compared with other more formal bodies.

Conservation work-camp organizations

These recruit young volunteers for practical management tasks, usually in nature reserves, national parks and recreational areas. Work may include dredging a pond, scrub clearance, tree planting, and construction of nature trails. The volunteers carry out the work under expert supervision at weekends or during longer residential camps. They develop skills with tools and techniques, and may also learn about the ecology of the area where they are working. There is a danger that young people may simply be used as cheap labour, but in Czechoslovakia, for instance, all youth camps held in the Krkonose and other national parks are obliged to include environmental education in their programme, and special training is provided for the leaders. Other well-known bodies which organize conservation work camps are: British Trust for Conservation Volunteers, Instituut voor Natuurbeschermingseducatie (Netherlands), Etudes et Chantiers (France), the Student Conservation Association and the Youth Conservation Corps (United States). In addition, many school clubs, environmental youth organizations and non-specialist groups have such work camps as an integral part of their programmes.

Work camps for agricultural and community development are widespread, involving young people from Cuba to Kuwait, and bodies ranging from the 4H and 4D Clubs to Pioneer organizations and government departments. As long ago as 1955, there were 795 such camps in India alone.

University and college student environmental societies

These are a mixture of faculty associations—biology, botany, zoology, ecology—and environmental action groups. They include: Pollution Probe (Toronto), Felag Natturfraedinema (Reykjavik), Auckland University Field Club, Survival (Cambridge), Tabiati Koruma ve Tanitma Türk Genclik Dernegi (Ege), Symbioosi (Helsinki). Their activities decline during vacations, but some national coalitions have been formed to conduct ongoing programmes. In the United States there is the Union of Young Environmentalists based at the University of Wisconsin, Green Bay; one of its projects is to find employment of an environmental character to give students practical experience during their vacations. In the U.S.S.R., a Youth Committee for the Protection of Nature has recently been formed by students at forty-two universities in co-operation with the republican societies for nature conservation and the Community Union of Youth; its programmes include a study of poaching as a social phenomenon, the effect of tourism and recreation on the environment, the recultivation of land following mineral extraction, and the formulation of legislation for protecting rare species and establishing nature reserves.

The Polish Students' Committee on the Human Environment organizes environmental activities within the framework of the Socialist Union of Polish Students; it holds multidisciplinary study camps during vacations, where the students' research is part of their degree course and also assists with management plans for national parks, the improvement of agricultural methods, urban and rural planning, and the control of industrial pollution; local, national and international seminars and study camps on environmental problems have been convened by the Committee since its formation in 1971. The Youth Environment Programmes for West Africa, which has been started for student teachers at the University of Ife (Nigeria), is also in this category.

In Thailand, student environmental groups have been instrumental in environmental reform, including the National Environmental Quality Act of 1975. The pioneer group was formed by students in the Natural Resources Conservation Group of Kasetsart University following the October 1973 revolution, in which the students played a big part. Now such groups are established in nearly every institute of higher education. At first, the students worked mainly for nature conservation and against pollution, but through their experience they realized that most environmental problems are caused by social and economic exploitation, so they are now working on a more political basis. In March 1975, after several months of protest, the students persuaded the government to withdraw mining concessions from the American-Dutch-owned Thai Exploration Mining Company.

The valuable role which student associations can play in working for a better environment is shown by the above examples from a few countries. In general, however, university education tends to be academic rather than practical, and the potential of students for environmental work in society is under-utilized.

School clubs

There are many thousands of school clubs engaged in environmental activities outside school hours in all parts of the world. Those for younger children are usually operated by teachers and adult organizations. The Blue and Green Patrols in the U.S.S.R. look after water resources and forests; in the R.S.F.S.R. alone, there are more than 5,000 school forests where children plant and take care of the trees and study the wildlife. In the United Kingdom, the Advisory Centre for Education recently launched a movement called 'Watch', with the assistance of a national Sunday newspaper; more than 30,000 school children took part in its survey of river pollution, and the current project is concerned with the architectural heritage. The Wildlife Youth Service also organizes projects in British schools in connexion with 'Project Tiger' and other fund-raising campaigns of the World Wildlife Fund. In Zambia, the Wildlife Conservation Society sponsors the Chongololo Clubs with their own magazine in over 250 primary schools.

Secondary school environmental movements organized by young people exist in several countries, and most depend on the active co-operation of interested teachers. The Wildlife Clubs of Kenya were started in 1969 and are established in 265 secondary schools. They arrange school camps and excursions in national parks, art competitions, teachers' workshops, and mobile film-units for lectures to school clubs, publish a quarterly magazine, and to date have furnished some 130 fortnightly radio programmes for Voice of Kenya schools broadcasts. In November 1973, they held a demonstration in Nairobi to present a petition to the government against poaching with some 8,000 signatures. Wildlife Clubs are also established in Zambia and have recently started up in Uganda. Other self-governing environmental organizations in secondary schools include the Schools Eco-Action Group in the United Kingdom, INSPECT which has branches in all the Australian states, and the Youth Environment Action Group which operates under the sponsorships of the Hong Kong Conservancy Association. In Venezuela, the first Centre of Science was set up in 1957 to introduce secondary students to the principles of conserving natural resources; the centres now operate in several towns. In some countries, school science clubs are undertaking environmental activities—for instance, the Federacion Espanola de Grupos Juveniles para la Iniciacion de la Ciencia, Jeunes et Science de Tunisie, and the Al-Ahram Science Clubs in Egypt. In the United States, there are local environmental movements in secondary schools such as the Open Land Project in Illinois, Foxfire, and Protect Your Environment; in addition there have been national efforts like Students Towards Environmental Participation, and a new project for an Energy Conservation Corps.

Competitions on environmental subjects have been organized for school children, particularly in Eastern Europe, where students are encouraged to undertake projects, design nature conservation posters and submit photographs; such competitions in Czechoslovakia are the 'Biological Olympiad' and 'Natura Semper Viva'.

The formation of a school environmental club or close co-operation with a local environmental youth organization are excellent means for the teacher to involve pupils in practical environmental activities.

Environmental action groups, ecology and recycling centres

A new vitality has been brought to the concept of popular democracy by the growing number of citizen groups formed to defend environmental interests in different parts of the world. With improving standards of education, the younger generation is challenging the wisdom of policies of government and industry which it sees to be detrimental to the environment.

Environmental action groups protest about environmental threats by lobbying parliament and local authorities, usually putting forward a viable ecological alternative to the proposed development. They have exposed vested interests in society which stand in the way of rational environmental decision-making. They conduct campaigns on basic issues such as food production and energy conservation, and they inform the public about their role as consumers and citizens. Most of the work is carried out at the local level in the form of community action.

The Friends of the Earth (FOE) was founded in 1969 in the United States and is now active in many developed countries. In the United Kingdom there are some 120 local FOE groups, and their activities are augmented by campaigns and research carried out by head-office staff. The programme of a typical local group operating in an area of London with some 100,000 inhabitants is described here:

The group was formed at the end of 1973 around a core of national FOE supporters who live in the area. The active membership is now about 20, but we do not seem to be able to increase this number. Most of our members are aged between 19 and 29, but the editor of our newsletter *Spaceship Earth* is 12 years old. Our first major activity was the monthly collection of newspapers from residents of local blocks of high-rise flats. We conducted an opinion poll and feasibility study to convince the local Council to make its own door-to-door collections; we were successful, but the Council has recently had to stop collections because of a fall in waste paper prices.

The Council allowed us to convert an empty shop into a 'recycling centre', open on Saturday mornings for people to bring in newspapers, jam-jars, aluminium foil, wine bottles and sump oil; the shop is now overflowing as the waste market has come to a standstill. With the money gained from recycling, we were able to insulate the roof of the local Old People's Friendship Club against heat loss, to print *Spaceship Earth*, and to put together a series of colour slides on environmental conservation and local issues which we show to local schools and colleges, youth organizations and housewives' groups. For the national General Election in October 1974, we organized an election forum on environmental issues. This was the only occasion when all the candidates spoke at the same meeting. We maintain a close co-operation with our Member of Parliament. With other local and national organizations, we have opposed commercial helicopter flights in London. As part of a national campaign for standardization and easier return of bottles and containers, we demonstrated outside a supermarket on the main shopping street and found the public very sympathetic. The manufacturers, retailers and Parliament, however, have failed to respond. We have organized 'bike-ins' and free bicycle repairs in order to promote better facilities for cyclists. We have cleared rubbish from derelict land and encouraged the local residents to make use of it for recreation and growing vegetables. We held an 'Eco Fair' and environmental exhibition at Christmas 1975 which was visited by several hundred local people. We invite the press and photographers to all our special activities, and each week we write an article for the local newpaper on conservation in everyday life—such as how to save energy in the home, or how to make better use of your garden.

Many environmental youth organizations are conducting campaigns against the waste of natural resources, such as excess packaging and non-returnable cans and bottles. A popular method is to have a street theatre in a shopping area to entertain and educate the passers-by. The Sveriges Fältbiologiske Ungdomsforening in Sweden held an action week in 1973 when members mailed 160,000 non-returnable containers to the offices of the government and the manufacturers; the issue was then taken up by Parliament and by the television, radio and newspapers. Friends of the Earth in the United Kingdom dumped several thousand bottles outside the head office of a large soft-drinks manufacturer, and linked the action with well-prepared publicity and statistics. In this manner they expressed their opinion that the consumer pays as much for the container as for the liquid inside it, he pays again in taxes for the municipal authorities to collect and dispose of it, and again in loss of energy and natural resources when a replacement bottle or can has to be made; he also has to pay for the unwanted advertising on the streets, in the media and through his letter box; in some cases he has to pay for pseudo-environmental competitions sponsored by the manufacturer.

Other issues taken up by environmental action groups include opposition to new motorways which are strangling many countries; campaigns in favour of better public transport, traffic-free city centres, public access to the countryside, and the introduction of environmental education in schools. The fight against pollution has to cope with more and more problems, such as the new menace of aerosol sprays. Actions against nuclear weapons tests in the south Pacific were undertaken in 1972 and 1973 by many groups including Green Peace and the Nuclear-Free Pacific youth conference in Fiji. There has been a world-wide campaign, involving Project Jonah and others, to prevent overhunting of whales and the import of sperm oil and other whale products. A strong movement exists in many countries in favour of free contraception and abortion to prevent unwanted children from being born on our overcrowded planet.

In certain instances, environmental groups have derived assistance from legal processes whereby the courts have restrained commercial exploiters—at least temporarily—as in the case of the trans-Alaskan oil pipeline; the anti-SST hearings by the aviation authorities in New York; the occupation in 1975 of the construction site of a nuclear power station at Whyl, Federal Republic of

Germany, by over 10,000 people, securing the legal review of the project which could not have been obtained by any amount of polite letters and petitions.

Many environmental actions have been unsuccessful, not just because they were unable to overcome the strength of vested commercial and political interests, but because they were attacking symptoms instead of root causes. When a citizen group supports the building of a new airport on another site to that proposed in its locality, it is only exporting the noise, pollution and concrete jungle to other citizens. The group should question the need for more air travel and whether aircraft represent the most energy-efficient and socially equitable form of transport.

In the United States, ecology and recycling centres are carrying out many of the above activities and, like many civic groups, are collecting waste paper and metals for re-use. In industrialized countries, there is a growing movement towards self-sufficiency in small rural communes, using alternative technology such as wind and solar power, and non-mechanized organic agriculture. Young volunteers are working on farms to produce organically grown fruit and vegetables, while in less-developed countries, too, young people are organizing themselves against industrial pollution, planting trees against soil erosion, pressing the authorities about water pollution, and educating the people about proper sanitation and family planning.

Museums, young naturalists' clubs and environmental study centres

Facilities for out-of-school learning in this category exist in many forms in almost all countries. Much of the work done in these 'learning environments' is carried out in co-operation with the formal school programme and the teaching staff. For example, in the United Kingdom there are some 400 field study centres with trained personnel and simple laboratories which school classes can visit for the day or where they can stay for a week or two. Various organizations run these centres, including the Youth Hostels Association and the Field Studies Council, which have built up considerable expertise in such programmes. In the United States there are over 800 nature centres. In the U.S.S.R., most towns have a Centre of Young Naturalists, whose counterpart in Bulgaria is the Young Biologists' Centre. The Zentrale Lehrstätte für Naturschutz at Müritzhof in the German Democratic Republic also conducts courses for training youth leaders in environmental conservation. In certain countries, national parks provide facilities for young people to learn about wildlife conservation—good examples are the Tree Tops School Camp in Zambia, and the Education Section of Kenya National Parks. In urban areas, where most schools are situated, there is a lack of such study facilities; the Council for Urban Study Centres in the U.K. is pioneering urban centres where school classes and community groups can study local history, architecture, town planning, noise pollution and traffic problems, and become involved in local issues.

Especially in the developing countries, there are scientific youth centres and clubs of young scientists. While most of these are aiming to develop scientific and technological skills connected with industry, some of them—for instance in Iraq, Upper Volta and Malagasy Republic—seek to introduce young people to ecology. Many museums are involved in environmental education, not only through displays, but in extra-curricular programmes; some examples are: the Museum of Natural History (Budapest), the Museo Nacional de Historia Natural (Santiago), the Nova Scotia Museum (Canada) and the National Museum (Kenya). Zoo clubs carry out similar activities, while the School Gardens Centre in the Netherlands is a rather special 'learning environment'. Junior sections of adult natural history societies and young animal lovers' societies have a fairly large though mainly postal membership.

Non-specialist organizations

Several youth organizations have traditional links with the country-side—among these are Scouts, Pioneers, Guides and 4H and other young farmers' clubs. In recent years, these and other youth and student organizations have incorporated environmental activities in their programmes, thus involving several million young people in some form of environmental education.

The World Scout Bureau has: (a) developed a World Conservation Badge in collaboration with the World Wildlife Fund; (b) organized a conservation training course for European scout leaders in Sweden in 1973; (c) included conservation in the programme of the World Jamboree in Norway in 1975; and (d) published a series of booklets on conservation topics and projects. Activities undertaken by scouts in the 104 national associations include clean-up campaigns, tree planting, famine relief and pollution monitoring. Half of the ninety-one national associations of girl guides and scouts have environmental programmes, including ecology workshops in Canada, tree planting to prevent erosion in Latin American countries, agricultural development in the Philippines, and beautification and litter clearance in Australia. The counterpart of the scouts in most socialist countries are the young pioneers. In Czechoslovakia, the pioneers have a long-standing environmental programme and have exercised a strong influence on the introduction of environmental education to the school system. In Cuba, the pioneers co-operate with the Committee for the Defence of the Revolution in saving electricity, planting trees, cleaning up towns and villages, linking the school with the community in recreational and cultural activities in the local environment.

In many countries, organizations such as the 4H Clubs are introducing young people to farming and countryside matters. Quite often these are connected to training programmes sponsored by ministries of agriculture. In North America, 4H Clubs have developed an energy conservation programme involving 48,000 students in South Carolina alone; while in Dahomey, the 4D Programme has a mobile educational unit which shows films and slides on agriculture in rural areas. The Young Men's and Young Women's Christian Associations, Moslem Youth Organizations, and other religious youth groups are becoming involved in environmental activities. The YWCA members in Aulstralia have undertaken clean-up actions in cities and campaigned against pollution and energy intensive technology. In France and Fiji they have objected to nuclear tests in the Pacific. In Japan they have focused public attention on pollution. United Nations Student Associations have organized seminars and programmes on environmental problems in Italy, Poland, the United Kingdom and Uruguay.

The Red Cross Youth are introducing principles of ecology in their health improvement programmes; the theme for World Red Cross Day in 1973 was 'You and Your Environment: Priority for Red Cross'. National associations of Red Cross Youth have undertaken actions against pollution (Finland), for parks and recreation areas in urban centres (Bulgaria), for urban and rural community development (United Republic of Tanzania) and clean-up campaigns in many countries. The World Assembly of Youth started a family-planning programme in 1969 which now embraces some twenty countries; national youth councils are involved in rural development schemes (Sri Lanka, Indonesia, Ghana and other African and Latin American countries), and many national student unions have environmental projects (New Zealand, Sweden, United Kingdom, etc.). The national affiliates of the World Federation of Democratic Youth also organize environmental activities. Government agencies in some countries sponsor environmental poster competitions, travelling exhibitions, study and work camps and school activities on the environment; but these initiatives are not very widespread.

International and regional co-operation

The first international youth camps for environmental studies (inter-camps) were held in the Netherlands, Belgium, Sweden and the Federal Republic of Germany in the early 1950s. Under the auspices of the International Union for the Conservation of Nature (IUCN), environmental youth organizations from eleven Euro pean countries came together in Austria in 1956 to create the International Youth Federation for Environmental Studies and Conservation (IYF). The federation is the only international youth organization specifically devoted to environmental conservation.

IYF sponsors an annual programme of intercamps, which have been held in countries such as Czechoslovakia, Finland, India and Switzerland. These inexpensive camps enable young environmentalists not only to appreciate the environmental problems of different regions, but to establish international friendship and understanding. IYF now has member organizations in eighteen countries, and its bulletin *Taraxacum* is distributed free of charge to environmental youth leaders in over ninety countries.

For its members, who are between the ages of 15 and 28, IYF organizes projects and annual themes on topics such as wetlands conservation, energy and environment, detergents and environment, endangered animals and plants, and action on the waste of natural resources. Its working group on education is producing material in five languages, and its working group on land use planning has organized international symposia for young professionals in Yugoslavia and Sweden. IYF depends entirely on the voluntary work of officers elected by member organizations at an annual General Assembly; it raises money for its projects from bodies such as Unesco, the European Youth Foundation and the World Wildlife Fund.

In August 1971, the first International Youth Conference on the Human Environment was convened by IYF, IUCN and Environic Foundation International. It was held in Hamilton (Canada), and attended by young environmentalists from seventy-five countries. The conference was invited to submit its conclusions to the 1972 United Nations Conference on the Human Environment. A set of action proposals and a statement of environmental policy were prepared.[3]

The Hamilton Conference was the beginning of world-wide co-operation between environmental youth movements, on the basis of autonomous regional development. IYF has appointed Regional Co-ordinators in each continent and has embarked on a programme of regional training courses, similar to its European Youth Leader Training Course which has been held each year since 1955.[4]

In 1974, the first Eastern Africa Youth Course in Environmental Conservation was attended by participants from eight countries in Nairobi.[5] This was a co-operative venture between IYF and a group of Kenyan organizations convened by the Unesco Regional Office for Science and Technology in Africa. As a result of the course, Wildlife Clubs were set up in Uganda and the United Republic of Tanzania, as well as an environmental youth organization in Mauritius. A second course for Eastern Africa is planned for Zambia in 1977. IYF, together with the Indian Environmental Society, convened the first Workshop in Environmental Education for Asian Youth in India in May 1975. Another course was held in Hong Kong in December 1975 to enable youth leaders from more countries in South-East Asia to participate. Regional training courses in West Africa and Latin America are being prepared.

International youth organizations have come together to co-operate on environmental issues within the framework of their informal meetings at the United Nations in Geneva. The first conference took place in 1971 as an input to the United Nations Conference in Stockholm in 1972, where eleven international youth organizations collaborated in a joint statement to the governments.[6] In 1974, the same organizations which meet regularly in Geneva organized the International Youth Population Conference before the World Population Conference in Bucharest. They also sponsored a follow-up programme of environmental projects. The international youth organizations held a workshop in Nairobi, in March 1976, with the planning being undertaken by the International Student Movement for the

3. *The Hamilton Documents, proceedings of the International Youth Conference on the Human Environment*, St Louis, Mo., 1972.
4. International Youth Leader Training Course, 1974 (IYF, 1975); *IYF Luneburger Heide Course*, 1955–69 (IYF/IUCN, 1971).
5. *Eastern Africa Youth Course in Environmental Conservation, Report and Proceedings*, Nairobi, 1974.
6. 'Statement of Eleven International Youth Organisations ...' op. cit.

United Nations (ISMUN), the League of Red Cross Youth and IYF. The purpose is to extend their environmental concern and co-operation to the regional and national level. The common ground of the environment, and the commitment of the younger generation in many countries to its improvement, can give a new impetus to international friendship and understanding.

Problems of implementation and possible solutions

Programmes for non-school youth

So many young people lack any opportunity for formal school education that it is important to provide them with an alternative source of environmental education. As many of these people may be illiterate, or perhaps have completed only primary education, greater use must be made of broadcasting and personal contact with the family unit and the village unit. Several countries have programmes which could be adapted for environmental education, such as the *enseignement télévisuel* in Ivory Coast, the *enseignement moyen pratique* in Senegal, and the radio clubs in Dahomey. Environmental topics could also be integrated in agricultural training schemes and in environmental hygiene programmes. In the execution of such programmes, it is always best to train one or two community leaders rather than to attempt to directly educate the local people, especially in rural areas. A proposal was made to the Unesco Biosphere Conference in 1968 that simple conservation principles should be incorporated in literacy and rural development programmes;[7] governments and international agencies could enlist the assistance of environmental youth leaders in this process.

