An overview of wildlife husbandry and diseases in captivity

M.E. FOWLER *

Summary: Wild animals have been maintained in close association with humans since the dawn of human creation. Tremendous advances have been made in the care and management of wild animals, but some areas still need improvement. It is therefore important to identify the husbandry factors which minimize or maximize the occurrence of infectious or parasitic diseases.

A universal influence on all animals is stress, and it is critical that managers, administrators, veterinarians and regulatory officials understand basic concepts and take steps to minimize stress in captive wild animal husbandry. To study the epizootiology of infectious and parasitic diseases, one must also understand the nidus concept of disease, which essentially holds that all animals evolved with a group of infectious and parasitic agents that have generally lived in harmony with their host. Now, with the movement of animals and agents throughout the world, explosive outbreaks of disease may occur, unless the responsible persons know which species may be closely associated, and follow appropriate husbandry practices and appropriate quarantine procedures.


HISTORICAL PERSPECTIVES

People have kept wild animals in captivity since the dawn of human creation. Some species (less than 50) of mammals, birds and insects responded to the care provided by people, adjusted to different feeds and environments, and became domesticated. The remainder of the nearly 50,000 species of vertebrates still exist in the wild, although many species may be tamed and trained to interrelate with humans.

Collecting wild animals into a single location was the province of royalty until the 19th century. Pictorial records from some ancient Egyptian kingdoms (2800-2500 BC) show collections of wild animals. One of the first clearly documented collections was that of Queen Pharaoh Hatshepsut around 1500 BC. In 1000 BC a Chinese emperor had a collection of animals which he called a ‘Garden of Intelligence’. The biblical King Solomon (974-937 BC) accepted gifts of camels from the Queen of Sheba.

Alexander the Great (356-323 BC) brought numerous species back from his travels and presented them to Aristotle in Athens. Alexander founded the city of Alexandria in the Nile delta, which became the seat of learning during the reign of the Ptolomies,
and included animal collections. The fall of the Greek Empire and the rise of the Roman Empire ushered in a period of scientific neglect, during which wild animals were regularly slaughtered at the Roman Games. During the early Christian era, the menagerie concept was developed. (A menagerie is an animal collection with no detectable scientific purpose.)

Charlemagne was a benevolent king of the Franks, and reigned in Western Europe in the 8th century AD. He founded three major animal collections in Europe, but none of these persisted. The Crusades of the 12th and 13th centuries preoccupied much of Europe and the Mediterranean region, and few people showed great concern for animals during this period. However, one Roman Catholic priest – St Francis of Assisi – was well known for his love and compassion for animals, ultimately becoming the patron saint of animals. During the 12th century, King Henry I of England maintained a menagerie at Woodstock, near Oxford. (The collection was later moved to the Tower of London and, finally, to the newly-established London Zoo in Regent’s Park in 1829.) In 1519, Hernando Cortez witnessed the extensive animal collection of Montezuma II at Tenochtitlán (near present-day Mexico City). Other zoos of this period included those of Chantilly in France (1530-1792), Karlsburg in Germany (1538-1875) and Versailles in France (1624-1643).

This was a period of intense scientific activity. Linnaeus (Carle von Linne, 1707-1775), a Swedish scientist, devised the binomial system of naming animals. A zoo at Prague (in the present-day Czech Republic) was first developed between 1530 and 1590, but in the 18th century the Habsburg Empress Maria Theresa (1717-1780) had the animals moved from Prague to her new garden at Schönbrunn Castle in Vienna. The only zoos to survive the Renaissance period were those in Vienna and Madrid. The London Zoo was the first zoo to be established in the English-speaking world.

MAINTAINING WILD ANIMALS IN CAPTIVITY: THE STATE OF THE ART

As seen above, collections of captive wild animals have a long history. Despite occasional periods of animal debasement, there has generally been steady improvement in the care and management of wild animals in captivity. At one time, restocking animals in a zoo meant capturing animals in the wild. This situation is changing. Most animals in modern zoos have been bred in captivity, through the co-operative efforts of the professional personnel of many zoos, as described in the articles in this issue of the Scientific and Technical Review of the Office International des Epizooties.

Maintaining animals in captivity is a facet of the culture of many peoples of the world. The purpose of this volume is to describe the state of the art of maintaining wild animals in captivity throughout the world, and to suggest methods to improve the well-being of animals by encouraging husbandry practices which minimize the risk of infectious and parasitic diseases.

Marked differences exist between collections of wild animals, which vary from roadside tourist attractions to menageries, safari parks, game ranches, research facilities and genuine zoos. Roadside tourist attractions are often staffed by untrained personnel, and the care of the animals is usually minimal, thus increasing profits. At
the other end of the scale, many accredited zoos are managed by professional zoo administrators, curators, keepers and veterinarians. It must be acknowledged, however, that no zoo is perfect. Many examples of good enclosures have been developed in the majority of zoos in the world but, conversely, examples of bad enclosures may be found in the best of zoos.

One of the most promising aspects of present-day captive wild animal collections is the change from a competitive mentality - 'My zoo is better than your zoo; I have more animals than you do' or 'I have the rarest animal in the world' - to the formation of inter-zoo and international co-operative groups which manage a species or a group of animals on the basis of scientific information. Historically, most zoos have primarily been recreational institutions. However, the London Zoo was founded by the Zoological Society of London and, for a time, only members of that society were allowed to view the animals in the collection. At present, the majority of zoos also have an educational objective, and numerous zoos are involved in conservation issues. A lesser number have research goals as well, sponsoring projects either within the zoo or in the field. Zoos, at least in the United States of America (USA), prohibit research which is likely to cause the death of an animal.

