THE ROLE OF SEPARATE RESEARCH UNITS IN A ZOO

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Introduction

"The cost of not doing research" is high (Gibson 1980). This is an accepted dictum in medicine. Physicians have accepted the notion that, if indeed we wish to free ourselves of some of the major scourges of illness, the latest of which is AIDS and a good example it is, then investigative efforts are an absolute necessity. We accept the fact that, without a clear understanding of the nature of the virus that causes AIDS, without knowing its receptor sites, the DNA make-up, the mechanisms of immune defense systems of the body and other aspects of this complex disease, a meaningful therapy, let alone vaccine will never come about. We have thus eliminated rickets, tuberculosis, childbed fever, poliomyelitis and other dreaded diseases of the past. And, in part for this reason, we have multiplied. Zoos are remiss in not having made similar progress in their evolution and it is high time they catch up with these developments (Benirschke 1987).

It is now urgent that research on endangered animals be more widely undertaken if we are really intent on preserving some of them for our descendants. At first blush one may ask whether the knowledge acquired in the study of human diseases and that undertaken on domestic animals would not suffice for the task of caring for endangered animals. To be sure, many regimens are perfectly transferable, e.g., the treatment for tuberculosis. In other cases, however, this is not so readily accomplished. Take the prevention of rickets for exotic species. In humans, the regular acquisition of vitamin D2 suffices, when sunlight is not available. This has been found to be insufficient for South American primates, however, where the need is to medicate with Vitamin D3, as their steroid metabolism differs substantially (Hunt et al. 1967). Numerous other examples can be cited to support this notion of investigative efforts on exotics. Indeed, one may justifiably ask why it is that so little is known about the biology of most exotic animals since many of them have been cared for in zoological gardens for over a century. Why did it take us so long to realize

this essential need for basic research into the biology of endangered animals?

One reason may be that it had been very much easier and cheaper to purchase new animals from foreign lands than it is now. Many new laws (e.g., CITES) govern traffic of many species and prohibit new acquisition. Also, with emerging new nations the stability in foreign lands has been erratic and the former professional catchers no longer exist. Most of all, however, there has been a dramatic decline of many of the favorite zoo specimens in the wild so that future importation is limited by a lack of their supply. This is best appreciated when one considers the reduction of the five rhinoceros species, favorite zoo exhibit. No Javan rhinoceros is ever likely to be shown in zoos again and, only with the greatest of efforts are now a few specimens of Sumatran rhinoceros coming into the best-equipped zoos with the hope of breeding a back-up stock. The other three species fare only slightly better (Bradley Martin 1982) although here the larger stock in zoos has laid the foundation for captive maintenance without the anticipated need of future importation. The same can be said for wild pigs, peccaries, many deer, many birds and reptiles. It would be redundant to catalogue them h ere

The veterinary profession, of course, has had the same opinion with respect to livestock and small animals, as the physicians. Research was needed for better milk production, better weight gain of cattle, avoidance of parasitism in swine, and so on. But veterinarians were unable to embrace all exotic species as well. For one thing, most veterinary schools were not located near zoos, there was no "demand" for these services either. It is only in the last two decades that veterinarians became established professionally in zoos and they had their hands full with putting out brush fires. Why has this not been an obligation of the curators in zoos ? Why did they not undertake this needed research in the past? This also is a complex question. Curators were not laboratory scientists. More often than not they used to be taxonomically oriented and had their hands full acquiring animals and managing the "collection" as best they could. Nor did they really see the need for investigative efforts on a broad scale.

What about the zoo managers? They were most of all concerned with the budget and often knew not enough of the essence of biomedical research to defend the need for it. Zoo budgets did not include a research staff and "basic research" has had its ups and downs in being defended before Congress over the years even for human medical research. So it is not really surprising that true basic research did not exist in zoological gardens and aquariums until very recently. And, when it started in the early seventies, it had a difficult beginning. It was problematic to defend basic research in the zoo world (ILAR 1975) and in the individual zoo internally because of its budgetary needs; it became a competitor with the needs of curators, and veterinarians and also, Humane Societies of all kinds found it necessary to demonstrate against its establishment, an ill-conceived notion.

So, with this as background, it is necessary now to first point at some of the current needs for biomedical research in exotic species. Then I wish to review its history briefly and the current distribution of zoo research units. Finally, I wish to analyze the likely future trends in this field, some funding avenues and the problem of manpower resources for the future.