Training of environmental youth leaders

The need for trained youth leaders able to carry out the essential elements of an environmental youth programme was identified as the highest priority by respondents to the survey made for this paper[8] and by the experts gathered at the Unesco Workshop in Belgrade. At present, the only training programmes are the regional and national youth courses cited in this paper, most of which are carried out by voluntary environmental youth organizations. In order to be more effective, these courses need more financial support, a good programme and the right participants. Using the existing manpower and experience, youth leader training programmes could be gradually expanded with the assistance of governments and international agencies. At a lower level, environmental study camps can provide the basic introduction for young people in ecology and environmental conservation; here programming is also becoming more sophisticated.

Obstacles to progress

Although environmental education should be a fundamental part of every individual's upbringing, it is still given a very low priority in education programmes around the world. When environmental education is given consideration at the national level, the out-of-school element is often neglected, despite its effectiveness. Compared with the facilities provided for social, religious and sporting bodies, environmental youth organizations receive little support. Thus, the development of out-of-school programmes is left to a handful of enthusiasts and to the initiatives taken by the young people themselves. When support is forthcoming, it is often directed towards superficial litter clearance programmes or to projects by groups which have no competence in the field of environmental youth activities—for example, the young volunteer's card for nature conservation issued by the Council of Europe in collaboration with the Touring Clubs of Italy and France. Environmental youth organizations are rarely, if ever, consulted by governments and educational bodies—even in their own special field of competence.

7. Jonathan Holliman, *Introductory Statement to the Commission on Education at the Unesco Biosphere Conference*, Paris, September 1968.
8. Withrington, op. cit.

Respondents to the survey of environmental youth leaders all mentioned the lack of money, equipment and facilities available to environmental youth programmes, and the poor response to youth initiatives. They also emphasized the apathy and lack of knowledge about environmental issues amongst the public in the face of so many material distractions, and the stifling effect on teachers and students of rigid school curricula.

Conclusions

Out-of-school environmental activities provide an enjoyable and constructive education for young people which will certainly be relevant in their adult life as citizens. Without fundamental environmental education, it is doubtful whether we can improve social and economic relationships in our world. The potential of environmental education for youth by youth can be utilized effectively through the co-operation of schools, adult organizations, funding bodies and governments with environmental youth organizations. The whole funding process must be reviewed to prevent environmental youth leaders spending half their time making funding applications, and funding bodies failing to provide adequate support for youth activities. If governments and international agencies allocated an annual budget for environmental education programmes for youth, each project could be judged quickly and on its merits.

Within the present framework of funding and given the limited opportunity for meaningful involvement in environmental conservation activities, young people are not being used effectively, especially in developing countries. The current environmental education programme of Unesco and UNEP may make it possible to improve this situation and help young people to create a better world environment for tomorrow.

Recommendations

In recent years, many conferences and organizations have made constructive proposals in support of environmental education for youth; the majority of these have not been adequately considered by governments and international bodies. Two important sources of recommendations have been:

1. The European Working Conference on Environmental Conservation Education which, in 1971, made eighteen proposals[9] for action by government and local authorities, adult organizations, schools and international bodies. They include establishment of national conservation centres; support for environmental youth organizations; an international fund for training courses, etc.; and environmental service as an alternative to military service.
2. United Nations Headquarters Youth Caucus Environmental Task Force, whose proposals, amended by the IYNGO meeting in Geneva in May 1974,[10] suggested that UNEP and other United Nations agencies arrange voluntary and professional posts for young people in their programmes; an annual youth campaign on tree-planting, water and energy conservation; support for the IYF bulletin; consultation on programme implementation; and an international youth conference on the environment.

Young people concerned about their environment have put forward coherent and consistent policies for changes in society to replace the current system of economic materialism and exploitation. The first Youth Manifesto on the Environment was presented by delegates at the thirteenth National Conference of the United States National Commission for Unesco in 1969. Several international youth meetings have issued declarations since then,[11] but the majority of govern-

9. Jan Čeřovský and David Withrington (eds.), *European Working Conference on Environmental Conservation Education, 1971—Final Report*, p. 40–4, Morges, 1972. (IUCN new series no. 34.)
10. *Proceedings of IYNGO Informal Meeting, 2–3 May 1974*, p. 2, Geneva, United Nations, Division of Social Affairs, July 1974.
11. T. Vethaak (ed.), *International Youth Forum for European Conservation Year, Report*, Inzmuhlen IYF, 1970; *European Symposium on Youth Strategy in Environmental Conservation*, Lillehammer, 1971; *International Youth Conference on the Human Environment*, Hamilton, 1971. *Hamilton Documents*, St Louis, Mo., 1972; 'Statement of Eleven International Youth Organisations . . .', op. cit.; *Statement of the International Youth Population Conference*, Bucuresti, 1974; *European Seminar on the Role of Youth in Environmental Protection*, Katowice, 1973.

ments and intergovernmental bodies have chosen to disregard them.

The participants at the Unesco/UNEP Workshop in Environmental Education in Belgrade, October 1975, discussed this paper on 'Out-of-School Environmental Education Programmes for Youth' and formulated the following proposals:

1. That test programmes for courses in leadership training should be developed at the regional and national levels, using the experience of existing programmes and personnel; that a special research effort should be made to devise courses suitable for young people who have not had any formal schooling.
2. That regional and national youth training courses should be supported as the most suitable means of expanding youth cadres for environmental activities in different parts of the world. That support should be given to the follow-up of such courses, including regional contact bulletins and the formation of new environmental youth organizations.
3. That in connexion with the Unesco/UNEP Environmental Education Programme, and based on its principles and experience, the Youth Environment Programme for West Africa be organized as a pilot project for Africa on teacher trainee youth leadership environmental programmes. Such a pilot project would form a supporting regional environmental education programme as a follow-up (currently restricted to West Nigeria).
4. That regional and national training courses be maintained free of charge to participants wherever possible, in order to prevent environmental education becoming the province of rich countries and rich people.
5. That the Unesco Environmental Education Unit be made permanent with specialist consultant staff experienced in practical environmental education programmes, including youth activities. The unit should have the following additional tasks: (a) visits to Member States in both industrialized and developing areas to assist with the implementation of out-of-school environmental programmes; (b) the distribution of information on environmental education activities relating to youth; (c) liaison with bodies carrying out international environmental education programmes; (d) provision of a translation service for selected environmental publications of interest to youth; (e) setting up of pilot projects in the field of youth leader training.
6. That central units responsible for environmental education be set up in each country, or strengthened in the case of existing ones. They should be staffed by people with practical experience in environmental education programmes. The tasks of such centres would be to co-operate with bodies active in the field, including environmental youth organizations; to organize publicity and distribution of information about current programmes including youth study camps and training courses; and to co-ordinate the distribution of financial support for such programmes. This unit should also keep in touch with the Unesco Environmental Education Unit. In many countries it will be appropriate for this government unit to organize training courses and other programme activities.
7. That governments set up an annual budget to support environmental youth activities. Funds are needed at the local, national and international levels to support regional and national seminars and training courses for young people, publications of environmental youth organizations, meeting rooms, equipment for field work, travel assistance and subsidies for administration.
8. That exchanges between Member States of youth leaders and students in the field of environmental education be encouraged under the auspices of Unesco/UNEP. Existing exchange programmes and expertise should be utilized.

A very relevant recommendation came from the discussion on secondary school environmental education:

That in order to encourage a greater involvement of secondary school pupils in the community and to assist teachers in organizing fieldwork, local authorities and/or organizations should compile a list of local branches of community groups and environmental youth organizations which could help in these tasks. Ministries of Education should authorize such bodies to participate in school programmes. Teachers should also encourage pupils to join in these activities on weekends and outside school hours; in some cases, special school environmental clubs could be formed for this purpose.

Bibliography

GLADKOV, N. A.; INOZEMTSEV, A. A.; OOUREYEVA, G. N. *Nature Conservation in the U.S.S.R.* Leningrad, University Publishing House, 1972.

HOLLIMAN, J. *Consumers' Guide to the Protection of the Environment.* Rev. ed. London, Pan/Ballantine, 1974.

LINDSTEN, C. (ed.). *Clean Water, No Litter, Precious Soil, Pure Air, Free Wildlife.* Geneva, World Scout Bureau and World Wildlife Fund, 1973-4.

LINDSTEN, C.; BIJLEVELD, M. *Conservation Information Centres*, Geneva, World Scout Bureau and World Wildlife Fund, 1973-4.

STEVENS, R. A. *Out-of-school Science Activities for Young People.* Paris, Unesco, 1969.

'Taraxacum'—Bulletin of the International Youth Federation for Environmental Studies and Conservation. Morges, IUCN.

UNESCO. *In Partnership with Youth.* Paris, France, Unesco, 1969.

WITHRINGTON, D. (ed.). *Youth and Environment, Proceedings of International Youth Conferences in 1971.* Amsterdam, IYF, 1972.

Youth and Environmental Action. Brussels, World Assembly of Youth, 1972.

Youth Involvement and Community Action. In: Robert Saveland (ed.), *Handbook on Environmental Education.* London, John Wiley & Sons, 1976.

11. Environmental education programmes for adults

Lars Emmelin
Lund University
Lund (Sweden)

The need for environmental education for adults[1]

Although the need for environmental education for adults has repeatedly been stated in general terms through such phrases as 'environmentally literate citizens', etc., the precise implications in individual nations have seldom been worked out. This seems to be true both in relation to the types of environmental problems encountered and to educational strategy.

Concern about environmental issues obviously leads to a call for environmental education for adults:[2]

> The adult education effort is to me most critical. First, because this element—now outside the formal channels of education—will continue to be the decision makers for the next 15 to 20 years, and it is within this period that the most critical and disruptive decisions will have to be made. We cannot afford to focus on youth and let the elders die off before changing our course, which, if time permitted, would be the most efficient way of instituting change. Not only are these elders the most difficult to reach but they are the most reluctant to accept the required changes in their life styles.

The United Nations Declaration on the Human Environment states that:[3]

> In the developing countries most of the environmental problems are caused by underdevelopment. . . . therefore, the developing countries must direct their efforts to development, bearing in mind their priorities and the need to safeguard and improve the environment.

The difference in situation would seem to create demands for very different approaches and educational content for adults. It may be correct, however, to claim that one of the main goals of environmental education is common to all situations. The need for a sufficiently sophisticated understanding of the functioning of the environment must be one of the requisites for coping with both those environmental problems generated by industrialization and technological development, on the one hand, and those created by under-development, on the other.

The levels of environmental education

In discussing adult education, it may be useful to consider briefly those products of environmental education effort that can be discerned and are usually called for.[4]

1. Integration of environmental concern, knowledge and skills into all relevant areas of learning.
2. An environmentally literate citizenry.
3. The preparation of experts qualified to deal with specific environmental problems.

1. The operational definition of 'adult education' adopted for this article is education for persons above school-leaving age but not enrolled in any institution of post-secondary/university education. The various further restrictions will appear in the article.
2. Statement by Peter S. Hunt in *Environmental Education: The Adult Public*. Report of a Workshop Conference sponsored by the American Institute of Biological Sciences, Washington, 6-7 April 1970.
3. The United Nations Declaration on the Human Environment, Sect. 4.
4. L. Emmelin, *Environmental Education at University Level*, Strasbourg, Council of Europe, 1975.

4. A deeper understanding of environmental matters by a large number of groups—politicians, planners, civic leaders, teachers at all school levels, and so forth.

What is the position of adult education in relation to these four goals?

The first point applies to all forms of formal education and thus to many adult-education programmes. It seems that the only educational sector in which there is in fact any progress towards integration of environmental considerations is in the compulsory school system.[5]

The role of adult education would seem to be of the greatest significance in respect of the second point for the reasons already cited. An environmentally literate citizenry may be achieved through formal education, including the use of mass media, direct citizen action and so forth.

The role of adult education in achieving the last two goals depends largely on the limits set to the term adult education. For the purposes of this chapter, the third point will be excluded since the production of experts is normally considered the task of post-secondary educational institutions. It is becoming increasingly clear, however, that this type of education will have to move into the adult-education sector in order to cope with the problem of updating expertise.

Select groups having, or believed to have, influence of some kind are often the targets for environmental-education efforts. In this case, there may be a quantitative separation in the goals one is trying to reach, although, for instance, the second of the points mentioned above might be achieved through action aimed at achieving the fourth. The reason for keeping the two sets separate is that there is more than a quantitative difference between them. In the sense used here, there is also a need for specialization in the knowledge and skills imparted in the fourth case—a planner's educational needs are different to those of a politician or an industrial manager.[6]

The status of adult education

The following classification of educational programmes according to personal needs is relevant to the fields of environmental education:

Remedial education: fundamental and literacy education—a prerequisite for all other kinds of adult education.

Education for vocational, technical and professional competence—this may be designed to prepare an adult for his first job or for a new job or to keep him up to date on new developments in his occupation or profession.

Education for health, welfare and family planning—including all kinds of health and family problems, consumer matters, planned parenthood, hygiene, family relations, child care, etc.

Education for civic, political and community competence—including all kinds of educational programmes about government, community development, public and international affairs, voting and political education, etc.

Education for self-fulfilment—including all kinds of liberal educational programmes, education

5. Of the few examples the author has been able to find, the most interesting seems to be the inclusion of a short, compulsory course on the environment by the Norwegian correspondence college—NKI Skolen. This school teaches mainly technical subjects at college of technology/community college level. For a discussion of the problems of integration see Emmelin, op. cit.

6. For a discussion of the role of recurrent education, see J. Bossanyi, 'Recurrent Education in Environmental Science and Management'. Document from OECD/CERI for the conference held in Rungsted in June 1974. Obtainable from the OECD as document CERI/HE/CP 74.10.

For a discussion of programmes of education for decision makers, see V. Giacomini, 'Courses for Decision-makers', *Environmental Problems and Higher Education*, Paris, OECD, 1976.

It is worth noting that a unique effort aimed at educating decision-makers took place in the United States during the month of August 1975. Fifteen people, led by a United States Congressman and members of the Interstate Commission on the Potomac River Basin, traced the entire length of the main stem of the Potomac River. Five members of the group were secondary school students. Each student was selected to represent a jurisdiction that drains into the Potomac (Maryland, Pennsylvania, Virginia, West Virginia and the District of Columbia). The group travelled by foot, bicycle, horse, coal car, canoe, sail boat, research ship and oyster-boat before reaching the Chesapeake Bay, 386 miles from the head-waters. The group met with residents in more than fifty riverside communities, from tiny upstream mining towns and downstream fishing villages, to Washington, D.C., a city of 3 million inhabitants, where 75 per cent of the Potomac Basin's population resides. Tours were taken of activities which impact on the Potomac and its people: power plants, water supply and waste water treatment plants, industries, mines and farms and key recreation areas.

in music, the arts, dance, theatre, literature, arts and crafts, whether short or long term; all programmes which are aimed primarily at learning for the sake of learning rather than achieving the aims included in the other four categories listed above.[7]

In relation to environmental education, the following brief comments seem appropriate. The second group is still the dominant preoccupation of adult education. In environmental education, this may be clearly seen in some of the university-type short courses given in the industrialized nations. These clearly originate in a perception of a lack of knowledge on the part of planners, politicians and industrial managers. Regarding knowledge, it is obvious that what such courses try to remedy is a lack of natural science information in planning processes and decision-making.[8]

In relation to the needs of communities, it would seem that the third group would be of the greatest relevance to the developing nations whereas the fourth group would be of particular interest in industrialized nations. The fifth group is perhaps characteristic of much of the present conservation education and some of the university-type courses.

Regarding the official status of adult education, Lowe makes three points concerning the situation which existed when Unesco planned its 1972 conference on adult education in Tokyo:[9]

First, governments seemed reluctant to treat the education of adults as an integral part of their educational systems. Second, except in one or two countries, the level of financial support was very low. Third, and above all, those who most needed education were not participating in adult education programmes because by and large the lower the level of a person's education and the lower his occupational status, the less likely is he to want to pursue his education in adult life.

Although the situation regarding adult education in general has changed somewhat for the better, this is hardly true to a significant degree in environmental education for adults.

The nature of the learner

At all educational levels defined by the target population, a number of more or less generally valid assumptions are made as to characteristics of the individual members of that population. It is obvious that no generalizations of any relevance to adult education can be made until the target population has been narrowed down considerably from the original definition of adult education.[10]

Failure to break down the 'general public' into identifiable target populations, with a number of defined common denominators from the educational point, may be one of the reasons for the inadequacy of environmental education for adults, which is a recurring theme of this chapter.

Knowles summarizes the most important assumptions on which the adult-education process is based:[11]

As a person matures 1) his self-concept moves from one of being a dependent personality toward one of being a self-directed human being, 2) he accumulates a growing reservoir of experience that becomes an increasing resource for learning, 3) his readiness to learn becomes oriented increasingly to the developmental tasks of his social roles, and 4) his time perspective changes from one of postponed application of knowledge to immediacy of application and accordingly his orientation toward learning shifts from subject-centeredness to one of problem-centeredness.

7. After Liveright and Haygood, from J. Lowe, *The Education of Adults—A World Perspective*, Paris, Unesco, 1975.
8. For a discussion see, for example, L. Emmelin, *Envrionmental Education at University Level*, AMBIO (In Press), or Emmelin, op. cit. It is not implied that all courses have this approach nor that it is the only one of those that have it.
9. J. Lowe, op. cit., p. 11.
10. Consider that we are dealing with education which may be aimed at any subgroup of the world's approximately 800 million adult illiterates or at a British school teacher (the latter group makes up about one-third of the students of the Open University).
11. Malcolm S. Knowles, *The Modern Practice of Adult Education*, New York, N.Y., Association Press, 1970. The quote seems to sum up in a reasonable manner some characteristics of the adult. However, the implications as to the nature of the child as a learner seem doubtful.

Based on this description of the adult as learner, Roth[12] states that 'because of its basic problem-centered, transdisciplinary nature, education for environmental issues should be a natural for adult education programs'. Roth goes on to note the increase in participation in adult education in general in the United States.

This trend has been much the same in other industrialized nations. However, there has been no similar increase (at least not proportional) in formal environmental education. Some of the reasons for this will be dealt with below.

It is clear from the examples examined by the author that thorough studies of the target group for environmental education are rarely conducted prior to the designing of the programme.[13] The fact, which is now becoming generally recognized in other adult-education efforts, that the target population has to be well defined and the educational effort (including the question of attracting students in the first place) geared to specific criteria defined by a careful analysis of the target population, seems to have had little impact on environmental education as yet.[14]

The typical learner who in fact makes use of adult education on the environment is described by Nowak.[15] His description may superficially seem to apply to the 'average citizen' in any industrial nation. One should note, for example, that a high percentage are interested for work reasons and that many are involved through their work in citizens' groups. Most educational efforts are more or less consciously directed at this kind of group since most of those who design courses, whether in universities or in organizations for environmental action, often equate this group with 'the general public' or realize that this is the category likely to be attracted.

In developing countries, the focus on various sorts of community leaders is often quite clear and intentional. The multiplier effect that this is thought to have is part of the economics of adult education in such situations. It is important for environmentalists to take into account those leaders who are accepted by the community in respect of various programmes.

Education needs

There seems to be a reasonable degree of consensus as to the need for an environmentally literate citizenry such as that envisaged by the Minnesota state plan for environmental education:[16]

> What is needed is a continuous stream of information to inform the public about environmental matters in general. Then when a crisis does arise, people will have a background of knowledge to use in dealing with it.

The plan discusses this concept in contrast to the usual sequence: a crisis arises, small informed groups organize to meet it and have to educate the public as a first measure before taking action against the crisis itself. This pattern is well known to conservation organizations all over the world and is a major motivation for their educational programmes.

Most plans of a national or regional type go from this position to outline courses of action which include clearing-houses for environmental information, liaison with action groups, conservation organizations, civic organizations and professional bodies, increased adult education and so forth.[17] The general vagueness of those recom-

12. Charles E. Roth, 'Formal Adult Education', in Albrecht and McInnis (eds.), *What makes Education Environmental?*, Washington, D.C., Environmental Educators, 1975.
13. For an example of a programme designed after careful study of the target population, see Sister Constance Banks, 'Police and the Environment: A Design Strategy for Adult Environmental Education', in Swan and Stapp (eds.), *Environmental Education*, New York, N.Y., Wiley, 1974. As pointed out in the text, environmental education in the developing nations—where it exists—seems more sophisticated in this respect.
14. See S. J. Muskin (ed.), *Recurrent Education*, Washington, D.C., National Institute of Education, 1973, for a set of articles and an extensive literature on the problems of identifying target groups.
15. Paul F. Nowak, 'The Development and Evaluation of an Innovated Approach to Environmental Conservation by Independent Study Through Correspondence', dissertation, University of Michigan, 1969.
16. 'A State Plan for Environmental Education for the Citizens of Minnesota', St Paul, Minnesota Environmental Education Council, 1972.
17. See, for example, *Michigan's Environmental Future*, Lansing, Mich., Governor's Office, 1973; *Umweltpolitik—Das Umweltprogramm der Bundesregierung*, Stuttgart, Kohlhammer, 1974; or *Environmental Quality: The First Annual Report of the Council on Environmental Quality*, Washington, D.C., 1970.

mendations dealing with adult education will be discussed below. The question here is whether in fact a need exists for formal programmes of education as a means of reaching the adult population. The answer is often, with little or no analysis, assumed to be 'yes'. Often this is for the very good reason that such programmes are in fact being requested. This may, however, bear little relationship to the goal of providing environmental information.

In order to answer the question it becomes necessary to examine the effectiveness of other means of communication as educational tools. The opinion that the formal education system is doing a poor job in providing citizens with useful information relevant to their daily lives and social functions is becoming widespread—not least among administrators and those dealing with educational theory: 'Most learning is not the result of instruction. It is rather the result of unhampered participation in a meaningful setting.'[18] The two means of environmental education for adults which are most frequently quoted as being of importance, and which for the purpose of the present discussion need examining, are the news media and participation in some kind of environmental action. The latter may be aimed at producing change at local, regional or national level through a wide range of mechanisms ranging from direct work such as cleaning up a piece of land to political lobbying and legal action at the national or international level.

The media as environmental educators

The learning of behaviour patterns and the acquisition of values directly detrimental to sound environmental development is an interesting aspect of education which lies outside the scope of this discussion. It would seem reasonable to guess that the role of mass media is considerable in this *anti*-environmental education process. What, then, is their role in the positive sense?

Sandman[19] discusses the role of news media in relation to the three educational goals of imparting knowledge, skills and motivation to the general public. He finds that

> their effectiveness as environmental educators is greatly diminished by their inattention to environmental skills training, their lack of educational goals for entertainment,[20] and their delivery of persuasive content (advertising) into the hands of the environmental exploiters.

Discussing the role of media as motivators, Sandman concludes that:

> Four relatively effective kinds of environmental information are: basic ecological principles; prescriptions for environmental action; early warnings of incipient problems; and assessments of blame for environmental degradation. The media tend to deemphasize all four of these information categories, stressing recent public events of passing environmental relevance instead.

Other studies seem to be in agreement with Sandman regarding the skills and knowledge. However, in motivating people, the educational role of the media may be rather more important. Surveys of attitudes towards pollution control and specific environmental problems show a reasonable correlation between awareness in a general sense of a given problem and the news coverage given to that problem. When, however, surveys are followed by any form of testing of factual knowledge about a problem, the sharp limits of the

18. Ivan Illich, *Deschooling Society*, London, Open Forum, 1971.
19. Peter M. Sandman, 'Mass Environmental Education: Can the Media Do the Job?', in Swan and Stapp (eds.), *Environmental Education*, New York, N.Y., Wiley, 1974.
20. The exception to this (as Sandman points out) may be such programmes as the series produced by Commandant J. Cousteau on underwater life.

educational role of media is usually clear.[21]

The tendency of media to concentrate on the form rather than the content of an environmental message, the emotional nature of the message and the focus on events rather than processes are among the characteristics that may explain the limited educational value of the media.[22]

The preceding discussion is relevant to situations where the media are to a large extent commercial. In many developing nations and in the socialist countries, this is not the case. For various reasons, the situation may not be any better in some of these countries. Although television and radio may not be directly commercial, the journalistic tradition may still be dominated by a commercially oriented press. Criteria used in the radio and television systems will then be largely those of the commercial media. The concentration on form rather than content is quite noticeable in non-commercial media systems.

In many countries, there are, however, examples of intensive use of the media for adult education in general. Some programmes exist which make use of television and radio for environmental education. Conservation educators have made very good use of television. Several Latin American programmes make entensive use of radio. Although radios are much more common than television sets in many parts of the world, it is clear that the educationally underprivileged are difficult to reach with this method in many countries. The use of radio and television in organized programmes of education is not the subject of this chapter. It should, however, be noted that the use of news media is possible and is often used as a complement to other methods. Examples of such programmes appear in the reports of Unesco consultant missions on environmental education.[23]

Environmental action

It is a well-recognized pedagogic principle that participation in concrete action directed towards a given goal greatly enhances learning. This is true whether the action is field work, laboratory work or participation in direct efforts for environmental change through official, private or other groups. This in itself is hardly controversial. For the present discussion, the question is: can such action be a substitute for formal education? There seem to be several reasons why this may not be so although this opinion depends largely on what degree of educational depth is aimed at.

In the many types of action taken by environmental groups, the educational limitations of some are evident. The time/space constraints on a teach-in, seminar, demonstration, etc., obviously make it difficult to achieve in-depth analysis of a problem, which can lead to fundamental knowledge. It is usual for either a large number of topics to be covered superficially or for discussion to be concentrated on a very isolated issue. In both cases, the educational goals of knowledge and skills training are usually fairly peripheral. The emotional and simplistic nature of the message in various environmental handbooks is also contrary to the principles of environmental education.[24] They may likewise give rise to the problem pointed out by Swan, namely that

21. The Swedish experiences with mercury contamination of fish may serve as a useful illustration of this. The problems which received great press coverage were exclusively related to mercury in fresh-water fish (particularly in the aquatic environment—there had already been intensive coverage of the effects of mercurial fungicides on wildlife and certain foods such as eggs). A large proportion of the press coverage dealt with differences of opinion between scientists involved, related to the Japanese Minamata case, etc. The National Institute of Public Health issued recommendations both on maximum allowable concentrations and on what species to avoid or to consume in limited amounts. In spite of a press coverage that included front page position in most Swedish dailies, subsequent investigation revealed an almost general ignorance of the exact content of the recommendations. A temporary drop in the sale of all sorts of fish—including frozen cod from the North Atlantic—was the most noticeable effect of this educational effort.

22. Russel D. Linke, *Environmental Education in Australia*, Part I, p. 87 (mimeo.).

23. Examples that emerge through the Unesco consultant missions are, for example, from Senegal, Zaire, the Ivory Coast, the Latin American Association for Radiofonic Education (ALER), programmes previously run in Chile in which more than 16,000 students and teachers participated, the Mexican Center for Eco Development radio programmes, etc.

24. An example of this category is Garret de Bell (ed)., *The Environmental Handbook*, New York, N.Y., Ballantine, 1970. See also Linke, op. cit., p. 82.

25. James A. Swan, 'Some Human Objectives for Environmental Education', in J. A. Swan and W. B. Stapp (eds.), *Environmental Education—Strategies Towards a More Livable Future*, New York, N.Y., Wiley, 1974.

'telling people what to believe may delay or even undermine any movement directed toward the improvement of environmental quality'.[25]

A further factor diminishing the educational value of certain types of action is the necessary symbiotic relationship with the media. Phenomena such as 'Earth Day', 'Whale Day', 'Bird Day', 'Forest Week',[26] etc., may be excellent mechanisms for focusing attention on problems and processes which otherwise get little attention due to their continuous nature, but their educational limitations are obvious.

None of this means that action by citizens to bring about environmental change is useless. The observations have merely been made to substantiate the claim that such action is of limited value as sustained education for a large sector of the public. Since adult education on the environment is a voluntary undertaking by the individual, citizen action on specific problems is undoubtedly of great educational value since it creates awareness, a political climate in which funds for education become available, and stimulation of educators. In interviews with participants in particular projects, it is not uncommon to hear variations on the theme 'we reached a point where we had to go back to school in order to get on with the project'. This is an ideal situation for the educator to operate in. It is the belief of the author that the system of adult education—or as often the lack of such a system—is grossly failing to meet the needs of citizens aware of the problems and in search of more knowledge.

The possibility for sustained learning seems much greater in cases where action is a planned part of an over-all educational effort. Such activity can be found, for example, in Cuba where campaigns form an integral part of the larger movement to save electricity and raw materials. The situation in Cuba is special in this respect since a well-organized network of local citizen groups exists in which action can be taken and continuity ensured. In literacy and health campaigns, the same mechanism has been provided by government bodies of a military or para-military nature.[27]

In some industrialized nations, the impulses for environmental action have come from above. (The rule in these countries normally being that environmental action groups are very much a grass-roots phenomenon.) The standpoint in such instances has been that 'a radical environmental policy requires the backing of a large and well-informed public opinion'.[28] The object then has been for governments to enlist support for appropriate measures—often legislation.[29]

Participation in planning and management of the environment

Participation in planning of the environment is a special case of environmental action which has great educational potential apart from the obvious fact that it is environmentally desirable. In practice in the industrialized nations, it is most often tried in urban planning. (The discussion here deals only with direct participation, not influence via democratic institutions which is a problem beyond the scope of this paper.)

The educational importance of participation may frequently be greater than the inputs into the planning process.[30]

A particularly instructive example of participation in environmental management is offered by the work of the Institutio de Desarrollo de los Resources Naturales Renovables (INDERENA)

26. K. H. P. Mirimanian and N. A. Gladkov, 'Conservation Education in Rural Districts in the USSR', *Proceedings of IUCN Eleventh Technical Meeting, New Delhi, India*, Morges, Switzerland. IUCN 1971 (IUCN Publications New Series no. 20).
27. Lowe, op. cit., p. 102.
28. L. Emmelin, 'Informing Public Opinion', *Environmental Planning in Sweden 16*, January 1971 (Royal Ministry for Foreign Affairs).
29. Many interests have also seen education as a means of meeting demands for action. It is one of the major problems of competent environmental education that it shows the complexities of most problems. Legitimately, it may thus be used to demonstrate the deficiencies of many simple remedies advocated.
30. 'People today may also have far more information available and possess far more knowledge than their predecessors. But this knowledge often obscures a person's perception and understanding of reality rather than shedding more light on it. The real reins of political power which most constitutions confer on the peoples, with sincerity or at any rate with great pomp and circumstance, are slipping more and more out of their grasp. Their participation in the decision-making process is beset with obstacles.' From Edgar Faure *et al.*, *Learning to Be*, Paris, Unesco, 1972.

in Colombia.[31] A comprehensive programme with many highly developed features is devoted to environmental education and management and aimed at peasants, fishermen, forest workers and other rural groups. The aim of the programme is specific—to introduce conservation of natural resources, stop overfishing, erosion, over-exploitation of forests and so forth. Among the important features are the direct involvement of the people themselves, the direct links between theory and practice, and the exchange of information in both directions. Examples worth mentioning are the decisions on fishing seasons taken by the fishermen's co-operatives. Since no scientific data was available on the economically important fish species, the fishermen themselves provided this information. In a two-way communication process, their first-hand knowledge was developed through education into an understanding of the basic ecological principles and a willingness to apply the knowledge to their own benefit in conservation measures. The code for natural resources that has been formulated has a measure of support through involvement.

An important principle which is stressed in the Colombian example is that alternatives to present practices should always be offered if the argument for changes is to have any effect. This may seem a rather self-evident truth but it is often disregarded in environmental education. Similar examples from developing nations suggest interesting possibilities for the development of education and simple practical research that would have great promise if universities, for instance, systematically entered into the kind of dialogue about what adult-education programmes can be. (The idea is by no means new. Farm extension services all over the world, when functioning properly, have used the principle of interaction between research and traditional knowledge.) Environmental education in a directly relevant and user-oriented setting should have great potential for devising appropriate technology for developing regions.

Working with illiterate or semi-illiterate groups makes it imperative that the education be practical and user-oriented. Thus, a great deal of thought and effort must be put into making the education relevant to a specific area or target group. It appears that more knowledge and experience in this area exists in the developing regions than in the industrial nations as regards adult education. An urgent task for developing adult education so as to encourage involvement of the people in managing their own environment would seem to be the collection and careful analysis of experience gained from various environmental education programmes that have been in operation for some time.

Relevance to the community and the individual

It is obvious that teaching environmentally sound development methods is only useful in a context where students have a reasonable measure of control over their own environment on both a macro and micro scale. Present efforts to prevent peasants from over-exploiting forests for fuel are likely to become ineffective in areas where large-scale, highly exploitative lumber operations are carried out. Innumerable examples could obviously be given. For the purpose of this chapter, it would seem sufficient to point out that environmental education is a tool for analysing exploitation of natural resources of all kinds.[32]

From the educational point of view, environmental education can and should be used to motivate people for all forms of education. Illich[33] notes that 'any adult can begin to read in a matter of forty hours if the first words he deciphers are charged with political meaning'. An interesting example of the importance of this type of relevance is provided by an example from the Latin American experience. A programme of education using the key words 'waste' and 'pharmacy' failed to attract popular interest and support. When the same programme was based on

31. J. Santander at the 1975 Unesco UNEP Belgrade Workshop on Environmental Education. The Latin American group at the Belgrade workshop provided several examples illustrating the points made in this section and the next.
32. See, for example, the United Nations Declaration on the Human Environment, para 1.
33. Illich, op. cit.

the concepts 'responsibility of local authority for removing garbage' and 'exploitation by patent medicines', the relevance problem was cleared up and the programme achieved support and participation.[34]

In the industrialized nations, it is obvious that the relevance problem has not been tackled to any significant degree in respect of large sectors of the public (if indeed it has even been recognized) by organizers of adult education.[35] Problems of occupational health and safety would seem to be the most obvious channel for environmental education in the near future, especially in the industrialized nations. Integrated teaching on the environment is important here since there would seem to be some risk that different areas of environmental concern may otherwise end up in conflict. There is a latent conflict between pollution control and protection of the quality of the environment in a factory.[36]

In developing countries, the relevance of environmental education to the individual must surely lie in the sector of adult education that deals with health, welfare and family planning. The integration of environmental concepts into education aimed at vocational, technical and professional competence would seem to be the area of greatest relevance to the community. In the words of the United Nations declaration: 'Therefore, the developing countries must direct their efforts to development, bearing in mind their priorities and the need to safeguard and improve the environment.'[37] Looking over the literature on education as regards these needs, one is struck by the virtual absence of the environmental aspect in the sense of the latter half of the quotation. The emerging literature on the environmental effects of uncontrolled or exploitative or unplanned development is beginning to be substantial.[38] Translating this knowledge into educational materials and activities is an urgent task. The need for integration of this knowledge into development activities is equally urgent. However, only by simultaneous education on the means of achieving development can environmental education be credible in the developing nations.[39]

Environmental education for adults has an important role to play in the recreation of a cultural identity for many minority groups and in cultural efforts at the post-colonial stage. The intricate balance between man and nature that has existed for centuries in many areas until destroyed by more intensive, exploitative systems has recently been given a new cultural significance in this movement.[40]

34. This is just one of several examples given at the Belgrade Workshop on Environmental Education which illustrate the importance of the semantic relevance even when the relevance regarding content is quite clear to the organizers of a programme.

35. This may be one of the reasons why so much of the adult education on the environment is in the fifth category of Lowe's classification—self-fulfilment (cf. 'Much of the Conservation Education').

36. The playing off of environment protection and pollution control against labour market considerations by some industries is another factor.

37. As an example, it is interesting to note that a recent World Bank publication, P. H. Coombs, *Attacking Rural Poverty—How Non-formal Education Can Help*, by Baltimore, The Johns Hopkins University Press, 1974, does not contain, for example, the concepts or words 'environment', 'pollution', 'ecology', 'erosion', 'pesticide' in its index.

38. Farvar and Milton (eds.), *The Careless Technology*, New York, N.Y., Natural History Press, 1972.

39. Since there is an increasing awareness that some environmental problems of developing nations come from the uncritical application of technology, for example overdoses of pesticides or use of agricultural methods suited for the temperate latitudes in the tropics, it is interesting to speculate on whether environmental education should not emphasize the need for a consideration of local, traditional methods of production. The student should be encouraged to inquire into the ecological bases for traditional methods and how this knowledge can be applied to development.

For a brief discussion of one aspect of integration, see C. W. Chang, 'The Role of Agriculture Extension in Conservation Education', *Conservation Education and Training*, Morges, Switzerland, IUCN 1968 (IUCN Publications New Series Supplementary Paper no. 11).

40. This is particularly apparent in some indigenous populations—often nomadic and in a minority position—which live in marginal environments. This was clearly demonstrated at the Environment Forum of the United Nations conference in Stockholm in 1972. One example was the Lapp group that held up their own harmony with nature as a contrast to the exploitation practices of the majority groups around them. Without wanting to romanticize on the harsh conditions of marginal environments, one can observe that such ecological viewpoints strengthen pride in a cultural heritage and serve as motivation for fighting to keep the environment intact and productive to their way of life.

Non-formal education

The relevance problem, together with such quantitative aspects as those mentioned in the section on organizational problems, indicates the urgent need for developing non-formal adult education in the environmental sector. Some Latin American examples have been given. In conservation education, the non-formal element has been well developed as has the necessary task of reaching people through the media, at parks, zoos and in the lower-school levels.

The role of non-formal education for development has long been recognized.[41] It has already been pointed out that environmental and non-formal education must join forces. However, the prospects do not look hopeful. Environmental education has its roots in environmental concerns largely founded in scientific research. The distance between science and non-formal education in most countries is great. The involvement of universities in the developing countries in environmental education presupposes an interpretation of academic freedom and responsibility that is unfortunately far removed from the elitist attitudes of many such institutions.[42]

Using the term non-formal education to denote non-traditional methods of learning, one may note the wide variety of pedagogic methods used in adult-education programmes.[43] The use of non-traditional materials and methods often serves two functions. First, it may be dictated by pedagogic necessity (the need to reach a largely illiterate group) or financial constraints. Second, many methods—poems, puppet shows, environmental action such as planting trees, etc.—serve to make environmental education competitive with other social activities and to introduce emotional elements which motivate and reinforce learning.

Conservation education for adults

Since the conservation movement is quite old in many countries and reasonably well organized and financed in several, it is natural that this sector should have the best documented evidence as to co-operation between action-oriented groups and educational efforts. A number of publications from the International Union for the Conservation of Nature and Natural Resources (IUCN) give examples of conservation education on a world-wide basis.[44]

Among the innovative functions performed by conservation education, the single most important is perhaps the pioneering of combinations of field work. Developments along this especially significant line are the British Field Studies Centres and the emerging urban counterparts.[45] It is also clear that adult education on conservation has had spin-off effects on university education and that a gradual widening of the concept of conservation has led to a transformation of the content of much education now given by conservation societies.[46]

University-type courses

For various reasons, adult education on environmental problems seems to be dominated by courses which in some ways are connected to a university or college. A major reason for this is

41. Coombs, op. cit.
42. Involvement does occur. In developing countries, examples can be found in Thailand and several Latin American countries. In the industrial nations, the most important examples seem to occur in the United States; see also Emmelin, *Environmental Education at University Level*, op. cit.
43. See the paper on methodologies by David Wolsk.
44. For example the IUCN Eleventh Technical Meeting: *Environmental Conservation Education Among Populations of Rural and Woodland Areas* (IUCN Publications New Series no. 20). *Final Report of the European Working Conference on Environmental Conservation Education* (IUCN Publications New Series no. 34). *Environmental Education in an Urban Society* (IUCN Publications New Series, Supplementary Paper no. 37). *Conservation Education and Training* (IUCN Publications New Series Supplementary Paper no. 11). *Conservation Education* (IUCN Publications New Series Supplementary Paper no. 12).
45. See the paper on instructional resources by Jan Čeřovský.
46. On the concepts of conservation, see A. Warren and F. B. Goldsmith, 'An Introduction to Conservation in the Natural Environment', in Warren and Goldsmith (eds.), *Conservation in Practice*, London, Wiley, 1974.

probably that there has been pressure on these institutions to provide environmental education. Unlike many other organizations, they have the competence with regard to subject matter while a number of factors such as declining student numbers have stimulated them to enter the area. Clayton[47] has also suggested that a research base is a prerequisite for sound environmental education which would give a further advantage to universities.

Pratt[48] has given a catalogue of many United States post-secondary institutions which operate programmes of varying length as part of their offerings in adult education. In most cases, these courses and programmes can be characterized as undergraduate-level courses and have much in common with these as regards both content and method. It has been argued that the most important aspect of some of these programmes is that they bring ordinary college students into contact with a wider variety of people and that the effect of this is to sharply increase the amount of 'teaching within the group'. In several European institutions of higher education, the mixing of undergraduate teaching with adult education is promoting community ties which these institutions have traditionally lacked.[49]

The open university

The United Kingdom's Open University is probably among the most significant developments in modern adult education. The innovations in method, dissemination of education, combination of traditional and non-traditional media, etc., are outside the scope of this chapter. In the field of environmental education, the offerings of the Open University at present are very limited,[50] a fact which may seem somewhat surprising in view of the lack of academic tradition, the stated aims of interdisciplinarity and the social relevance of the Open University.

Examining the synopsis for the undergraduate course on environment, one is struck by the fact that it resembles traditional environmental survey courses such as are given by most university science faculties. However, any analysis of the content and method of this course is impossible without access to the material broadcast over radio and television.