Current Needs for Research

With the increasing inability to obtain additional wild animals for exhibition there is need to manage the zoo animals in a manner consistent with the new principle of zoos, namely to create "self-sustaining populations" (Benirschke 1986). Moreover, zoos have a moral obligation to participate actively in the conservation of species and the various chapters of this book give testimony to their intent. The general lack of precise knowledge of the species to be managed hampers a successful execution of this task. In particular, too little is known of the genetic make-up of wild animals in order to avoid the effects of inbreeding and the creation of studbooks is only a first step into the direction of adequate management. Clearly, genetic research of all sorts needs to be executed. Prominent among these studies are chromosomal examination, as many species differ in their cytogenetic complements. This is best known from the acknowledged differences in Bornean and Sumatran orang-utans (Seuanez et al. 1976) but spider monkeys, Aotus, gazelles of different kind and many more wild animals have chromosomal complements that make it mandatory that they be studied prior to establishing breeding groups (Benirschke and Kumamoto 1987). In retrospect most managers would decry that, some time in the past, a domestic mare found access to the breeding group of Przewalski's horses and such accidents should be avoided at all cost in the future. One can make a similar point about the need to understand better the genetic homogeneity of the cheetah (O'Brien et al.1983) and ascertain, whether a similar situation exists for possibly other species with poor reproductive proclivity. More modern studies such as the delineation of the genome by DNA analysis are also best executed in zoos and, while it may be at present difficult to "defend" such research before the wider public, indeed zoo managers, their results have paid off handsomely in the study of human diseases and it is likely that it will ultimately benefit zoo populations. Hand in hand with this goes the need to store samples of the remains of dead carcasses for later DNA study or the creation of a bank of frozen tissues, the so-called frozen zoo (Benirschke 1984).

Research into the reproductive physiology is equally important and, when reviewing the abundance of research efforts into this field (Finley and Maples 1986) it is apparent that many zoos are cognizant of this need. Clearly, the precise understanding of reproductive hormones and their routine analysis by sophisticated tests has allowed physicians to manage patients infinitely better than is currently possible with wild animals in captivity. This will of course require that one must take cognizance of the very wide variety of reproductive means among the vertebrates in captivity, their differences in hormonal makeup, seasonality, placental differences and so forth. It is much easier to talk loosely about embryo transfer among species, surrogate mothers, pregnancy surveillance and other technical advances from which man and domestic animal production have benefitted than to execute it on pandas, giraffes, okapis and other species. On the other hand, the manipulation of infertile animals, such as reptiles with modern technologic advances such as GnRH pumps (Phillips et al.1985) clearly shows that this exploration has wider promise.

Infectious diseases continue to haunt larger zoo collections, particularly when species are intermixed. A good example is the occurrence of malignant catarrhal fever, presumably originating from inapparently infected gnus, that has raised havoc in a number of collections amongst exotic hoofed stock (Heuschele et al. 1984 a). Parasitism of animals continues to be a problem and, considering the availability of many drugs for the control of worms, greater efforts

must be made in the study and prevention of such infections if the promise of self-sustaining collections is to be met.

Behavioral studies have been conducted in the zoo environment perhaps for the longest time. That is probably so because it is the least invasive and can be conducted most readily by outsiders, i.e. students and professionals from nearby universities. Their findings have not often made a significant impact on the management of the animals studied, however, and the need for " in-house " efforts are clearly apparent. Such aspects as mothering behavior, incompatibilities, social relations amongst species are needed. Why, for instance, is it that white rhinoceros have been so difficult to breed in pairs, while the opposite is true of black rhinos ? Are larger groups of white rhinos needed, is more space the important issue or what are the circumstances that have led to such dramatic population expansion of the white rhinoceros herd at San Diego's Wild Animal Park while before their placement into that environment no reproduction occurred ?

Of similar importance must be adequate nutritional support of wild animals in captivity. This has been recognized for long, of course, and numerous papers and books have been printed to that effect. Nevertheless, zoos continue to prefer to feed the cheap and processed materials such as ground beef for carnivores or monkeys pellets for all monkeys, rather than study the precise needs of each species. The case for Vitamin D 3 has been made before. One must similarly wonder why it has taken so long before it was recognized by a university investigator that leaf-eating primates have very special needs that were not always met in the captive situation because they possess such complex stomachs (Kuhn 1964). To be sure, it will often be impossible to meet all of the special requirements, of leaves in this case, or other "natural" foodstuffs in all zoos, but a recognition of these needs is the first assignment. This can only come by in depth study of nutritional requirements. The neonate and his need for specific milk support, inclusive of antibodies for a prolonged period (Heuschele et al. 1984 b) is an obvious contender for such sophisticated approach.