In the absence of any hard evidence, only a few speculations can be made as to the reason for the very limited contribution to environmental education made by the Open University. In traditional universities, a combination of student pressure, faculty involvement and decreasing numbers of students for certain types of courses have combined to promote environmental education.[51] None of these forces would seem to operate with the same strength in the Open University.[52] Devotion to traditional academic excellence[53] and the fact that so far the Open University has to a large extent educated people in the teaching professions[54] may in part explain the limited offerings in environmental education. The members of the teaching profession who are enrolled in Open University are not likely to be in search of environmental education until it becomes a more prominent component of the school curriculum.

47. K. Clayton, 'Environmental Education at East Anglia', *Environmental Education at Post-Secondary Level*, Vol. 1, Paris, Ceri: OECD, 1974.
48. A. L. Pratt, 'North American Institutional Organization for Post-Secondary Environmental Studies', Document CERI/HE/CP/74.04.
49. L. Emmelin, 'The Environmental Studies Programme', *Environmental Education at Post-Secondary Level*, Paris, OECD, 1974.
50. *Courses Handbook 1974* and *Post Experience Courses Prospectus 1975*. The courses listed for 1975 are an undergraduate course 'Environment' (½ credit) and a post-experience course 'Environmental Control and Public Health'. A number of undergraduate courses are also of direct environmental relevance ('Regional Analysis and Development', 'Urban Development', 'The Earth's Physical Resources', 'Ecology', 'The Man-made World').
51. Emmelin, *Environmental Education at University Level*, op. cit., Section 2.2, 'The Origin of Programmes'.
52. The *Report of the Vice Chancellor*, 1972, does, however, reflect discussions of this nature but the results do not as yet appear in the catalogue of offered courses.
53. *Report of the Vice Chancellor*, op. cit., p. 43–4.
54. In 1973 teachers constituted 29.5 per cent, housewives 12.9 per cent, professions and the arts 11.7 per cent, technical personnel 11.2 per cent, clerical and office workers 9.7 per cent. *What is the Open University?*, Milton Keynes, The Open University Press, 1974.

The University Without Walls

This programme, which is carried out by the Union for Experimenting Colleges and Universities, a union of thirty-four United States institutions of higher education, is similar to the Open University in aiming at reducing the time/space barriers against higher education.

A comparison between the teaching methods of the Open University and the University Without Walls (UWW) indicates that the great flexibility of the UWW may be more conducive to environmental education. In the undergraduate field, the Open University is offering a set of courses backed up by an impressive logistics system including television, radio, regional study centres, production facilities which ensure that the material received by students is of high quality, reviewing boards, external examiners ensuring high academic standards, and so forth. The careful structuring of the Open University has led to very good results with drop-out rates apparently in the range of 25 to 30 per cent and high standards of performance among students completing courses.[55] On the other hand, the UWW has a very loose structure, being based upon learning contracts, i.e. 'written plans of study drawn up between you and faculty sponsors which specify clearly stated educational objectives, methods of study, resources, evaluation procedures and credits'.[56] Since a learning contract may contain internship, field and job experiences, independent study and research, individual and group project activities, seminars, tele-lectures, programmed-learning facilities and travel,[57] the freedom exists to build into the education those components of a practical nature that the Open University construction may have difficulties in accommodating but that are central to environmental education.[58]

Although at present their contribution to the environmental education of the adult population may be small, the potential of structures such as the Open University and the University Without Walls would seem good. Their limitations may be that they are active only in what is called 'creaming' the educationally disadvantaged.[59] In relation to environmental problems, the group that can be reached are those already involved professionally, in civic organizations or otherwise. The major advantage is the possibility of getting them far beyond the level of knowledge and skills training possible in most other types of adult education efforts so far discussed.

Other examples

Both the Open University and the UWW involve several innovations necessary for effective education, which they have in common with such varieties of successful university-type formal education as the Cornell University conservation correspondence courses.[60] The latter, along with the course 'Man and the Environment' developed by Miami-Dade Junior College and the series entitled 'The Environment and the Citizen' developed by the University of Michigan, are perhaps the most significant examples of correspondence education in the United States.[61]

The production method for the University of Michigan course is interesting in that it comprised a sequential process in which production and evaluation alternated, and in that responsible agencies outside the university were heavily involved. Nowak[62] states the general criteria that must be met if an educational programme is to be successful:

55. The term 'apparent drop-out rate' is used since the Open University system of guaranteed registration makes it possible for students to make a pause in their studies. cf the American 'statute of limitations' which creates problems for recurrent education particularly for women.
56. From brochure *The University Without Walls—an Alternative Approach to a Degree at the University of Wisconsin-Green Bay.*
57. ibid.
58. For a discussion on the value of practical work, laboratory work, etc., in undergraduate education, see, for example, Weidner, *Environmental Education at Post-Secondary Level*, Vol. 1, Paris, Ceri: OECD, In Press, or Emmelin, op. cit.
59. S. M. Miller, 'Demand for Recurrent Education', in S. J. Mushkin (ed.), *Recurrent Education*, Washington, D.C., National Institute of Education, 1973.
60. R. J. McNeil, 'Studying the Environment by Mail', *The Journal of Environmental Education*, Vol. 3, No. 2, p. 36.
61. Roth, op. cit., note 12.
62. Nowak, op. cit.

One, the program must be built around a core of minimal knowledge necessary for informed citizen action because of the differences in formal education, the wide individual variations in casual information obtained and the changes which are occurring in our culture. Two, the educational materials must be easily disseminated to all who would like to participate, not just those who can easily reach an educational institution. This is true in urban as well as rural areas. Finally, the program must be made relevant to the learner.

The University of Michigan course is not unique in being designed to meet these criteria. Its major innovative aspect is the use of the student's own immediate environment for experiment and study. In the assignments which go with each of the units that comprise the course, there are special activities which include active exploration of the student's own environment.[63] Another interesting aspect of independent study through correspondence is that adult study groups can be involved in taking the course, thereby facilitating an exchange of information and experiences.

Institutional problems

It has been stressed several times in this chapter that there is a serious lack of organization for adult education. This is substantiated by Lowe.[64] The remedy may not, however, be the creation of new organizations competent to deal with the entire complex of adult education. In the opinion of the author, the integration of environmental matters into the programmes of education and the integration of educational efforts into the work of environmental agencies is likely to be more effective. In environmental policy statements, it is quite evident that the adult-education sector is added as an afterthought or is there not because anybody knows what to do about it, but because of a vague feeling that something ought to be done. Other recommendations are specific and aimed at identified agencies or public organizations but those on adult education have no clearly designated recipients.[65]

The organizations that do exist in many countries are either—as in the case of conservation organizations—too limited by finance or competence or specialized in marketing vocationally oriented education—as in the case of most correspondence institutes and community colleges. Funding procedures for developing a major educational effort tend to give institutions of higher education a distinct advantage. As has already been pointed out, these have been in a position, with regard to available competence and manpower, to exploit the increased interest in environmental education. Many organizations dealing with adult education do not have the means of producing sufficiently well-prepared grant proposals to get a programme going.

One possibility for increased environmental education would be to introduce more sophisticated material into organizations which have distribution facilities such as trade unions and some large organizations normally concerned with aspects of adult education, e.g. some of the major correspondence institutes and the armed forces.

The responsibility of individual government agencies in environmental education for adults has been largely neglected. The exceptions are normally either those agencies concerned with conservation or specialized agencies which have responded to criticism by environmental groups. If citizen participation in planning is to develop,

63. Nowak unfortunately does not go deeply into the implications of this method. It would be useful to examine the quality of both the answers to questions like 'make a statement about noise pollution in your community' and the comments made by tutors on such statements. Many of the questions asked are of a very general nature. One problem with this type of activity would seem to be that in order to evaluate the answers a rather detailed knowledge of the environment which is under investigation is needed in the teacher. It would also be useful to have information on the nature of the continued exchange of information between the tutor and the student that occurred as a result of specific answers to questions—whether a renewed effort, aided by specific reference to sources of knowledge, was in fact made by students who produced unsatisfactory responses. Correctly used, the method must be a powerful tool to enhance learning but if insufficient attention is paid to tutoring after the initial round, the method will produce both incorrect knowledge and inadequate skills training. The number of questions asked in each assignment seems to be so large that a considerable amount of staff time must be available if the number of students is at all large.

64. Lowe, op. cit.

65. See footnote 17, above.

the educational responsibilities of many agencies must be recognized. There is, however, a need for some kind of co-ordination of this effort and the lack of institutional organization in most countries is quite clear.[66]

The special characteristic of the adult learner is a further complication in environmental education. Motives for participating in most adult-education programmes are related either to career improvement, due to increased knowledge and/or certification, or to hobby interests. This may be the reason for the failure of environmental education to expand parallel with adult education, as noted earlier.[67] At present, job expectations will bring only a small proportion of the adult population to environmental education. The importance of conservation education, which broadens to environmental education, has been pointed out and is relevant in respect of hobby interests.

Conclusion

In conclusion, it seems important to point out that although this chapter deals largely with deficiencies in the environmental education of adults, there are encouraging examples of progress in all regions of the world.

In developing adult education on environmental problems and in seeking to integrate it with other educational work, it is necessary to recognize the enormous needs for adult education and the fact that systems must build on active participation, individual enthusiasm and the hope that the effort spent on education will give concrete results in the form of a better environment. All systems—whatever their organizational structure or financial status—are conditioned by these factors.

66. The recently conducted second stage of the national Swedish physical planning may be an example of relevance to this discussion. After the Swedish parliament had decided upon the principles and some of the basic data for the national physical planning, the stage in which the individual municipalities decided on how to implement these began. During this work, most municipalities presented the national physical planning work to the citizens, showed plans for the local implementation of this planning regarding land use, urban development, service, etc. The people were asked to contribute towards this process both with comments on the municipal plans and with concrete alternatives. The political parties engaged in this, as did many environmental action groups. Hearings, seminars, demonstrations in schools and to groups of adults took place. The free access to information that Swedish law gives every citizen is one feature that many environmentalists consider more important than educational activity by government agencies as a means of achieving citizen involvement in planning.
67. Roth, op. cit.

PRINCIPLES OF INTERPRETATION

Through interpretation, understanding
Through understanding, appreciation
Through appreciation, protection

– Anon

WHAT IS INTERPRETATION?

INTERPRETATION has been defined in many ways.

According to the Freeman Tilden, interpretation is "An educational activity which aims to reveal meaning and relationships through the use of original objects, by first-hand experience, and by illustrative media, rather than simply to communicate factual information".

York Edwards says, "It is an information service .... a guiding service .... an education service .... an entertainment service .... a propaganda service .... an inspiration service."

Harold Wallin believes, "Interpretation is the helping of the visitor to feel something that the interpreter feels -- a sensitivity to the beauty, complexity, variety and inter-relatedness of the environment; a sense of wonder; a desire to know. It should help the visitor develop a feeling of being at home in the environment. It should help the visitor develop perception."

According to Don Aldridge, "Interpretation is the art of explaining the place of man in his environment to increase visitor or public awarness of the importance of this relationship and to awaken a desire to contribute to environmental conservation."

Interpretation is the communication link between the visitor and the resources - be it geological processes, plants, animals, ecological communities, history or prehistory of man.

Who Is an Interpreter?

An interpreter is a communicator who combines an understanding of natural or cultural history with a love for sharing knowledge and feelings with others. He uses the skills of an actor, teacher, and researcher in communicating information and creating educational experiences.

by Ron Miller

Interpreters are employed at parks and protected areas, historical sites, museums, zoos, and other places where educational and recreational opportunities are offered to the public.

The specific duties of interpreters are as varied as the sites at which they may work. They may, for example,

- conduct educational activities for school groups.
- guide visitors around the site.
- plan and present programmes to the public.
- demonstrate crafts and skills and provide hands-on learning opportunities.
- write articles, television or radio scripts; or design slide presentations.
- design trails, brochures, interpretive exhibits, and signs.
- research flora and fauna or historical aspects of an area.
- administer visitor centres, museums and interpretive services.
- develop fund-raising events and programmes.

> *Interpreters are known for developing skills in a variety of areas to increase peoples's awareness and understanding of cultural and natural resources issues.*
>
> *– National Association of Interpretation*

Effective interpretation is a process in which meaningful interaction takes place among its three main components viz., the protected area/zoo/museum, the visitor, and the interpreter.

What are the intricacies involved in this process?

Perception Each of us sees the world in his own unique way. With the advance of age, we assimilate varied experiences, get to know more and more people with different types of values, and are exposed to new developments in science and technology and historical research. All these change our way of looking at things.

Media Saturation There is an information revolution taking place all over the world. We are getting exposed to various media - newspapers, magazines, radio, television, films, computers, etc. All these are helping replace old values with new ones.

Changing World The world is constantly changing, taking everything within its purview. While some changes are taking place very rapidly, others are taking a longer time frame. No more are the natural resources and conventional energy sources as plenty as used to be earlier. The rapid growth of human population and modern lifestyles has caused a serious threat to the survival of nature and natural resources on our planet.

How can interpretation be done in such an ever-changing context?

Interpretation can be fruitful here only if the underlying principle is understood. That is, the interpter must determine where each of the three components stands at the time of interpretive contact. In essence, the interpreter should know about the visitor, the PA resources being interpreted and last but not the least, himself.

OBJECTIVES OF INTERPRETATION

The objectives of interpretation are:

- To help the visitor in developing awareness, appreciation and understanding of the area,
- To make the visitor's experience enjoyable,
- To create conservation awareness,
- To achieve management goals,
- To help in building public support for the protected area.

Accordingly, to achieve the objectives, interpretation --

Informs about

- what needs protection (animal species, habitat, historic site, etc.)
- why they need protection
- management problems
- research

Satisfies people's curiosity

Creates concern for

- endangered species
- ecosystems

Publisizes the available activities and attractions

Provides orientation

Warns and guides

TILDEN'S SIX PRINCIPLES OF INTERPRETATION

Freeman Tilden in his book *Interpreting Our Heritage* has put forward six principles of interpretation on the basis of which any interpretative programme, will take a proper shape as well as direction. These principles are:

i) Any interpretation that does not somehow relate what is being displayed or described to something within the personality or experience of the visitor will be sterile.

ii) Information, as such is not interpretation. Interpretation is revelation based upon information. But they are entirely different things. However, all interpretation includes information.

iii) Interpretation is an art, which combines many arts, whether the materials presented are scientific, historical or architectural. Any art is in some degree teachable.

iv) The chief aim of interpretation is not instruction, but provocation.

v) Interpretation should aim to present a whole rather than a part, and must address itself to the whole man rather than any phase.

vi) Interpretation addressed to children (say, up to the age of 12 years) should not be a dilution of the presentation to adults, but should follow a fundamentally different approach. To be at its best, it will require a separate programme.

TYPES OF INTERPRETIVE MEDIA

Never fear to use little words
Big words name little things,
Big things have little names, such as life, death,
Peace, dawn, day, night, hope, home.
Use little words in a big way,
It is hard to do but they say what you mean,
When you don't know what you mean, use big words,
They sometimes fool little people

-- ***Bruce E. Kendall***

COMMUNICATIONS is a process of passing any information from one source to a person or group of persons with the hope that the receivers will understand all or as much as possible of the information sent to them.

In order to communicate we have to use media that can carry information to a group of receivers. Communication media are newspaper, magazine, leaflet, brochure, billboard, radio, slide set, motion-picture, television and video.

Since media can reach people in a large number, it certainly has its own impact. Public opinion can be formed through an editorial in the newspaper. Goods can be sold successfully through an advertisement on the television screen. University students can learn a certain subject by listening to a radio's educational programme. One can learn how to do things by looking and following the action in the video programme.

Of these, with the exception of the video, all are external and independent media. Video is the only media over which park managers can exercise some kind of control and decision.

However, within the protected area there are a host of avenues by which the park authorities can plan out their interpretation and conservation programmes.

The internal interpretive media can broadly be divided into two categories:

Attended services

Information desk
Conducted tours or activities
Presentations
Audio-visual

Unattended services

Written material -- signage, publications
Self guided trails
Exhibits
Visitor centre
Audio-visual

ATTENDED SERVICES

INFORMATION DESK

The Information Desk is located at a place easily accessible by the visitor - at or near the park entrance, at the visitor centre, etc.

Visitors to a zoo, being strangers, would first of all like to have information on the what-n-where of the place and other information. They will, perhaps, expect any employee of the protected area to be able to answer their queries. Therefore, all employees must be able to (and be instructed to) handle such queries, even if all they can do is direct the visitors to the proper source for answers.

However, some people may be employed specifically to man the information desk and attend to the visitors' all sorts of questions and enquiries. On the one hand, the information giver provides a necessary service and, on the other, relieves the others of this task. He also creates a favourable impression for the protected area and the organisation.

The following qualities may be expected of the person or persons manning the information desk:

- Pleasant appearance and personality
- Poise and maturity
- Politeness
- Ability to control emotions and keep patience
- Knowledge of the protected area and the organisation's functions
- General knowledge
- Ability to communicate articulately
- Ability to organise
- Ability to work closely with the others
- Ability to work alone under loose supervision

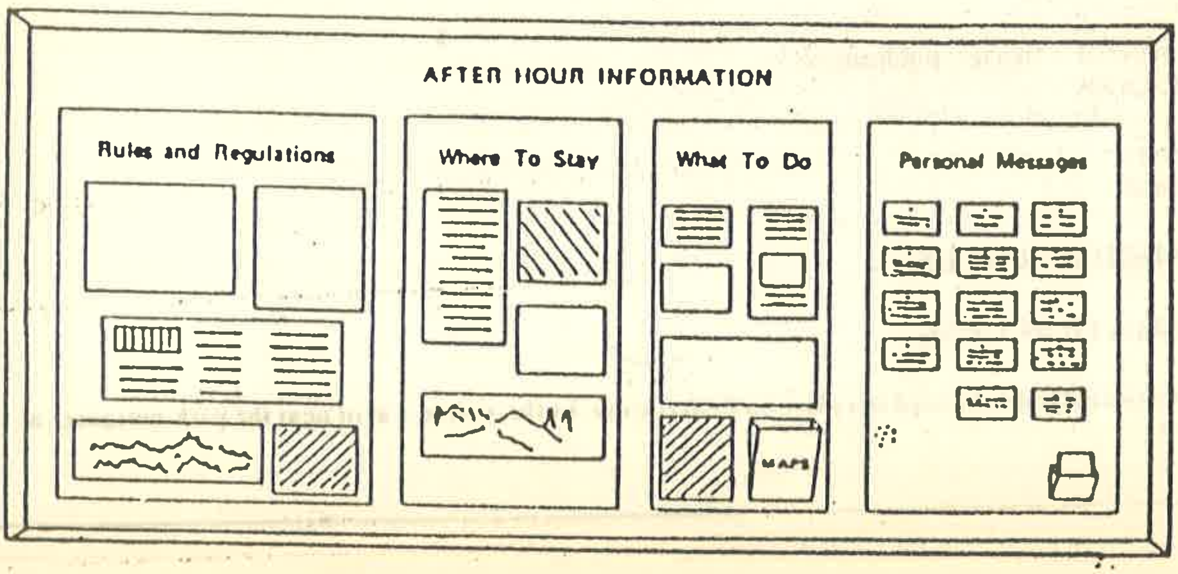
Quite surely, the attributes of being genuinely pleasant, friendly and enthusiastic are important, and the person must be able to keep these in evidence for several hours at a time in the face of what might apparently be mundane questions or, as might occasionly happen, the visitor wishing to register a complaint.

While most of the enquiries at the information desk may be of the "where is it" type, there can be others about the area's natural and human history, about the organisation, its policies, objectives, and facilities, etc. So the person in-charge must be informed on these.

The information checklist must be uptodate. If the visitor is asking for directions, the reply must be precise and to the point. In case of a complaint, listen carefully, write it down and where needed, pass it to the relevant person for proper disposal.

Free publications (as well as priced ones) could be distributed from the information desk.

What about when the information desk is not manned -- e.g. during after-hours. In such a case, a board at the information desk can display the essential requisite information like rules and regulations, where to stay, what to do, maps, checklists, etc.



CONDUCTED ACTIVITIES

Conducted activities are a special type of interpretation. During this, the interpreter takes the visitor through a ... of on-site experiences in a sequence which presents actual features as well as opinions. These include nature walks, hi... elephant rides, automobile tours, boat trips, etc. In all these activities, the objectives are to create awarene... sensitivity, understanding, appreciation and commitment among the group members through direct experienc...

Conducted activity in its best form urges the use of all the five senses by the visitor. It is generally recognised that peo... retain about --

10% of what they hear,
30% of what they read,
50% of what they see, and
90% of what they do.

Making conducted activity effective

Pre-activity

- Arrive at least 15 minutes before the starting time. Greet the visitors and establish rapport with them.
- Start the activity on time.
- Warn the visitors of any danger (if it exists) or likely inconveniences.
- If there are any special restrictions, explain the reasons.
- Describe the activity clearly and briefly - where it starts, ends and the time it will take.
- Explain what the visitor is expected to do, if the activity requires visitor-participation or if it is a field exercise.
- Carry a first-aid kit and be prepared for emergency.

Along the way

- Conduct the group in a way that the activity does not appear to be static.
- When the visitor group is large, reduce the number of activities to be covered.
- Stay in the lead, but keep a pace that is okay for the entire group and is neither tiring nor boring.
- Keep a head count.
- Face the group while talking, make sure all can see and hear.
- Warn the group when to be still and quiet.
- Encourage the use of all the senses.

For effective interpretation

- Establish a friendly relationship with the group.
- Don't take yourself too seriously - no one else does!
- Never place yourself above the visitor - talk with them, not at them!
- Always keep the whole group in mind.

- Be genuine in your communication- DON'T PREACH!!!!
- Explain the purpose of the trip and what can be expected.
- Your information must be easy to understand. Names are secondary, more is gained by telling something about an object.
- Avoid technical jargon except where necessary, and then explain it.
- You have built-in status - the audience assumes your credibility.
- Your information must be reliable. Say "I don't know" where necessary.
- Be inspirational - convey enthusiasm for the subject.
- Your information should stimulate thought. Mere recital of facts is deadening. Ask leading questions; try answering a question by asking one yourself.
- You should stimulate people to see for themselves.

PRESENTATIONS

Presentations would generally mean giving a talk to an assembly of visitors, with or without aids like, slides, charts, models, blackboard, etc. It could be a formal talk from a podium or in an informal atmosphere - or the same talk could have both formal and informal phases. The audience could be a specialist gathering or a mixed one - in age, interest and qualifications.

A good presentation will pass the message clearly and effectively. A poor presentation will not only muddle the message but also not reflect well on the organisation.

What would one need to make a good presentation? Verbal skills, yes -- clear articulation and pronunciation; an ability to translate the technical and complex language of the environment into a non-technical, simple one, without loosing out on information and authenticity. Equally important would be the non-verbal skills like tone, pitch, speed and modulation -- an attempt to converse rather than lecture, be friendly rather than didactic. And, of course, the need to prepare in advance.

The three phases of a talk are --

- *Introductions* -- A kind of lead-in to attract the audience's attention, stimulate their curiosity and desire to hear the rest of the talk.
- *Body* -- The details on the theme, the actual meat of the message and information. Everything the presenter wishes to talk about the subject.
- *Conclusion* -- To wrap up the loose ends, perhaps summarize what was said, and end the talk. May include follow-up information and instructions, where necessary.

For an effective talk

Preparation

- Research your subject.
- Organize your thoughts in an orderly and concise way.
- Prepare a talk framework having a beginning, a body and an end.
- Include new concepts and objects, illustrations or exhibits.
- Don't use too much of jargon.
- Don't memorise your talk. Prepare notes on cards.

Delivery

- Use a friendly and conversational tone.
- Speak with interest and enthusiasm. Don't be over-serious.
- Maintain eye contact with the whole group while talking.
- Use teaching aids.
- Speak loud enough.
- Provide clean breaks between sentences instead of slurring "ah", "and uh", etc.
- Pause to emphasize important points.

Attitude toward the audience

- Be interested in the audience. Enjoy speaking to the visitors.
- Keep the visitors' attention.

General appearance

- Be properly dressed.
- Stand erect and poised.
- Don't fidget around.

AUDIO-VISUALS

Though presentations these days are increasingly being made with the aid of slide displays, we cannot call these audio-visuals. Here, the slides are used essentially to illustrate or clarify some points in the talk.

However, the medium of audio-visuals has quite come into its own, and is being effectively used for dissemination of information. For purposes of interpretation and conservation education, it can be used forcefully. A set of slides is projected, and the presenter talks about what is shown. The essential difference between using slides in presentation, and making an audio-visual presentation is that in the latter, the slides (or the visual) are the more important vehicle of conveying the theme, with words (or the audio) used in a supporting role.

SIGNAGE

Signs are the most widely used method to direct visitors. Good signs help people find their way and prevent tedious enquiries. They furnish interesting information at the wayside and warn, where necessary.

Broadly, there are three kinds of signs -

Directional signs -- These signs show the way to the entrance gates of the area, beginning at the nearest town of importance. Past the gate, they help people find destinations and attractions inside the park.

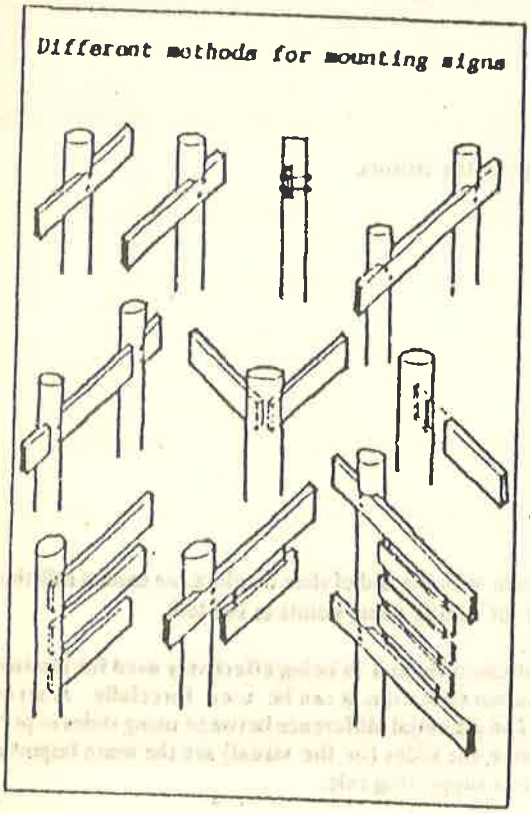
Orientation signs -- These are signs of the "you are here" type, and give instructions or help the visitor orient himself, and comprise entrance signs, area maps and building labels.

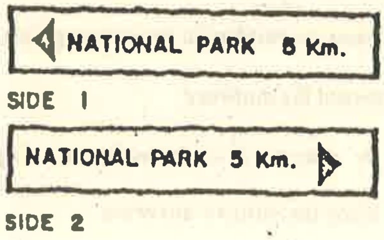
Interpretive signs -- These signs are put up along trails or at scenic viewpoints to draw attention to and explain interesting features and/or convey some conservation message. The simplest type of an interpretive sign is a number sign which refers to text in an accompanying guide booklet.

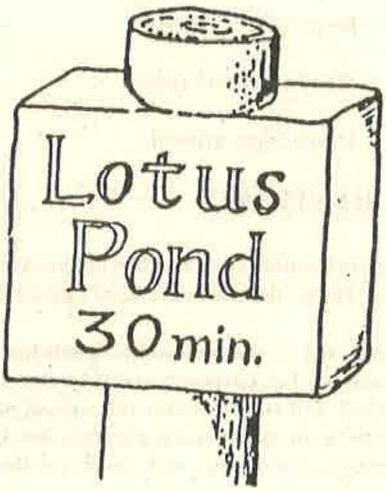
As highly visible products of management efforts, signs deserve more care than they commonly receive.

Planning and designing

Directional signs should be put up at all places where people may conceivably go in the wrong direction. These are necessary at all road diversions, bifurcations and intersections, but should be put up only after traffic flow has been decided. The indicated direction should be unmistakable (use conspicuous arrows). If the sign has to be read from both sides, ensure that the directional arrow is on the left of the lettering on one side and to the right of the lettering on the other. Indicate distances in kilometre or in terms of time needed to cover it.







Orientation signs, especially entrance signs should be large and conspicuous, interesting but not over-elaborate or ostentatious.

Area maps are essential in places which receive many visitors. One map must be placed near the entrance. More might be required elsewhere.

To identify places in the development sites like restaurant, administrative offices, ticket booth, etc. building labels are required. If necessary, these may also carry additional information, like timings. etc. Longer texts like tariff charts or programme schedules are better presented on a separate board.

Building labels can be mounted flat against the building wall or on posts in front of it.

A great proliferation of signs dotting the wayside in some parks and sanctuaries is probably someone's idea of the usefulness of signs. But this is over-killing. The golden rule of signposting is - **Keep the numbers of signs to the absolute minimum.** To avoid putting up superfluous signs one must very carefully decide where they are truly needed and of what kind.

Well designed, functional and sparingly placed signs reflect well on the management. The signage text and layout, as well as construction of other interpretive signs require professional skills. They cannot be made and maintained without skilled craftsmen. A standardized design can enhance recognition and appearance. Tattered, rusty, faded and illegible signs indicate poor management. Therefore, never put up a sign you cannot maintain.

Materials and construction

When choosing materials for signage, cost, ease of construction and durability are important considerations.

Wood and stone are the natural and preferred materials, but tin sheets or plywood may be sometimes necessary especially when large surfaces are needed. Sandstone which is available in many parts of India and which is very durable could be used very effectively.

If you wish to use wood, you don't have to cut timber for it, You could salvage fallen trees and driftwood to build signs which can be attractively and imaginatively done, and which would be durable as well. The heartwood of some species is very resistant to moisture and termites, even without treatment.

The signpost must be anchored firmly in the ground. Its base could even be cemented or grouted in concrete.

If wooden signposts are frequently being damaged by wild elephants, you could improvise and have a stone or wooden slab set into a pile of stones cemented together. This would then become "elephant proof"!

Lettering can be painted on or carved (which is much more durable) into the signboard surface. However, carving is more time consuming than painting and mistakes cannot be erased.

Standardized design

It is always best to have a standardized design. This facilitates message recognition and maintenance. Consider standardizing the following :

Materials -- Specify the signboard and post material (type of wood, thickness of board, size and height of posts).

Language -- Depending on your location, decide which language is most appropriate. Are bi-lingual or tri-lingual signs required?

Lettering style and size -- Must be simple and easily readable. Select a set of three letter sizes to fit various purposes.

A letter height of 5 cm is sufficient for most signs. For longer messages use letters 3 cm high. This is also the smallest size which can be conveniently carved on wood or stone.

Lettering which may be read from passing vehicles should be 7.5-10 cm high.

Letters on large entrance signs may have a height of 10 cm or more.

Symbols --Symbols can make signage easier to read and follow, but choose only symbols which are easily understood by most people and which are not too difficult to reproduce.

Colour -- Bright colours are not in keeping with the objectives of a national park or sanctuary. The colour contrast of signs with red/green background widely used in some parts of India detracts from the text they carry. Lettering should be in a colour contrasting to that of the board or sign.

Consider colour-coding of some information. White lettering on a dark (brown or black) background should be chosen as a rule. Wood can also be stained, while sandstone should be allowed to retain its original colour. If this is reddish or ochre, lettering has to be black in order to contrast.

Tips

MAKING SIGNS EASIER TO READ

- Do not set the text in a solid block form.
- Keep adequate margins.
- Do not capitalize the entire text. Use upper and lower case lettering.
- Use bold or *italic* letters to emphasize words.
- Keep adequate regular spacing between words in a sentence.
- Leave an extra space at the end of a sentence.
- Leave extra space between paragraphs.

Layout

The signboard or post should be placed at easy eye-level. The text must be placed in such a way that it is easy to read and is "visually balanced". Centering the text on the board is the most common method to achieve visual balance, but size of board and text have also to be considered.

Signage record

Keep a signage record which describes all signs and shows their locations on a map. Each sign should be given a serial number under which it is entered on the map. The corresponding description would include text, sign material and date of first posting. This will systematise inspection and maintenance. Ensure that all signs are periodically checked and these inspections should be entered in the record.

AREA MAPS AND DRAWINGS

Maps are important orientation signs. Visitors, having arrived at the entrance gate to the park, would like to take their bearings, know what the park offers and which way to proceed. An area map provides that information at a glance.

Location

An area map should be placed prominently near ticket office or car park at the gate (or gates). The map should be so oriented that for the observer, the entry road on the ground is in the same direction as on the map.

Other than these, a single area map is enough where activities are limited to a single scenic or wildlife viewing drive. If there are a number of distinct activity areas, additional area maps of these sub-units may be required at trail heads or other distinct sub-units of the recreation zone. However, if area maps are not possible to set up in these places because of cost factor or maintenance problems, these maps can be shown as insets on the printed maps of the park.

Information content

Information is shown on the map itself and contained in brief text written on the s. me board. In order for people to remember, information must be minimum and clearly presented. The various individual attractions within an activity area may often be too numerous for an area map to accommodate comfortably so, *don't clutter it with detail.* The attractions offered in these areas are thus best noted not on the map itself, but in the legend.

The pictorial part of the map contains:

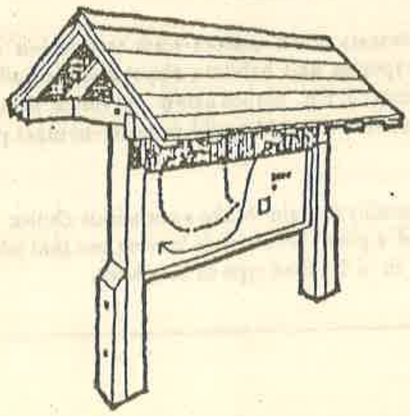
- Position of the map ("you are here")
- Boundary of the area
- Entry point or points
- Parking lots
- Open roads (closed roads are irrelevant)
- Major attractions or activity areas
- Major bodies or water/rivers/streams
- Major amenities (day use area, toilets, etc.)
- Scale/distance

The text part may contain all or some of the following:

- Welcome and/or name of the area. Legend
- Description of major attractions and activities
- Rules for access (e.g. areas open for walking)

Construction materials

The choice of materials offering a smooth large surface is limited. Plywood, readily available in most places, has to be protected from rain and well finished by paint. Acrylic plastic which is not susceptible to weathering and which comes in many colours is expensive and not readily available. Tin sheet can be used if nailed to a sturdy frame, or backed by timber boarding.



The support structure is best made from timber although natural stone may be used where timber is difficult to get. The roof cover can be made of tiles, shingle, thatch, clap-board or bamboo.

PUBLICATIONS

PAMPHLETS AND BROCHURES

With increasing popularity and visits to parks and zoos, more managers will need to produce professionally executed brochures which are attractive and hold the visitors' interest in the protected areas. At some stage of your career you may have to produce a publication on the protected area under your charge.

A pamphlet is produced, first of all, to satisfy an information need. So, you must know who to inform. The information given must be adequate and inform about opening and closing timings, the location of the visitor centre, programmes and activities offered, etc., written in a personal, straightforward style. The information should be presented in logical sequence, with the text interspersed with graphics and illustrations. What about the map? The recommendations/requests should be explicit and unambiguous. The pamphlet may also carry an address, which the reader can contact if he wishes to.

You may produce a pamphlet yourself if you have no budget or as a practice exercise. Ordinarily, you leave the job to professional writers, designers and artists. Nothing left for you to do?

Far from it. You supply the information to be conveyed, specific points to be made, instructions, credits, photos, maps, a description of the people the pamphlet is meant to reach. You depend on professionals to produce it but it's you who would be responsible for the final product.

A professionally done attractive pamphlet also reflects well on the image of the issuing agency and the people involved in its production, including you.

Brochures are a more voluminous version of pamphlets, advertising the attractions of a national park or sanctuary with the help of pictures, maps and text containing highly condensed information.

Broadly, there are three kinds of brochures --

- *Brochures which promote visits to an area and help people plan the visit*

  These introduce the major attractions of the area. Information about type and location of access, best season to visit, opening and closing timings, accommodation and booking procedures is given. An overview map shows the wider region around the park and the main roads, nearest railway stations and airport. Examples of such brochures are brought out by the tourism departments or tour operators.

- *Brochures which provide information about attractions and activities, and help the visitors find their way around in the park*

  Brochures of this type give a more detailed description of points and areas of interest and list the available types of activities. Rules and timings are given. A map shows entry points, accommodation, trails and roads, and attractions. It happens frequently that brochures of this and the former types are combined into one but there's always the possibility of maps becoming difficult to read, the text becoming very crowded and information incomplete.

- *Brochures which inform about specific activities or attractions in more detail*

  These brochures, called theme brochures, may become necessary when visitors want to find out or the park authorities wish to give more information about certain species and habitats, about historic buildings, or about certain activities which are to be highlighted and promoted, e.g. nature camp. At times, these may well turn out to be booklets rather than brochures, in which case they should be sold in order to meet part of the production cost and also curb wastage distribution.

Resist the temptation to pack a brochure with all the information it can possibly contain. Make a conscious choice about text which *has* to be included and which *might* be included. The secret of a good brochure is leaving out that which is less relevant and appropriate. Species lists are not appropriate except in a detailed type of brochure.

Determine how many copies will be required for one season and how they will be issued - sold or handed out free of charge. Note the approximate budget appropriations to be made. Consult the printer to determine cost for different size runs.

There are many advertising and designs agencies all over the country which take on design and production of the pamphlets and brochures on a professional basis.

Supply them with the information and the specific messages to convey, maps and pictures and a description of the people the brochure is meant to reach.

NATURE TRAILS

Trails, perhaps, are the best way to acquaint the visitor with the forest and its environs. They enable the person to see, hear and feel first-hand the flora, the micro-fauna and, hopefully, the larger wildlife. There is no better way to experience wilderness than while taking a trail on foot, alone or in a small group. Trails add variety to the visitor programme and bring visitors into closer contact with nature. If provided with interpretation they have considerable educational value.

Except those in the high altitude region, most of the protected areas in India do not allow travel on foot. The reasons are the high adverse impacts, the difficulty in controlling such movement and the inherent hazard to human life in wildlife areas. Generally travel on foot is restricted to specific routes or trails.

Some parks offer elephant rides but generally park visitors, often with a large group, enjoy wildlife and scenery from inside a vehicle. Viewing wildlife from a car or *machan* is sometimes the only permitted activity.

Short (up to one hour) and easy trails in the vicinity of day use areas or overnight accommodation can be established as self-guided trails. Sometimes one hour may be too long for people unaccustomed to walking in the forest. A graded series of trails (30 mins, 45 mins, etc.) should be considered.

If trekking trails require several hours of strenuous walking or even overnight stops, then on such trails visitors may have to be accompanied by an official guide.

Planning and constructing a trail

- Survey the areas having potential for nature trail. A good trail leads past pleasant or spectacular scenery, e.g. forest glades, panoramic views, cliffs and gorges.

- Prepare an inventory of possible interpretive themes.

- Points of interest e.g. exceptionally old stands of trees, animal burrows, large termite hills, old clearings, caves, nesting sites, oxbow lakes, waterfalls, maintain interest and lend themselves to interpretation.

- Join the resource points by a foot track (not more than four feet wide) and indicate them by markers and numbers.

- Consider the length of the route and time it will take to cover. It should be normally between 1 to 2.5 km and should take from 45 minutes to 2 hours.

- Avoid steep and slippery ascents, mud and swamps or difficult stream crossings. If a short stretch of waterlogged ground cannot be avoided, raise the trail surface by filling with soil or gravel. Other obstacles should be negotiated by building wood or stone steps, boardwalks and bridges. Over short distances, the more expensive boardwalks can be considered. But over long stretches these can be costly and substantially increase the maintenance burden. Choose a trail route so as to skirt steep ravines or cross streams at shallow places where stepping stones would be sufficient.

- Avoid firelines or long straight stretches. Do not disturb or remove anything from the trail unless absolutely essential in the interest of comfortable trail use. Trails can easily lead around obstacles.

- On reasonably dry and level ground it is not necessary to give special treatment to the trail surface. Do not make the trail appear artificial. The trail edges may be marked with rocks but grass, moss, or fallen leaf need not and should not be removed.

- Impress upon the workmen that under no circumstances should timber or saplings right next to the trail be cut.

- Avoid building the trail where it will obviously become an artificial stream bed. Anticipate waterflow and divert it off the trail before enough can accumulate to do serious damage.

- People must be able to easily find the starting point of a trail by a prominent sign.

- Once on a trail, people must be reassured by direction and distance markers at intervals of 50 to 100 mts. Paint markings on rocks or trees are the easiest ways of doing this. Wooden posts sunk in the ground are better.

TRAIL INTERPRETATION

Managers frequently complain that the majority of visitors to parks and ... zoos are seeking thrills: that only a close encounter with large wildlife species will satisfy them. Howsoever true, this is partly due to lack of suitable interpretation which can maintain a visitor's interest even if animals are not seen. Trail interpretation is drawing the visitors' attention to features along trail or viewing routes and explaining them.

Encourage people to look for and see the seemingly insignificant detail. Help them discover the amazing world of micro-fauna and flora, examples of mimicry and adaptations in nature. Highlight interdependence and relationships between plants, animals and abiotic ecosystem components, that will give the visitor an insight into the inherent resilience as well as the fragility of the natural systems.

One often finds labels with local and scientific name stuck to trees. This, it must be stressed, is not interpretation. The interpretation of a tree would say something about its wood, how much water it evaporates, about its seeds or about the animals that live and feed on it. Interpretation should satisfy people's natural curiosity. Therefore interpret what is conspicuous, that which people would ask about if they had a guide. At the same time, draw attention also to the inconspicuous, e.g. how ants and termites are important links in the recycling of organic matter.

Trail interpretation can broadly be divided into -- the general subject and the special theme, according to the character of the trail.

General subject trail -- You interpret whatever seems worthwhile. The features interpreted are not linked to each other by any common theme.