Physiological research is not very obviously an item that might be listed separately here, nevertheless, it bears considerable importance for a better future management of animals. For instance, it must be important to better comprehend the seasonality and their dependence on light, hormones such as melatonin and perhaps diet than is currently the case. Not only would such information make it possible to manage the animals better according to their own preferences, e.g. the ability to get away from too much constant light, and thereby improve their well-being, it may also be useful for more intensive management, e.g. more rapid breeding. It is likely that it has significant consequences for their survival and reproductive success. Similarly, it has been shown recently that a better management of the available temperature (shade for animals; heat from floor devices rather than the ubiquitous red, hot-lamps used in zoos) has beneficial effects on animal management (Phillips 1986). A better understanding of these simple parameters makes management easier and at times even less expensive. Of course, many other aspects of physiological studies need be undertaken and some are encompassed by endocrinology and nutrition, save to say that this not necessarily "popular" research endeavor needs to be taken more seriously than it is at present.

It goes without saying also that pathologic studies are mandatory on all deceased animals.

Only by this means has it been possible to recognize most of the human diseases and make them thereafter amenable to diagnosis and therapy. Autopsies are considered to be the first need in proper management and it is perhaps presumptuous to include this topic here as a research need. Nevertheless, not all zoological gardens perform autopsies and this desirability should be encouraged. With the performance of post mortem examinations also comes the availability of tissue samples for genetic, virologic and other studies and a surveillance mechanism is being created that allows supervision of the health of an animal colony. The pathologist can also be materially helpful were he to collect and study the placentas of the wide variety of mammals kept in zoos, as knowledge of comparative placentation is not only seriously deficient (Mossman 1987) but also because it is helpful in predicting possible success in interspecies embryo transfers (Durrant and Benirschke 1981). Computerization of data, ideally with inter-zoo transfer possibility, is highly desirable.

Why Separate Research Units ?

It is impossible of course for any scientist to embrace all of these different disciplines' techniques and the breadth of their developmental progress. Consequently it becomes important to bring the expertise into different laboratories. Traditionally there have been few true research laboratories in zoological gardens. In many European zoos scientists entertain laboratory efforts, however, these are more directly related to the health and maintenance of the collections. Thus, for instance in the Tierpark Berlin, East Germany, several scientists engage in the research on pathology and microbiology of collection animals. They are severely understaffed and their ability to stretch beyond the immediate diagnostic needs is limited. Only at the London zoo, England, has there been true scientific research in a variety of fields during the past few years. Here, the Nuffield and Wellcome Institutes, recently combined, have been directly associated with the zoo but they were funded separately and acted reasonably independently. Their research into genetics, endocrinology, biochemistry and other topics is well known and has led to significant advances. Moreover, through their aegis many important scientific meetings have been sponsored and published. In the United States a major research laboratory was established in Philadelphia, the Penrose laboratory, in which much nutritional, microbiological and other studies were undertaken. The New York Zoological Society, also engaged in research, has focused very importantly on field research and has made very many most important studies of the ecology and general biology of many endangered animals. They continue to undertake this work and have recently expanded to in-house investigations as well. In San Diego, where autopsies have been systematically done on all animals since 1956, a complete research department was formally established in 1975 and it has employed scientists from several different disciplines with good results. At the National Zoo in Washington, the Smithsonian Institution has long fostered active research and important results have profoundly influenced the maintenance of animals in other zoos. Moreover, the investigative efforts have been notable in our understanding better the biology of insectivores and South American Primates. More recently, other zoos (Cincinnati, Columbus, Los Angeles, Minnesota, to name a few) have also established departments that are solely devoted to investigative efforts.

Many zoos have espoused some type of research by inviting scientists from nearby

universities to use their collection for education or research. More often, however, zoos have been approached by scientists to make available to them tissues from necropsies, blood from animals incidentally handled and other materials for such research as on the mechanisms of aging (Jones 1985), taxonomic questions (Sibley and Ahlquist 1983,1984), biochemical studies (Doellgast and Benirschke 1984) etc. This has often led to conflicts, as the scientists do not perceive the difficulties of specimen collection and often they have been remiss in making available the research results. Often, their scientific studies have found little compassion in the zoo community and certainly they have frequently had little immediate relation to the animal maintenance. Thus, that the acquisition of important specimens has frequently met with difficulty. It is truly rare that the zoological community has gone out to scientists in universities with the request to solve some of their immediate problems and then, frequently, they have not met with a positive response. For all these reasons it is clearly important that in zoological gardens independent research units be established.

If one further examines the analogy with medical research, which is easy to justify as very major advances have come about in the therapy and prevention of human diseases because of systematic and basic research in recent years, then one will have to agree that the practicing physician cannot be directly involved in making these "breakthroughs". He is too busy with diagnosis and therapy and not capable any longer of embracing the multitude of modern research tools. Likewise in the zoo community. A curator or veterinarian is unable to fulfill the demands placed upon him where he also to be expected to make major advances in the understanding of basic biologic facts upon their charges. To be sure, he can aid in advancing knowledge by exploring better husbandry, prevention and cure of disease, behavior modification, taxonomy and so on. The task of acquiring truly new knowledge will rest upon individuals who do not have the constant obligation of management and therapy. It requires dedicated investigators of a variety of disciplines. Where to find them, how to organize them and how to fund their efforts are the remaining and important questions to be discussed.