Special theme trail -- On this trail all the interpreted features are linked by a theme. This would depend on the features present, the interpretation they lend themselves to, and the conservation message that we wish to convey. For example, the themes could be:

- Life in a stream
- Forests protect soil and watersheds
- Birds of the seashore
- Past and present misuse of the land
- Habitats, vegetation type of XYZ
- Seeds and their adaptations
- Fig trees in a rainforest ecosystem, etc.

Methods of trail interpretation

Trails can be interpreted through:

Printed handout -- A sketch map with interpretive resources marked, and to help the visitor orient himself. The text of the handout refers to easily recognizable features along the trail or to station numbers.

Wayside exhibits -- These are symbolic or representative picturisation of the feature, along with interpretive text. However, waysides are expensive, difficult to make and maintain.

Guides -- One or more guides can be appointed to accompany the visitors on the trails. This would be especially mandatory in the more sensitive or hazardous areas. However, for economic or other reasons, even if trained guides exist, they cannot be made available for every group.

Handout Examples

...ERAL SUBJECT TRAIL

- Fallen trees pro... ...for many animals. A monitor lizard uses this one. Others may be inhabited by porcupines or cover the entrance to a hogbadger burrow.

- Porcupine signs are often noticed on the following 100 m of the trail. Look for footprints and drag marks ... ...tail quills. The cigar-shaped droppings are about 5-6 cm long and pointed at the ...

- What do you notice when you compare both the river banks? This side, within the national park, is covered with vegetation and therefore stable. The other bank is caving in and washed away by the river because there is no vegetation, probably removed by people and livestock.

- Fig trees provide food and shelter for a lot of animals: monkeys, gibbons, civets, birds, bears, pigs and deer. When the fruit is ripe, animals congregate in large numbers and it becomes an excellent place to watch wild animals. This is why the trail is open only on special permit for about four weeks in April/May for people to view from the hide.

- About 100 m past this station you will come out at a forest road. Turn left on this road and after about a 5-minute walk you will return to the starting point of the trail.

- We hope you enjoyed the walk. Please come again.

SPECIAL THEME TRAIL

Acquatic Life in Thanda Pani Nul...

Introduction
The trail starts at the small bridge near the Information Centre. Follow the arrows up on one side of Thanda Pani Nullah and back on the other. About 30 min. leisurely walk.

Attached to this handout is an illustrated checklist which will help you identify some of the creatures found in the stream. Glass bottom boxes for underwater viewi... ...re available against a deposit.

Stream Environment
Where the stream is narrow, the water flows fast and the s... cannot settle. Where it becomes wide, the current slows and allows suspended sand to settle. Sand contains no nutrients and is not very stable. The sandy areas you see support very little life. Most of the small creatures in the stream live in or near water weeds, dead leaves, wood or among the pebbles and rocks washed by the swift currents.

Walk slowly and try to find the fish, amphibians and insects in the stream against the checklist. Note which environment they prefer. You can easily discover seven different species and even ten or more if you are a good observer.

Please do not attempt to catch the animals. Help us keep the stream banks clean. Throw all papers, cans and plastic bags into the rubbish bin at the trail head. Thank you.

EXHIBITS

An exhibit is a device which publically displays text, photographs, illustrations and objects. It is a visual medium, but may at time use sound and, in some instances, even allow the use of the sense of touch. As a means of communication and message delivery, the aim of the exhibits is to get the visitor to --

- stop in front of it, and
- remain long enough in front of it and ponder over it.

The main advantage with exhibits is that they may display real and original objects -- an antler, a skull, a forest produce or just about any memorablia. The value of a real object over its pictorial or textual description is immense.

Exhibits also allow the visitors to move through an interpretive experience at their own pace, and pause at their convenience around exhibits that interest them.

Another advantage is that they allow the outdoors to be brought indoors, and the large to be reduced or the tiny to be enlarged to tell the story.

Within the protected areas, exhibits are displayed in the visitor centres or other such public-use areas. However, exhibits can also be mobile, which allows them to be carried and displayed in - for instance - conferences, fairs, outdoors, when required.

Generally, there are four kinds of exhibits --

- **Objects or three-dimensional exhibits**
  Here the use of the object, one or more, itself gives the third dimension to the exhibit. These objects for public display are kept within glass or other protective cases. Various devices like mirrors, light beams, or spotlights, magnifying glasses, etc. are used to draw the viewer's attention.

- **Flat work or two-dimensional exhibits**
  These are sketches, illustrations, photographs, maps, detailed artworks, etc., supported by narration and put up on a flat board against the walls or in the flip-board or chart style.

- **Dioramas**
  These are another type of three-dimensional exhibits, using carefully moulded or carved figures (miniatures or lifesize) and objects in the foreground which merge into a curved, painted background -- thus giving an illusion of depth. The objects and the background painting are complementary to each other. Use is also made of audio devices, adding to the effectiveness of the exhibit.

- **Models**
  These are generally miniaturised representations of objects or maps. There can be a topographic models of the protected area, displaying the park terrain, forest or other large land area. The models are not small so as to show as much details of roads, streams, lakes, etc. as possible, but they are not so large either that they place the viewer too far from the centre to see much details.

The factors important in setting up exhibits are --

- Location
- Mobility
- Safety from vandalism and theft
- Viewing distance
- Accessibility to electricity
- Exhibit materials
- Design and layout
- Storage and maintenance

For outdoor exhibits (wayside or roadside), the added considerations would be --

- Light
- Rain or moisture
- Other elemental and climatic factors

VISITOR CENTRE

A visitor centre is a built location where a visitor to the protected area might like to be when he's not outdoors, on the trails or elsewhere. The centre provides him refuge as well as assistance and information, complementary to what he sees or does in the park outdoors.

Objectives

A visitor centre will have all or some of the objectives listed below. Examine each objective in turn. Has it been addressed by different methods? Will the visitor centre lead to a significant improvement in attaining the objective? etc.

- Inform arriving visitors about what they can see and do.
- Provide a focal point for activities and services related to the public in the protected area.
- House a workshop for display, manufacture and maintenance work.
- House an exhibition room to increase people's interest in and understanding of the area's value by providing information through displays and exhibits about its history, ecology, habitats, wildlife, research and management problems.
- Increase public concern over nature conservation in general and regional/local conservation issues in particular.
- Entertain and educate visitors in the evenings or during the hot afternoons.
- Provide an outlet for the sale of local arts and handicrafts and park publications.
- Accommodate the office of education officer and his staff.
- Public toilets

Optional components

- Library-cum-reading corner
- Discovery room for children
- AV equipment and store
- Auditorium
- Amphitheatre
- Large covered porch for rest and enjoyment of scenic view

Only the most sophisticated centre would have all of the above mentioned. A visitor centre is one of the most expensive facilities in a [illegible] zoo.. If operated and maintained properly there is a high annual recurring cost. Both capital and recurring cost need to be related to expected use. If it turns out that, over a period of five years, the cost of a single use hour is Rs.15 or more, one may consider a more moderate design or a more cost-effective facility. To reduce expenses some functions can be combined, e.g. staff office and AV equipment store. Each centre requires staff ranging from cleaners and attendants to skilled craftsmen and trained communication experts to use and develop the facilities.

The fundamental steps in planning a visitor centre are --

Site selection

Zoo management should pre-select several sites. These can be inspected together with the architect before deciding on a final site.

The site for the visitor centre should be within a development area of the tourism zone. Suitable sites may also be found outside the zoo as long as they are located so that the visitors have to pass it on the way. Most visitor centres will be near the main gate or a day use area or the tourist accommodation complex if there is one.

The potential site should also be chosen for its scenic qualities. A centre built on a high land overlooking a meandering river, in a grove with stately old trees, or next to a waterfall will be much more attractive than one built in nondescript surroundings.

Although, by judicious planting, the shortcomings of a site can be covered in time, the possibility of improvement through planting up should not be used as an argument to justify the choice of an inadequate site.

Design

Anybody can order a visitor centre "off the shelf" from any architect with relevant expertise but there is the risk of getting a grandiose design half of which will lie unused. It is important to be clear about the purpose of the centre. This will also enable a park manager to meaningfully interact with the designer before the work on it begins. How many visitors can we expect to have in the building at any one time? Do we have enough literature for sale to warrant a sales desk? Such questions need to be answered before and during the design stage.

The designer must be informed about all essential components which are to be incorporated before he even begins to plan architecture.

The visitor building is a highly visible structure which, nevertheless, should blend in with its natural surroundings. A good architect will adjust the design to land contour and vegetation, and plan around the standing trees or rock outcrops instead of removing them or levelling the building site.

Design is also influenced by climatic conditions, the type of equipment to be used as well as the nature and size of exhibits, if any. Airflow, lighting, wall space and ceiling height have also to be considered. An adaptation of the local architectural style often yields the most pleasing and cost-effective designs.

There should be a minimum use of "cold" materials, e.g. steel and concrete, corrugated iron and plastic. "Warm" materials, like brick, clay roof-tiles, sandstone or slate, natural rock, bamboo, timber, thatch, even cowdung plaster, are preferable. Designs should be such that the need for artificial lighting and air conditioning should be none or minimum.

Makeshift or temporary visitor centres

A full fledged visitor centre requires a substantial budget and staff to operate it. If your budget does not allow a proper visitor centre or there are other constraints for the present, consider alternatives, e.g. an annexe to the ticket office with information about the attractions and activities offered, a temporary exhibition set up in native style buildings or the conversion of an unused park building. Occasionally rooms in a historic building can be converted into adequate visitor centres.

AUDIO-VISUAL

As an unattended service, audio-visuals essentially mean video programmes. These are centrally controlled programmes to be viewed on monitor screens placed at vantage locations in a visitor centre, museum or other such indoor areas which receive visitors. Detailed information on how to make video programmes is discussed in Session VIII.

SLIDE-TAPE SYNCHRONISED PROGRAMME

A well presented slide-tape combination, commonly called an audio-visual presentation, can be a very effective medium of communication of our message. The visuals and the soundtrack together communicate more effeciently than either can perform alone. The combined impact of the visual and the audio stimulus where one reinforces the other, makes slide-tape a very forceful medium.

These remarks may seem obvious, but all too frequently we see programmes that completely ignore this important characteristic. In the extreme, the finished product is either a series of 'pretty' pictures to which the sound-track adds very little, and can indeed intrude upon aggressively, or the programme becomes a talk to which the visuals have only a vague relevance in which case they merely remain a presentation.

Usually an unsuccessful slide-tape is the result of inappropriate initial planning. Sometimes, a series of pictures is shot or collected 'off the cuff' and then a soundtrack is prepared around the pictures. Worse, and more common, is the enthusiast who writes a wordy script thinking purely in terms of the story he wants to tell and then calls upon the photographer to fit pictures to his words. He has forgotten that a large share of his story will be told in pictures so the outcome is jagged and ineffective.

The storyboard technique

The most practical approach to preparing a slide-tape presentation is to use the storyboard technique which encourages us to think in terms of both visual and sound together. This is simply a series of thumbnail sketches of the pictures with a brief caption written underneath as a guide to the content of the soundtrack. Something on the lines of a strip cartoon except that you don't need to be a skilled artist. Simple pin figures or even a written description of the visual will suffice. The purpose of the storyboard is to help us get away from our normal habit of thinking in words and instead to think in terms of pictures. The storyboard emphasises that the picture makes the initial statement and then the soundtrack makes that statement more specific. Planning a programme by this method is the one sure way of determining close harmony between the audio and visual channels.

Neither difficult to prepare nor inconvenient to carry around, slide-tape is such a flexible medium that it can be successfully applied to a wide range of programmes from pure entertainment to those concerned with instruction or motivation.

The following basic plan of campaign can be adopted step by step:

Step 1: TREATMENT
Briefly outline the theme and content of the programme. Ensure that slide-tape is the appropriate medium for the subject, and determine the eventual form of presentation.

Step 2: STORYBOARD
Translate the outline into visual terms with simple thumbnail sketches and concise written notes as outlined above.

Not until these two planning steps have been completed should the next three practical steps be taken.

Step 3: GATHERING PICTURES
The storyboard is sufficiently detailed to guide the cameraman in specific viewpoints, type of shot, the style of photography, etc.

Step 4: GATHERING SOUND EFFECTS
The sound effects may be natural sounds taken on location or 'stock' sounds from records but don't overdo them. Differentiate between general background sounds and particular sounds.

The role of the zoo in wildlife education and conservation.

by

Phillip Coffey,
Education Officer, JWPT

Millions of people visit zoos every year, attracted by the opportunity to see live animals at close quarters. Principally, they go for a day out, for enjoyment, but their very presence represents a challenge that zoos should try to meet. We have the opportunity to influence their attitudes, to enhance their understanding and appreciation of wildlife, to interpret the factors which threaten the survival of animals and their habitats and to convey the zoo's role in captive breeding and research. Today, there is increasing pressure on zoos to provide justification for keeping animals in captivity. Conservation is one reason; education is another - probably the more important of the two. Because, if we are going to conserve wildlife in the long term, we need the help of an informed and caring public. Education is the key.

We have to decide what message we want to convey and this has to be a corporate message from the zoo as a whole. Then we have to think about our audience whether it be: families, school children, university groups or individuals. The approach will vary according to the need and different media will be employed, such as: signs, zoo guides, films, the use of volunteers and hands-on experiences.

There seems to be a growing demand to include natural history and environmental education in schools' curricula in many different countries. Zoos have a part to play and should link in directly with the needs of teachers. We can help to teach science skills and therefore help to mold the next generation of scientists and of well-informed adults.

Through the use of imaginative education programmes that focus on the local environment and its problems, zoos can raise the communities' level of environmental awareness and make them ask, "What can I do?" and hopefully, lead them in the direction where they can do something personally.

This local awareness can be used to develop a concern for the total environment and its associated problems; that is, the acquisition of a global ethic which is environmentally positive. In the much quoted words of Baba Dioum of Senegal;

**"In the end we will conserve only what we love.
We will love only what we understand.
We will understand only what we are taught."**

MISCELLANEOUS

ENRICHING THE LIVES OF ZOO ANIMALS: WHERE RESEARCH CAN BE FUNDAMENTAL

Michael H. Robinson
National Zoological Park,
Smithsonian Institution, Washington D.C. 20008

"It has been realized that the extraordinary interest shown by the public in collections of living animals should be used to excite interest in everything concerned with the life of animals. In short, the didactic responsibility of the modern zoo extends much further than that of the ordinary museum - and the fulfillment of this responsibility is urgent...."

W.K. Van der Bergh. 1962

INTRODUCTION

The subject of enriching the lives of the animals in their collections is one that looms large in the minds of most zoo directors and animal care staff. It is something that springs out of our very *raison d'etre*. We are dedicated professionals, intellectually and emotionally involved in a passionate love of animals. Many of us are also biologists, and a substantial number of those of us who are organismic biologists became interested in science by way of enthusiasms for pet-keeping or natural history, or both. These interests may reflect an ancient atavism, born of the history of our species and its origins in an overwhelmingly long period of closeness to nature. Hominids were hunter-gatherers for 99%, or more, of their existence. Barefoot biology is built into our psyche. Add to this an appreciation of the perfections of evolutionary adaptation, ecological and ethological specialization, and the sheer beauty and wondrous nature of the living world and one uncovers the profound roots of the *biophilia* that moves us to dedicate our lives to bioeducation and conservation.

The lure of biophilia is very powerful. It is a subject that cries out for anthologizing testimonies to its force in moulding and moving the minds and actions of many people.

The self-generated pressure to enhance the lives of the creatures that we care for in our zoos, arising from these roots of commitment, is constantly seeking outlets. In addition, many of us believe that zoos, along with other bioexhibits, exist to propagate not just living species but biological and scientific literacy in the interests of conservation and culture. We wish, as evangelists on behalf of the battered and endangered biosphere, to to spread the ideas that illuminate and inspire our lives and give them meaning. For many of us, engaged in this struggle to save the future, the best testaments are those of our exhibit animals **if they are seen** by visitors as exquisite creatures doing exciting and intriguing things. Markowitz (1982) put this point with quiet simplicity: "From the standpoint of the zoo visitor, it increases excitement to see an animal in a natural setting, and it certainly contributes to the educational experience when plants and terrain similar to those native to the animals home in nature can be included. However, much of the *beauty of most species involves their behavior*, not just their "backdrop", coloration, and physical features." (my italics). In short we can powerfully reinforce our message if we enhance the lives of our animals, so that they do things other than retire or sleep.

Such a process clearly involves removing negative messages. Opposition to zoos, now vocal and organized in many parts of the world, stems from several concerns, intellectual and emotional (see for instance Robinson 1991b, 1992b). Some of the negative messages derive from ignorant preconceptions or naive anthropomorphisms. Others are based on perceived or real aberrant behaviors, seen in some species, under some conditions. Both the perceived and the real have been lumped together under the term *zoochosis,* described as: "a term used by behaviorists to describe mental illness in animals caused by the stress of captivity" (PETA 1993). This has become a particular focus for attacks on zoos by Zoo Check in the U.K., and by its U.S. allies. (It is noteworthy that to classical Behaviorists the term mental illness is sheer anathema when applied to animals.) If zoos are to function as important vehicles of education these attacks have to be mitigated so that their opponents, with the exception of the absolutely intransigent, can see that these criticisms are distortions. For this reason, too, we should concern ourselves with ensuring that our animals are as behaviorally healthy as they are physically at their peak.

HISTORY

The great pioneer in the field of enriching the lives of zoo animals was Hediger (1955, 1964, 1969) long before the terms behavioral enrichment and environmental enrichment were in use. He was keenly aware of the need to consider the ecological and behavioral needs of animals in zoos, and the urgent need to study them. His analyses are pioneering and remain an inspiration to us all. However, many subsequent treatments of enriching the lives of zoo animals are frequently pragmatic, concerned with problem-solving, and without any specific theoretical underpinning. Hutchings et al (1978-9) deal at some length with the use of *behavioral engineering* (then a buzzword) in solving the problems of behavioral enrichment, opposing this solution and (1984) arguing the case for using nature: "as a model to formulate an alternative approach to zoo management which we feel is more appropriate, less expensive, and has a greater potential for solving the behavioral problems of captive animals." Chamove (1989) reviews rather broadly the subject of behavioral enrichment but concentrates on particulars rather than precepts. Eisenberg and Kleiman (1977) argue that: "there are too many species that have been maintained unsuccessfully in zoos, the failures in part resulting from a lack of knowledge of the species natural history."Although advocating the use of natural history data in enhancing zoo exhibits, many of the examples of enhancement that they cite have their origins in captive studies, including the observation of abnormalities. Tudge (1991) reviews examples of relatively simple pragmatic changes in zoo exhibits and comments: "Nothing smaller than a national park could truly simulate the wild..." In a more extended treatment (Tudge 1992, 192-240) he deals, at length, with the interpretation and analysis of behavior before moving into the subject of behavioral enrichment. There he very perceptively recognizes a fundamental dichotomy in past approaches to this subject. One, attributed to Hagenbeck, is the creation of naturalistic-*looking* habitats (in zoos); the other attributed to Yerkes, is the approach solely concerned with the welfare of the animals (in research establishments), and not the *appearance* of their environment. The one tradition produced what might be called a human-viewpoint-based 'naturalism', the other produced solutions based on apparatus (very much in the style continued by Markowitz). In fact there is here a dichotomy, which may or may not be fundamental, that can be seen as based on the theoretical constructs of experimental psychology (apparatus), rather than of ethology or 'natural' behavior. This is often not stated in such terms but it may be heuristic to categorize it this way. Hyperbole is often provocative. Chamove (1989) goes so far as to state: "the study of enrichment may be viewed as a conceptual extension of past research investigating the effects of early experience on the development of behaviour". (In passing it is interest to compare this dichotomy of approach with a parallel case in the evolution of museum exhibitry. In museums, one style is the tradition of the diorama and carefully crafted behind-glass natural-looking exhibits, and the totally different approach seen in the new tradition of the *exploratorium*, where exhibits function as apparatus to be used by visitors.) More general reviews often fail to systematize the range and complexity of the issues involved. The largest single publication on this subject, that of Markowitz (1982), devotes only 15 pages out of 210 to introducing the topic and raises only one major theoretical construct (that I can discern) that of whether *naturalness* is a desirable quality in solutions to behavioral deficit problems.

In this context it is worth considering the relevance of the concepts of classical ethology. Morris (1970) characterized the difference between the methodology of ethology and that of experimental psychology, in an extreme and oversimplified form, by suggesting that ethologists asked "not what we can make animals do, but what do they do? Instead of applying a simple stimulus to produce a simple response and then varying the relationship between the two, in the manner of animal psychologists, we set out to observe the response of a particular animal to as wide a variety of natural stimuli as possible". Although this something of an exaggerated, and even outdated, antithesis, the insights of ethologists can usefully illuminate the approach to environmental/behavioral enrichment. I have reviewed (Robinson 1989, 1992a) the views about zoos and the condition of animals in them expressed by some of the leading figures in classical ethology. For instance, Morris (1968) very usefully categorizes mammals as either specialists, or non-specialists. Of course this is an oversimplification since there is clearly a broad spectrum between these extremes. However, despite the simplification involved this is a very useful concept. Morris (ibid) comments: "The specialists are those animals that have put all their evolutionary effort into one survival trick"."The non-specialists, on the other hand, are forced to live the lives of opportunists, forever investigating, forever on the move." "The opportunists are precisely the animals that find the sterile, restricted life of the zoo so frustrating and damaging. The nervous system of the opportunist seems to abhor inactivity. And inactivity is just what the zoo cage has to offer." The consequences of being a specialist, Morris argues, is that the animal has relatively simple needs and if we satisfy them, then it is happy. Examples are Koalas, Pandas of both kinds, anteaters, and grazers of grass. Give a Koala eucalyptus leaves and it is well-satisfied, it does nothing for hours on end. In fact wild koalas often look like children's stuffed toys, immobile and inscrutable. Pandas eat bamboo and do little else. Observations of wild pandas suggest that their time budgets are very simple. For instance, Schaller et al (1985) found that Giant Pandas spend nearly 96% of their time either resting or feeding and only 2.1% of their time travelling! Provide an anteater with food and it relaxes, give a grass eater lots of grass and it does not get restless, and so on.

Lorenz, in his glorious book *King Solomon's Ring* (1952), saw essentially these same problems with zoos, he remarks "in larger zoos one will frequently find that people are in the habit of wasting sentimental pity on animals that are absolutely contented with their lot, while genuine suffering....may pass unnoticed." Further he asks the question" which are the animals that are really to be pitied in captivity?" He then lists animals that clearly belong to the category Morris calls generalists/opportunists.

What are these? The examples that Morris quotes are: dogs and wolves; raccoons, martens and mongooses; the monkeys and the apes, and of course, humans. These, and similar animals can be a remarkable challenge to us all, one that we in the zoo profession have already gone some way towards meeting. For most species, there is probably nothing insoluble about the challenge of the opportunists given time, money and good research. How Tinbergen would have appreciated the essence of this behavioral enrichment challenge! He called his collected works, published in two volumes in 1973, *The Animal in its World*. It is still the essence of ethology to discover and then define the world in which species live; it is the role of those of us responsible for the care of animals in zoos to provide the animals with *their* world. For this we need to strengthen ethological studies so that we can identify the components of habitat that animals attend to. An analysis of articles in journals dealing with zoo biology, animal behavior and ethology shows that studies of the reactions between species and their environment are in a small minority compared to studies of intraspecific or social behavior. This is highly regrettable. If Niko's example and precepts are to persist, studies of species cannot ignore the analysis of those components of their environment to which they respond with important and complex behaviors. We know so little about this. We do not even know what components of the *mileau exterior* are essential for a full and 'happy' existence for most species. We guess at these things or adjust them by crude trial and error; we seldom study them logically or systematically. In fact we probably know more about housing farm animals, based on scientific study, than we know about the environmental needs of wild animals. This must become an area of concentration and for crucial research. It can lead us to better zoos, it will almost certainly enhance our conservation efforts, and lead to a wider appreciation of our world.

In 1990 the IUDZG conference in Copenhagen highlighted the subject of *Zoos and Behaviour*, and produced a number of exciting papers on behavioral enrichment. Since then the subject has moved rapidly into the limelight and there has been, this year (1993) in Portland an entire symposium on this matter, which unfortunately I did not attend Despite my ignorance of the proceedings, and possible repetition of the views expressed there, I think the subject is worth revisiting. A few of the major issues involved are, I would suggest, the following:

1. What precisely do we mean by enrichment?
2. Do we have adequate data (ecological, ethological, psychological or based on zoo-studies) to act from some sound basis?

3. Whatever the answer to that question, to what extent do we use field data on habitat requirements and behavioral needs in designing exhibits, or, alternatively how much of the progress so far is dependent on simple tinkering pragmatism?
4. What kinds of research should we be doing in this area?
5. How important is naturalism in enriching zoo habitats and the behaviors of zoo animals?

The subject is so vital to our future that any redundancy of approach is no detriment, and probably not a problem. I think that this is a field awaiting review and that some formal schematization of the issues at stake would greatly help to clarify both the basic problems, and additionally, some of the problems arising from some existing attempts to provide enrichment. This is really the basis of this paper. It is intended to stimulate and provoke and I make no claim that the treatment is exhaustive.

TOWARDS A THEORETICAL BASIS FOR STUDYING ENRICHMENT

One way to deal with complex questions of this type is to start by defining the issues involved. Here is an attempt to do so by classifying them.

1. What **ecological** needs do given species of animals have when maintained in zoos?

Subsumed under this question are several subsidiary questions:

(a). What are our sources of knowledge to make these determinations; how reliable are they; what can we do if the necessary data are absent; are there species whose needs are predictably easier to assess than others; and so on?

(b). How fixed are these needs; do they vary within species, between populations; if so why; do they apply only to wild-caught individuals; do they diminish or disappear in zoo-bred animals; can they only be satisfied by naturalistic approaches, and so on?

(c). How are the ecological needs of one species related to those of others that may be kept in the same exhibit?

(d). What role do people (keepers, other staff, and visitors) play in the ecology of zoo animals

(e). Do people's perceptions of ecological needs differ from reality; can these needs, and false perceptions, be used as bases for educational programs; and so on?

2. What **behavioral** needs do animals have that should be satisfied in the zoo environment?

Subsumed under this question are several subsidiary questions:

(a). What are our sources of knowledge to make these determinations; how reliable are they; what can we do if the necessary data are absent; are there species whose needs are predictably easier to assess than others; and so on?
(b). How fixed are these needs; do they vary within species, between populations; if so why; do they apply only to wild-caught individuals; do they diminish or disappear in zoo-bred animals; can they only be satisfied by naturalistic approaches, and so on?
(c). How are the behavioral needs of one species related to those of others that may be kept in the same exhibit?
(d). What role do people (keepers, other staff, and visitors) play in the ecology of zoo animals
(e). Do people's perceptions of behavioral needs differ from reality; can these needs, and false perceptions, be used as bases for educational programs; and so on?

3. Are there some **species which it is impossible to adequately exhibit** in terms of ecological and behavioral needs?
Subsumed under this question are several subsidiary questions:

(a). What kinds of data are available to make such determinations; are they based on field observations or on analyses of zoo-based behavior?
(b). Can we predict which categories of animals are most likely to present insoluble problems (for example of such generalizations see Morris 1968)?

4. What is the **importance and role of "naturalism"** in satisfying the environmental and behavioral needs of animals in zoo conditions?

Subsumed under this question are several subsidiary questions:

(a). How far is it desirable to use non-natural functional substitutions for components of environments?
(b). How far is it desirable to modify the behavior of zoo animals by conditioning (or other behavior-modification paradigms) so that natural motivational systems are given non-natural outlets.

Ecological needs

Data

The ecological needs of an animal are part of a continuum of subject matter that ranges from habitat analysis through behavior to physiology. In fact this overlap is recognized in adjectival and other semantic subdivisions of the subject areas involved. For istance we recognize*behavioral* ecology; the *physiology* of behavior; *aut*ecology; *syn*ecology; *community* ecology and so on. Despite this it is worth formally separating habitat enrichment from behavioral enrichment for purposes of discussion. The substance of ecological needs can be made clear by analogy. At our Copenhagen conference I was most impressed by Diettrich's (1990) use of the term *functional substitution* to describe the replacement of an element of the natural environment with something that serves the same function for the zoo animal. A striking example of functional substitution in human habitat requirements would be the replacement of grass surfaces with Astroturf in arenas for the play/aggressive behaviour involved in American Football. The material was designed to provide the characteristics needed by humans as a substratum for running, skidding, flailing, kicking, fighting, falling, scrabbling in heaps of bodies and so on. Note that football players have no biological requirement for the grass substitute to be photosynthetic, edible, aesthetically pleasing, or diverse in species composition. This comparison is not an extravagent attempt at humor; there is a real point to be made here. We **can** precisely define the habitat requirements of the ecology of football playing. The the fact that the grass, comprising the surface of the original playing field, is a plant capable of being utilized as food by a wide range of animals, and that grass grows on soil, which is a complex ecosystem in its own right, is ecologically irrelevant to the activity that occurs on it. Interestingly enough we **cannot** define as precisely the ecological requirements of most of the animals that we maintain in zoos. In my opinion, this is simply because,in the overwhelming majority of cases, the necessary research in the wild has not been done. This is partly due to the fact that most research does not focus on the interactions of animals with those components of the environment that are not members of their own species (see analysis in Robinson 1990).

But there is a more fundamental issue here. Ecological research has not tended to isolate those aspects of evironmental ambience to which animals have a specific response. Putting this in the most simplistic terms one thinks of zoo visitors criticizing exhibits because the animals in them cannot see/experience blue skies, sunshine, leaves on trees, or even "smell the flowers". We have absolutely no idea whether any species reacts to any of these phenomena in the manner inferred from our own subjective experiences. (We probably don't even know whether all human beings have common *ambience* requirements, I would guess that they do not, and that cultural overlays are very powerful in this respect. As Wordsworth put it: "A primrose by a river's brim, A yellow primrose was to him, And it was **nothing more**.") This is where functional substitution is relevant. In the wild it is an ecological fact that klipspringers stand on rocky outcrops, this has adaptive significance, it may be hard-wired. But: 1. does this sentinal-post need to be real rock, 2. does it need to be of a certain elevation, or 3. will these animals be satisfied if we provide them with wooden platforms 2 meters tall? Ecologists cannot normally determine the answers to the first and last questions in the wild, of necessity they are most easily susceptible to experimentation in zoos. They can only answer the question about elevations if they can find situations where this is the only variable and then only if they are very astute and sensitive observers. This is, in many ways, an example of a generic question. And it is a simple case when compared to the relevance of blue skies, sunlight, real trees with bark and leaves and so on to the life of animals. Thus the conclusion is fairly simple. We know little about the 'fine print' of habitat requirements and zoos are probably a one of the few feasible sites for careful study of this fundamental problem (see Robinson 1990).

Clearly such studies could be experimental, involving carefully thought out and controlled changes in enclosure conditions. However, it is also possible, as suggested by Adams & Babledais (1977), to carry out studies of zoo ecology, applying normal ecological methods to *existing* zoo habitats=exhibits, comparing the results from such studies with data, however inadequate, on the same species in the wild. Such zoo-habitats may be the product of insights, guesswork or simple tinkering but they do constitute a basis for ecological study. They **are** 'homes', however inadequate, to the animals they contain. Furthermore, interzoo comparisons between the different zoo-habitats of animals of the same species (as suggested by Adams & Babladelis, ibid) are a potentially fruitful and largely unexplored field for research. Such studies would best be carried out by trained ecologists, and preferably the comparisons of a species' responses to the different recreations of habitats, in different zoos, should be made by the same person or team.

Insights and experiments

The possibility that the ecological needs of some species are easier to predict and satisfy than others is very likely indeed. The discussion about specialists and generalists is a case in point. For instance, grazing and browsing herbivores that spend the majority of their waking hours cropping grass or leaves, and then masticating them or sleeping would seem to be predictably simple animals to provide for. The number of complaints by zoo visitors that involve ungulates, for instance, is very low indeed. Observations on the daily life of sloths and koalas suggest that highly specialized folivory does not usually involve high levels of complexity in habitat requirements. (Although sloths need to be able to descend trees, at considerable intervals, to bury their feces, Meritt, 1985). Data on the perceptual worlds of animals can also enrich our assessment of relevant factors. Color is clearly irrelevant to animals with monochromatic vision, odor to microsmatic animals, and so on. In this respect we need to bear in mind one of the important lessons of ethology; that animals do not necessarily *attend* to all the stimuli that they are capable of perceiving. One area that we neglect because of our own sensory biases is the olfactory environment. Because of considerations of hygiene and housekeeping we may remove, daily or regularly, all the odor marks that macrosmatic animals make and in the process destroy the sense of security that home-range markers provide. By alternating indivual animals in enclosures we may provide threatening situations through the odor markers of rivals. This may not be a negative factor but we must consider its effects carefully. All these factors need to be part of our efforts to educate against anthropomorphisms and other naive conceptions of animal behavior, by designing appropriate exhibits.

One important way of exploring the validity of insights can be through experimental modifications to zoo habitats. One can then measure the animal's response to the modifications, perhaps by monitoring increases in desirable activity and/or decreases in undesirable activity. We can even measure physiological indicators of stress; these can include non-invasive assays of stress hormones (Carlstead et al, 1993). A further empirical evaluation of insights can be derived from choice tests. These have been strongly advocated by M.Dawkins (e.g. 1977, 1980, 1983) for investigating maintenance conditions for farm animals. In designing enrichments for zoo animals one can present the animal with a choice between the old conditions and a new environment modified according to the insights into needs. As always, choice tests should, ideally, be designed to test one variable at a time. The testing of exhibit designs with living animals, , prior to building them, is clearly feasible, although it may be expensive. This approach was extensively used for the development of the London Zoo's Clore Small Mammal facility (Morris 1961b, 1965) and seems not to have been used very extensively since. During tests the novelty of a new environment may be either a positive or negative factor, making one-trial tests may then be inappropriate.

Variability

Assumptions about the fixity of ecological requirements are dangerous. One of the spin-offs of the golden-lion tamarin breeding and reintroduction program has been the realization that zoo-bred tamarins have significant behavioral deficits when reintroduced into the wild. These may simply be related to the absence, under zoo conditions, of environmental factors that present in the wild. The missing factors could include predators, small dangerous animals, varying climatic conditions and complex and nonstatic/impermanent three-dimensional structures within fluctuating ranges. Zoo-raised tamarins often have difficulty in exploring, and coping with a variety of environmental factors including unstable substrates (for instance, bouncing tree branches), venomous or other dangerous animals (snakes, spiders, poisonous frogs), and predators. All this is suggestive of considerable propensities for variability.

Mixed species situations

Providing appropriate ecological ambience for mixed-species assemblages is not simply a multiplicative process. On logical grounds there is clearly a possibility that species from the same habitat can have overlapping or even conflicting needs that are not a problem in the wild. In the zoo these needs may be a problem because of the scale of exhibits, or because natural resolutions of interspecific conflict, by fighting for instance, are subject to public scrutiny and objections. Evolution has resulted in spacing behaviors based on competition, territoriality, aggression and predation that are important to maintain multi-species ecologies in nature but may be unacceptable in zoos.

The role of humans in the zoo ecosystem

Clearly the presence of humans can affect both the quality of the zoo ecosystem and the behavior of the animals. Such effects can be positive or negative. In a brilliant early essay Leyhausen (1961) analyses such impacts on small cats. Since small cats are themselves subject to predation they have to be fearful, and visitors adversely affect their behavior. On the other hand Leyhausen (ibid) concludes that "the keeper is, of course, the most important item in the captive cat's life." He shows how the good keeper minimises stress and enriches the lives of the animals under his care with positive interactions, particularly play. This is a controversial area that we will return to later.

Perceptions and education.

This subject constitutes a very important and largely unexplored opportunity for educating zoo visitors in environmental biology and ecology. As already stressed above many public perceptions about the habitat requirements of animals are flawed, unreal or grievously distorted.

Putting forward the real situation, if this is done entertainingly and forcefully, could be a major step towards defusing many animal rights criticisms.

Behavioral needs

As suggested above there is a continuum from ecology to behavior and many of the above remarks apply to both subjects. In the field of behavior there is certainly a dearth of studies, relatively speaking, of interspecific behavior, foraging, food-finding, reactions to environmental components, and so on. This is particularly true of field studies of many of the major vertebrates that commonly comprise zoo collections (see Robinson 1990, and references therein.). In these circumstances there are a number of alternatives available to us:

Insights and experiments

Some insights into behavioral requirements of animals derived from classical ethology have already been cited in the introductory section on the history of this subject (pages 3 -5 above). Additional insights can be derived from studies of captive animals, in non-exhibit conditions, which revealed fixed patterns of behavior (e.g. Leyhausen 1961, 1973, 1979, Lyall-Watson 1967, Kleiman 1974, Morris 1962, and references in Robinson 1990). Analyses of many of the early behavioral studies carried out on zoo animals raise the question of how far the animals were expressing natural behaviors. This is discussed in Robinson (1990), Kummer (1957, 1968), and Kummer & Kurt (1965). In general there are good reasons to assume that such basic studies can provide insights for behavioral enrichment. I have suggested (1991b) that despite some recent emphases on the variability of intraspecific behavioral there are many areas of behavior where we should expect that selection has operated to reduce variability. These are the areas where enrichment is easiest to provide. For instance, there is little doubt that hunting animals should have little variability in their response to the movement of prey-sized objects. A huge range of animals, from tigers and cheetah to leopard cats; piranhas and pike to squid; and crocodiles, lizards and boas to frogs, will clearly need to be stimulated by such movements.

The occurrence of behavioral deficits in zoo-raised animals is also a source of insights into the ontogenetic needs of animals. Zoo-bred Golden-lion tamarins released into a patch of temperate forest at the National Zoo exhibit a wide range of behavioral deficits relating to food-finding, exploration, predator-avoidance and so on. For instance their exploration and movement within natural vegetation (real trees) is very limited. At first they are extremely reluctant to leap from tree to tree, even descending to the ground to bridge gaps. These observations suggest that such behaviors as normal arboreal locomotion may be dependent on the richness of their (early?) experience (see for example in Bronikowski et al, 1989, Beck et al, 1991)..

There is a possibility that we may be ignoring an important area of behavioral deficits in our collection animals. We know so little about whether outlets for the expression of aggression, territoriality, and competition are an essential part of healthy life that it is possible that even the most apparently 'satisfied' of our animals may be deprived of important behavioral components. Neither do we know what is the role and extent of unpredictability and stress in the lives of animals in nature. (Humans, in the relatively benign lifestyles of our century, indulge in sports that appear often to involve goal-seeking for danger, fear, and stress. This suggests that we may have such behavioral needs). In our animal management procedures we try to minimize aggression, fighting and unpredictability and may unwittingly be doing our animals a disservice.

Many of the experiments that have been used to develop methods and systems of behavioral enrichment have frequently involved what I think must be called **tinkering.** (Tinkering is defined as repairing in a makeshift way). Tinkering is frequently applied to existing problem exhibits. Of course we should try to remove problems, and eliminate behaviors that rightly or wrongly diminish the educational impact of our exhibits, but tinkering is a fundamentally backwards methodology. However it is widespread, and there is a growing literature on this approach. For instance, my analysis of the abstracts of papers presented at the recent Portland conference suggests that the great majority of those that dealt with concrete examples fall into the tinkering category. I think that we should do the experiments before building the exhibits, not after.

Variability

We now know that in some behaviors there considerable differences between populations of the same species, and that these are most frequent in some kinds of behaviors. The work on 'cultural transmission' of food-processing behaviors in Japanese macaques is a case in point (e.g. Itani 1958). The extent to which various kinds of learning affect behavioral repertories of animals, particularly primates, is an area of relatively scant information.

Mixed species situations

Robinson, M. H. 1992a. *Classical Ethology and Zoo Exhibits: Homage to Niko Tinbergen and Konrad Lorenz* Fourth Symposium of Paignton Zoological & Botanical Gardens. Whitley Wildlife Conservation Trust, Paignton, U.K.

Robinson, M. H. 1992b. Environmentalism and attacks on zoos, truth or fiction? *Scientific Proceedings of 47th Conference International Union of Directors of Zoological Gardens . Vancouver*, 78 -98.

Schaller, G.B., Jinchu, H., Wenshi, P. and Jing, Z. 1985. *The Giant Pandas of Wolong*. University of Chicago Press, Chicago and London.

Tinbergen, N. 1951. *The Study of Instinct.* Oxford University Press, Oxford.

Tudge, C. 1991. A Wild Time at the Zoo. *New Scientist*, 1750: 26 -30.

Tudge, C. 1992. *Last Animals at the Zoo*.Island Press, Washington D.C.

Van den Bergh, W.K. 1962. The Zoological Garden- Noah's Ark of future generations. *International Zoo Yearbook* IV: 61- 62.

first they are extremely reluctant to leap from tree to tree, even descending to the ground to bridge gaps. These observations suggest that such behaviors as normal arboreal locomotion may be dependent on the richness of their (early?) experience (see for example in Bronikowski et al, 1989, Beck et al, 1991)..

There is a possibility that we may be ignoring an important area of behavioral deficits in our collection animals. We know so little about whether outlets for the expression of aggression, territoriality, and competition are an essential part of healthy life that it is possible that even the most apparently 'satisfied' of our animals may be deprived of important behavioral components. Neither do we know what is the role and extent of unpredictability and stress in the lives of animals in nature. (Humans, in the relatively benign lifestyles of our century, indulge in sports that appear often to involve goal-seeking for danger, fear, and stress. This suggests that **we** may have such behavioral needs). In our animal management procedures we try to minimize aggression, fighting and unpredictability and may unwittingly be doing our animals a disservice.