The Nature of a Research Department

In the best of all possible worlds scientists work in a separate unit within the zoo, have close affiliation with the university departments of their disciplines, have an active participation with other zoo staff, are responsive to the needs of the curators, veterinarians and animals, and are funded by a special zoo budget as well as by grants. Such a world does not exist as yet, in part because we, all those concerned with this area of endeavor, have not spoken up loudly enough. Hardly any zoo has created its own facility in which to do serious laboratory investigation, few zoos have earmarked budgets for such an effort and, in part for this reason, dedicated scientists are difficult to find to undertake this very needed task. The task is also more difficult than would appear on first look. While it may be possible to find a first-rate scientist, say a geneticist, who is turned on to wildlife research, he will have his own idea of what is important, for instance DNA-DNA hybridization and he may not be willing to undertake the time-consuming but important task of studbook analysis or the cytogenetics of orang-utans. Scenarios of this kind exist in abundance and from them comes the occasional hostility that develops between various segments of the zoo community. In large measure this is so because research is so new and still an orphan

child in zoos. It is bound to change and the creation of this chapter is testimony to the recognition that change is needed. It is curious that Hediger (1969) already expressed it so well and still, little has changed since then. Said he :

> "However galling it may be....it has to be admitted that scientific research is usually placed last in zoological gardens, if indeed it has any place at all."

Hediger (1969) also strongly advocated that zoos be closely associated with universities, as a "pressing need of our times" and suggested that then at least zoologists and other scientists would be available for such research. It is my strong opinion that we, as the zoo community, cannot wait for university scientists to execute the needed research observations for the management of our stocks. It will have to come from in-house efforts.

Colleagues of mine in the medical community are aghast when they learn of the paucity of research on such vast and interesting problems as seen in zoos. They suggest, and this is not a bad analogy, that they also would not invest their money in stocks of a company which did not have at least 3-5 % of its budget working in R & D. Clearly, this is a significant challenge for all zoos but one of the most important ones to be faced straight on. The administrative staff of all zoos, large or small must make this difficult decision of setting aside that kind of money for serious research efforts. It will then become another matter to decide which research is most suitable for their park and how to get the scientific staff integrated into their community.

In order to attract serious scientists to modern zoos we will have to do much education and will probably have to begin with it at the college level. The young aspiring students will have to be lured into our community by the challenges, our need and the developing opportunities. When I see the enormous number of medical and allied scientists having been lured into cancer research and, more recently into AIDS research then I must admit, however, that it is not so much the challenges as it is the availability of research funds and some sort of stable outlook for their future development. It would seem to me to be highly desirable if the zoo-employed scientist had a firm appointment in a university department. He would remain credible because publication of his investigative results would be a necessity for promotion, his contact with students would continue to keep him au courant in research techniques and scientific knowledge and it would give him access to graduate students and other help. Most important, he also would "rub shoulders" with fellow scientists and learn by this association of new technology, collaborators etc. The zoo administrators, in turn, will have to accept a somewhat different behavior from scientists than they are accustomed to from other staff. In their quest to succeed, scientists will be very much more irregular in their hours at work, they will need to be given time to teach and they will also be critical of aspects long held traditional in zoos. But all
this will be for the better of the modern zoo, even though it will require adjustments and perhaps more generous salaries than zoos have traditionally paid.

With all of these needs, there remains a real quest for the acquisition of research funds. The plight of endangered animals is sufficiently propagandized so that it is readily accepted by the public. The cure though, allocations of national resources, has been extremely slow and trivial, compared with the funds available for medical research. It must be an urgent task of the

zoo community at large to seek through Congress, the National Science Foundation and Private Foundation, allocation of substantial sums of money analogous to other research endeavors. It must here be said that much of the needed research for zoos is presently "trivial", compared with the molecular biologic investigations currently being undertaken at universities. A rapid catch-up is needed and it is possible. Much of the trivial research can be undertaken on the side, say chromosomal studies of gazelles or orang-utans as we , in Medicine, also accept the need for the routine performance of the diagnostic amniocentesis along with quests to better understand the nature of the fragile site of the "fragile-X syndrome". It should be possible to obtain specifically dedicated endowments for research from benevolent donors and larger Foundations to create "Chairs" in research. A notable beginning has been made in this direction by the establishment of the Kleberg Chair in Genetics at the San Diego Zoo's Center for Research in Endangered Species (CRES) by the Cesar Kleberg Foundation, Texas.

Finally, it should be cautioned that Humane Societies will keep an eager eye on such research establishments as many shudder when they hear the words "animal research". Education in that direction is equally needed as is the meticulous adherence to animal welfare, a topic which is hardly in need of being mentioned in this context.

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