Many of the experiments that have been used to develop methods and systems of behavioral enrichment have frequently involved what I think must be called **tinkering.** (Tinkering is defined as repairing in a makeshift way). Tinkering is frequently applied to existing problem exhibits. Of course we should try to remove problems, and eliminate behaviors that rightly or wrongly diminish the educational impact of our exhibits, but tinkering is a fundamentally backwards methodology. However it is widespread, and there is a growing literature on this approach. For instance, my analysis of the abstracts of papers presented at the recent Portland conference suggests that the great majority of those that dealt with concrete examples fall into the tinkering category. I think that we should do the experiments before building the exhibits, not after.

Variability

We now know that in some behaviors there considerable differences between populations of the same species, and that these are most frequent in some kinds of behaviors. The work on 'cultural transmission' of food-processing behaviors in Japanese macaques is a case in point (e.g. Itani 1958). The extent to which various kinds of learning affect behavioral repertories of animals, particularly primates, is an area of relatively scant information.

Mixed species situations

Providing behavioral enrichment for zoo animals may be subject to constraints resulting from conflicting behavioral needs of other species housed in the same area. At the very simplest level there could be conflicting activity cycles, needs for the coincident use of substrates and so on. Given our limited knowledge of the range of requirements of many animals this is a really important factor to be borne in mind as we progress from single-species to multi-species exhibits.

The role of the human/animal relationship in behavioral enrichment

This is an area of considerable controversy treated separately below. Kiley-Worthington (1990, 1993) is a good source of background material.

Perceptions and education

The behavior of animals in zoo exhibits is often the primary negative factor affecting visitors to zoos. Misperceptions abound. This is an area for major educational efforts.

Possibly impossible species

There is certainly a logical, if not actual, possibility that some species have ecological or behavioral requirements that make them unsuitable as zoo animals. The criteria that we might use to arrive at a determination of unsuitability are not easily defined. They would include an inability to satisfy real rather than perceived habitat requirements, and real rather than perceived behavioral needs. In the latter category my own view is that behavioral imperatives need not be satisfied by natural means as long as we can provide other outlets that exhaust the appropriate drives of the species concerned (see below). For example, artificial lures can provide outlets for hunt, chase and kill drives. *A priori*, one can make a number of predictions about which types of animals should be carefully and critically analyzed for the potential exclusion list. For instance the large whalebone whales, which cruise over enormous distances may be intrinsically unsuitable for zoo exhibits, so might those whales that sing in the ocean depths. Birds which soar on thermals could be behaviorally deprived in normal zoo conditions. Should it be determined that soaring is a strongly motivated behavior, and it should not be assumed, automatically, that it is, then it is possible that a good designer could build a thermal-producing device into a condor aviary. At first sight this seems improbable but the possibility should not be dismissed. Animals that exist in large social groups in the wild may be cases where the majority of zoos are incapable of providing an adequate social mileau for the full expression of group behavior. As suggested above we also may be ignoring behavioral appetites for aggression, competition and rivalry which could mean that some animals are deprived of major consummatory behaviors in zoo conditions. All this needs examination.

What is the role of naturalism?

There are very strong views within our profession on the question of naturalism. At present I would guess that the overwhelming majority of zoo directors and program planners as well as professional zoo exhibit designers stand strongly in favor of *habitat exhibits*. These universally replicate natural-looking habitats, ecosystems and even biomes. They are frequently triumphs of art and technology. One hesitates to say it, but they are also triumphs of art and technology over reality - elaborately sophisticated stage settings, often like the towns in Western movies all 'store-fronts' and nothing of substance behind the facade. There is no doubt whatsoever that it is very important to educate our visitors about the disappearing ecosystems of the world. For instance, replicated rainforests are a powerful tool in highlighting the wonder and glory of that biome. Good habitat exhibits are convincing to us because we design them literally from our point of view. But *Homo sapiens* has a rather distinct perceptual world; as a species we have what is almost certainly a minority viewpoint. We have stereoscopic color vision that is acute only at distances related to our social interactions, upright posture, and evolutionary history. Compared to most other mammals we have a relatively inefficient sense of smell, and a limited range of hearing that deteriorates with age. Most of us realize that our world is very different from that of the cats and dogs with which we share our houses. Despite this we seldom apply a similar understanding to the rest of nature. That leads us into many delusions based on anthropomorphisms.

In addition, we have ourselves have totally abandoned naturalism in our civilized lives. We live in insulated, climate-controlled, houses for a substantial part of each day, in these we are separated from most of our conspecifics. We cover our bodies with clothing, remove our body hair and natural odors, decorate our faces artificially and eat a wide range of substances that are either extremely rare or totally absent from the natural world. We amuse ourselves in vicarious ways and transport ourselves by mechanical devices at speeds unimaginable to humans in the wild state. One could extend this list of unnaturalisms almost indefinitely. The real point is that civilized life is of such a more desirable quality than natural life that it is the overwhelming urge of humans to constantly extend its non-naturalness. And as for Rousseau's noble savages living in a pre-Fall Eden.......

For all these reasons I would argue that we need to be careful about the siren song of naturalism when it comes to the life of animals. We need to produce exhibits that satisfy the environmental/behavioral needs of animals, and I would insist **that we need to show visitors the differences between the world of other animals and ours; this is an urgent educational task.** This leads straight back to the concept of *functional substitution*, and to the need for basic research into animal needs.

Functional substitution

In the case of habitat= ecological enrichment, the functional substitution of some elements can proceed fairly simply, in the absence of field data, by using a number of pragmatic approaches. One is to present choice tests on such matters as substrate, bedding, sleeping areas, daily feeding regime, and so on. In this instance our naive perceptions of the characteristics of the natural components of these elements may be misleading. The animal is programmed by evolution to respond to stimuli that we cannot ourselves readily distinguish and have not discovered in our studies.Thus cats may habitually use grass-straw to line their sleeping holes in the wild, but actually select something as unnatural as wool strands if offered them in a multiple choice test. The stimulus characteristics of straw only occur in straw in the wild situation but there may be dozens of substitues available in the zoo that trigger the same response. Eibl-Eibesfeldt's (1963) experiments on nest-building by rats are full of insights into functional substitution and the stimuli involved. Bower birds (in our increasingly trash-covered world) choose pieces of blue plastic to garnish their courts in response to the same innate program that lead them to choose blue fruits and flowers in the unpolluted past The behavior worked correctly for milennia! In captive experiments Morris (1962) found that green acouchis carried out their elaborate scatter hoarding behavior with large dog-food pellets. This was clearly an acceptable functional substitution, the pellets triggered the response more than adequately. It is possible that acouchis would even select pellets in preference to the palm nuts that they hoard in the wild, but he did not test that. Since choice-tests may require conditions such as plentiful space, and a standardized lay out, they may be difficult to carry out in public exhibits. (Although if they were they could be exploited in educational programs and thus be doubly worthwhile).

Alternative testing includes using insights into potential functional substitutions - derived from a variety of sources (see above) - and monitoring the animal's behavior both before and after making the changes. This approach verges on tinkering, but may be an economic and time-saving short-cut, provided that the insights are of high quality. Insights can also be useful in deciding which aspects of zoo conditions may be susceptible to functional substitution. Once again I would emphasize how desirable it would be to do experiments on the responses of animals to exhibit components before the designs are finalized. Furthermore there is a very strong possibility that inter-zoo comparisons can be very useful if they are carried out in a systematic way, objectively (i.e. not simply based on the evaluation of the zoo staff), before installations are made.

In terms of behavior, functional substitution has often been equated with behavioral engineering, which involves various kinds of conditioning. This approach has been critically appraised by Hutchins et al (1978, 1982, among others). Their papers are an interesting historical vignette, worthy of a parenthesis:

> Their treatment is trenchant, and as an ethologist I have a predisposition against the emphases of experimental psychologists, however they fail to take note of one of the most important lessons of ethology that of the importance of *relevant* stimuli -that animals do not attend to all the stimuli that they are capable of perceiving. (In translation: *species differ in what is natural to them.*) On the contrary they espouse what to me is a naive anthronaturalism: ".....should argue for a more enthusiastic attempt at simulating the character and content of the animal's natural habitat in the zoo setting. If this can be achieved with the use of natural materials so much the better; aesthetics and concern for authenticity are both *important for the sake of public education*" (my italics) Ibid (1978). This viewpoint, of course, should be set in the context of the times, when as they point out (Ibid, 1984) zoos had a prevailing atmosphere of: "metal bars, asphalt, concrete, and gaudy colors.....Bleak and uninviting spaces for animals and people are typical of both indoor and outdoor exhibits." no wonder they emphasized naturalism!

In fact the question of whether we can, and should, exploit behavioral engineering by *training* animals to do things, or by the use of complex apparatus, or by a direct human/animal relationship, is an interesting one. There is clearly a continuum from the extreme of training animals to do things outside their natural behavioral repertory (of survival behaviors) at one extreme, to providing 'natural' circumstances and stimulation in which they are able to find outlets for all their drives, at the other. At one end is the chimpanzee's tea party and the harmonica-playing elephant and at the other is the food-burying acouchi. In between are all those behaviors that are a fascinating part of the animal's survival apparatus but redirected at a functionally substituted stimulus. For example an orb-weaving spider responding to a tuning fork is exhibiting natural behavior directed at a stimulus that adequately substitutes for a prey item in stimulating attack. A cheetah chasing a moving object, albeit a tattered plastic bag pulled by a cord powered by an electric motor, is qualitatively in the same category. And a tiger swimming in a moat playing with a floating beer-barrel is still exhibiting elements of natural behavior. All these cases seem legitimate. Behaviorally engineered responses can convey totally wrong messages about animals. The potential for this result increases as the objects involved become less likely to be identified with natural situations, and also as the behaviors become more trivial and less obviously connected with survival and 'real life'. But with good interpretation important lessons can be taught by most of the behavior that involve stimulus substitution and not training for unnatural acts. That a tuning fork can substitute for a fly, or a moving plastic bag for a gazelle, can in fact teach very important lessons. Incidentally, the fact that zoos cannot give predators live prey is one of the main arguments I would use against zoos if I were ranged on the side of the opposition. Hutchins et al (1982) have an excellent discussion of this issue, that of normally unfulfilled predatory behavior, and deprived animals.

Experiments

Apart from the experiments in functional substitution suggested above I think that zoos can contribute to fundamental research by systematic investigations into the importance of environmental factors in the biology of animals. This means carrying out studies that are, in a sense, incidental to enrichment, but may contribute to it. Their primary motive would be to advance understanding, they would be in the best traditions of classical ethology and extensions of the approach of trying to understand what stimuli animals actually attend to. Instead of concentrating on intraspecific stimuli -the majority of such studies have been on social behavior- they would concentrate on the non-social environment. There are so many unanswered questions when it comes to habitat requirements. As a trivial example, we simply do not know whether fruit bats attend to any aspects of the trees that they visit other than their flowers and fruits. When visitors complain that Great Apes do not have a chance to see blue skies, bask in sunshine and smell the flowers it would be nice to know whether any of these factors are relevant to their lives. Only in zoos can we manipulate things so that such a systematic study would be possible.

Conclusion

This attempt to systematize an approach to enrichment raised five major questions at the outset. These were:

1. What precisely do we mean by enrichment?
2. Do we have adequate data (ecological, ethological, psychological or based on zoo-studies) to act from some sound basis?
3. Whatever the answer to that question, to what extent do we use field data on habitat requirements and behavioral needs in designing exhibits, or,

alternatively how much of the progress so far is dependent on simple tinkering pragmatism?

4. What kinds of research should we be doing in this area?

5. How important is naturalism in enriching zoo habitats and the behaviors of zoo animals?

Enrichment is clearly an important task for us all. It means, quite simply, that we should ensure that the animals in our care have the greatest possible capacity to express their full range of natural behaviors and satisfy their behavioral imperatives. If we succeed we will all have more interesting zoos. The answer to the question about adequate data is overwhelmingly negative, we do not. However, the absence of such data does not mean that we cannot proceed to enrich our exhibits and enlarge the lives of our animals. This is because we can use a variety of insights into animal needs, derived from several sources, to pragmatically change our exhibits and test out a wide variety of functional substitutions. As we do this, if we work systematically and document our procedures, we will be accumulating data. These data, and our insights, should suggest topics for pursuing fundamental research into the animal/environment relationship, and into fundamental aspects of the motivation and mechanisms of behavior. Zoos alone may be the places where it is possible to conduct such research. This research may have great utility in conservation and in animal welfare. Finally there is the vexed issue of naturalism. If this means replicating natural environments without relevance to those elements that are significant to the animal species that they contain, then we may be failing to educate and even promoting an anthropocentric view that is positively harmful. On the other hand we need to create a feeling for habitat preservation and the protection of biodiversity, and to do so requires us to inspire and move people to concern for the environment. To balance these two factors will require all our skills.

AFTERWORD: Conditions external to zoo habitats and their effects

Zoo exhibits are unusual as animal habitats in that they abut, on the outside, areas often densely packed with humans of all ages, shapes and sizes. These humans frequently produce a very considerable volume of noise through vocalizations, and may actively try to engage the attention of zoo animals in a variety of ways. The noise level in zoos may be exacerbated by mechanical noises, music from boom boxes, licit and illicit, vehicular transport, and public address systems. The inside perimeter of zoo exhibits is often bounded by keeper areas or maintenance space where other forms of disturbance may abound. Vacuum cleaners are often disregarded noise sources there. All these factors have their effect on animal habitats (see for instance Carlstead et al, 1993). Enrichment is an important factor, but insulation from stress-producing disturbance is frequently ignored.

BIBLIOGRAPHY

Adams, S. & G. Babladelis 1977. An ecological approach to animal groups in zoos. *International Zoo News.* 24: 14-22, 25: 8-15.

Carlstead, K., Brown, J.L., & J. Seidensticker. 1993. Behavioral and Adrenocortical Responses to Environmental Changes in Leopard Cats. *Zoo Biology.* 12: 333 -352.

Beck, B. B., Kleiman, D.G., Deitz, J.M., Castro, I., Carvalho, C., Martins, A., & B. Rettberg-Beck. 1991. Losses and reproduction in reintroduced Golden Lion tamarins *Leontopithecus rosalia. Dodo* 27: 50 -61.

Bronikowski, E.J., Beck, B.B. & M. Power. 1989. Innovation, exhibition and conservation: free-ranging tamarins at the National zoological Park. *AAZPA Annual Conference Proceedings.* 1989: 540 -546.

Chamove, A. S. 1989. Environmental enrichment: A review. *Animal Technology,* 40: 155- 178.

Dawkins, M. S. 1977. Do hens suffer in battery cages? Environmental preferences and welfare. *Animal Behaviour.* 25: 1034 -1046.

Dawkins, M. S. 1980. Animal Suffering, the Science of Animal Welfare. Chapman & Hall. London.

Dawkins, M. S. 1983. *The current state of preference tests in the assessment of animal welfare.* In: Farm Animal Housing and Welfare. Martinus Nijhoff, The Hague.

Dow, S.M. 1986. *Behavioural enrichment for captive animals.* Symposium of the British Veterinary Zoological Society, London.

Dittrich, L. 1990. Zoos and Behaviour. *Scientific Proceedings of 45th Conference International Union of Directors of Zoological Gardens*

Denmark 3-16.

Eibl-Eibesfeldt, I. 1963. Angeborenes und Erworbenes im Verhalten einiger Sauger. *Zeitschrift fur Tierpsychologie*. 19: 165 -182.

Eisenberg, J.F. & D.G. Kleiman. 1977. The usefulness of behaviour studies in captive breeding programmes for mammals. International Zoo yearbooks. 17: 81 -88.

Hediger, H. 1955. *Studies of the Psychology and Behaviour of Captive Animals in Zoos and Circuses.* Translated by G. Sircom. Butterworths, London.

Hediger, H. 1964. *Wild Animals in Captivity. An Outline of the Biology of Zoological Gardens*,. Translated by G. Sircom. Dover Publications, New York.

Hediger, H. 1969. *Man and Animal in the Zoo.* Delcorte Press, New York.

Hutchings, M. Hancocks, D. &T. Calip. 1978. Behavioral Engineering in the Zoo: a critique. *International Zoo News*. 155: 16 -23.,156: 18 -23., 157: 20 -27.

Hutchings, M. Hancocks, D., & C.Crockett, 1984. Naturalistic Solutions to the Behavioral Problems of Captive Animals. *Zoologische Garten*. 1/2: 28 -42.

Itani, J. 1958. On the acquisition and propagation of a new habit in a natural group of the Japanese monkey at Takasaki-Yama. Primate. I: 84-98.

Kiley-Worthington, M. 1990. *Animals in Circuses and Zoos -Chirons World?* Little Eco-Farms Publishing, Basildon, U.K.

Kiley-Worthington, M. 1993. Handling and teaching zoo animals. *International Zoo News*. 243: 14 -23.

Kleiman, D. 1974. Patterns of behaviour in hystricomorph rodents. *Symposium of the Zoological Society of London*. 34: 171 -209.

Leyhausen, P. 1961. Smaller Cats in the Zoo. *International Zoo Yearbook* III: 11-21.

Leyhausen, P. 1973. *On the function of the relative hierarchy of moods.* In: Motivation of Human and Animal Behavior: An Ethological View. Van Nostrand Reinhold. New York.

Leyhausen, P. 1979. *Cat Behavior.* Garland Press, New York.

Lorenz, K..1952. *King Solomon's Ring.* Methuen, London.

Lorenz, K. 1970. *Studies in Animal and Human Behaviour.* Volume 1. Methuen & Co. London.

Lorenz, K. 1971. *Studies in Animal and Human Behaviour.* Volume 2. Methuen & Co. London.

Lyall-Watson, 1967. A Critical Re-examination of Food "washing" Behaviour in the Raccoon (*Procyon lotor* Linn.). *Proceedings of the Zoological Society of London* 141: 371-393.

Markowitz, H. 1975. *Analysis and Control of Behavior in the Zoo.* pp.77 - 90. In: Research in zoos and aquariums. National Academy of Sciences, Washington D.C.

Markowitz, H. 1982. *Behavioral Enrichment in the Zoo.*Von Norstrand Reinhold. New York.

Meritt, D.A. 1985. *The two-toed Hoffmann's sloth, Choloepus hoffmani Peters.* In: The Evolution and Ecology of armadillos,Sloths, and Vermilinguas. Smithsonian Institution Press, Washington.

Morris, D. 1961a. Active Life for Zoo Animals. *New Scientist.* 241: 773 -776.

Morris, D. 1961b. A new approach to the problem of exhibiting small mammals in zoos. *International Zoo Yearbook* III: 1-9.

Morris, D 1962. The behaviour of the green acouchi (*Myoprocta pratti*) with special reference to scatter hoarding. Proceedings of the Zoological of London. 139: 701 -732.

Morris, D. 1965. Experimental nocturnal house at London Zoo. *International Zoo Yearbook* V: 240- 243.

Morris, D. 1968. Must we have zoos? *Life*, Nov. 8.

Morris, D. 1970. *Patterns of Reproductive Behaviour.* Jonathan Cape, London.

Morris, D. 1990. *The Animal Contract.* Virgin Books, London.

PETA, 1993. Be a Zoo Checker. *People for the Ethical Treatment of Animals, Washington, DC.*

Polakowski, K. 1987. *Zoo Design: The Reality of Wild Illusions.* University of Michigan School of Natural Resources,

Robinson, M.H. 1989a. The role of biological research in the development of facilities. *Journal of Animal Science* 67: 2441-2451.

Robinson, M. H. 1989b. Homage to Niko Tinbergen and Konrad Lorenz: Is Classical Ethology Relevant to Zoos? *Zoo Biology* 8:1-13.

Robinson, M.H. 1990a. Ethology: Zoo studies versus field studies. *Scientific Proceedings of 45th Conference International Union of Directors of Zoological Gardens Denmark,* 119-164.

Robinson, M.H. 1991a. Animal Rights, objections to Zoos, and the evolution of Bioparks. *Scientific Proceedings of 46th Conference International Union of Directors of Zoological Gardens . Singapore.*, 18 -45.

Robinson, M.H. 1991b. *Niko Tinbergen, comparative studies and evolution.* In: The Tinbergen Legacy. Chapman & hall, New York.

Robinson, M. H. 1992a. *Classical Ethology and Zoo Exhibits: Homage to Niko Tinbergen and Konrad Lorenz* Fourth Symposium of Paignton Zoological & Botanical Gardens. Whitley Wildlife Conservation Trust, Paignton, U.K.

Robinson, M. H. 1992b. Environmentalism and attacks on zoos, truth or fiction? *Scientific Proceedings of 47th Conference International Union of Directors of Zoological Gardens . Vancouver*, 78 -98.

Schaller, G.B., Jinchu, H., Wenshi, P. and Jing, Z. 1985. *The Giant Pandas of Wolong*. University of Chicago Press, Chicago and London.

Tinbergen, N. 1951. *The Study of Instinct.* Oxford University Press, Oxford.

Tudge, C. 1991. A Wild Time at the Zoo. *New Scientist*, 1750: 26 -30.

Tudge, C. 1992. *Last Animals at the Zoo.*Island Press, Washington D.C.

Van den Bergh, W.K. 1962. The Zoological Garden- Noah's Ark of future generations. *International Zoo Yearbook* IV: 61- 62.