The primary emphasis in this volume will be on husbandry practices which have an impact on the spread of parasitic or infectious diseases. Each article deals with either an animal group or an institutional approach to these matters. However, a number of management factors affect the entire spectrum of wild animals in captivity, as follows:

- appropriate nutrition and feeding
- unique nutrient requirements
- genetic drift
- understanding of anatomy and physiology
- behavioural alterations
- stress
- climate and environmental factors
- carriers in one group of animals which cause fatal diseases in other groups.

An understanding of stress and of the nidus concept of disease is fundamental to an understanding of the control of infectious and parasitic diseases, and a few introductory remarks will provide an overview of these subjects.

**STRESS**

'Stress' is a much used and abused word. All animals must cope with potentially lethal forces in the environment. Animals have developed systems to recognize destructive environmental changes and stimulate responses which normally allow the animal to adapt to the new conditions. If these normally protective mechanisms become overstimulated, however, destructive influences are brought to bear on animals; the effect of these influences is generally termed stress. Over millennia, domestic animals have evolved to be less susceptible than wild animals to stress. Zoo
personnel (e.g. keepers, veterinarians, curators and biologists) must be continually reminded that all husbandry practices should be based on principles which minimize stress.

Stress is the cumulative response of an animal resulting from interaction with its environment via the senses. Stress is basically an adaptive phenomenon. All responses to stimuli are primarily directed at coping with environmental change. In fact, the development of protective behavioural repertoires may depend on the mildly stressful interaction of an animal with its environment. Nevertheless, intense or prolonged stimulation may induce detrimental responses in the animal.

It is essential to understand that stressor stimulation is primarily a positive influence on an animal. Only when stressors act for a prolonged time, or when effects accumulate, is harm done to the animal. The well-being of an animal is in the hands of a manager, who is responsible for feeding, handling, transporting, treating, housing and providing a proper environment for the behavioural needs of the animal.

**Physiology of stress**

Any animal is continually stimulated by environmental changes (heat, cold, sounds, sights, tastes, touches) via receptors for all of the senses; all such stimuli are potential stressors. Other stressors include apprehension, anxiety, anger, rage, overcrowding, upset biological rhythm, lack of social contact, territorial or hierarchical dispute, malnutrition, toxins, parasites, infectious agents, drugs and, most important of all, confinement itself.

Specialized organs of the nervous system analyze and process impulses from the receptors and feed responses back through various components of the nervous system to organs which are capable of producing a response. Each animal attempts to maintain a balance in its life. Scientists call this process ‘homeostasis’ (maintaining stability in the internal functioning of an animal) (Fig. 1).

If a wild animal is approached by an unfamiliar animal, the first reaction is to attempt to pull away, kick or bite. Receptors are stimulated, the information is relayed to the brain and a signal is returned to appropriate muscles to stimulate a response (Fig. 1, left side). At the same time, the middle pathway in Figure 1 may also be activated, as the psychological response is to be frightened. Fright stimulates a response — via the nerves and brain — in the adrenal medulla (central portion of the adrenal gland), causing it to secrete adrenaline (epinephrine) and causing the ‘flight or fight’ response (pupils dilate, heart beats faster, hair becomes more erect and breathing rate increases). All these immediate responses are vital to the ability of the animal to cope with an unpleasant situation. Once the episode has passed, the body returns to normal.

The right-hand pathway in Figure 1 is more difficult to explain, but it is the true basis for an understanding of stress. The same stimuli and receptor pathways to the brain which produce muscle and adrenaline responses also affect the neuroendocrine system. Endocrine glands (e.g. thyroid, ovary, testicle, pituitary and adrenal cortex) produce hormones which assist in the function of body systems. Prolonged or intense overstimulation of these endocrine glands during stress episodes may damage systems controlled by these glands.
The neuroendocrine response of the adrenal cortex is directed via hormones secreted in the base of the brain (hypothalamus). The pituitary gland secretes a hormone (adrenocorticotrophic hormone) which is picked up by the blood and carried to the adrenal cortex, causing the secretion of cortisol. The biological effects of cortisol are manifold, and affect numerous body systems. Cortisol stimulates the breakdown of protein, with a resultant decrease in muscle mass (weight loss). Hair follicles decrease in size and may disappear, resulting in a poor-quality fleece with decreased density. Bone formation may be impaired. Wound healing and scar-tissue formation are impaired, slowing surgical healing. Sutured wounds may rupture.

Cortisol reduces the heat, pain and swelling associated with inflammation, an effect useful in the treatment of many diseases; resistance to disease is decreased, however, as the production of lymphocytes (one type of white blood cells) is inhibited. Cell-mediated immune responses are also diminished, an effect which may interfere with tuberculin-testing programmes or the development of an appropriate immune response following vaccination.

Heat stress

Heat stress (hyperthermia, thermal stress) is an important consideration when maintaining animals adapted to a temperate climate in hot, humid environments. Heat stress occurs when the core body temperature is elevated above the normal range (99.5-101.5°F [37.5-38.6°C] for most eutherian mammals, but possibly lower in marsupials and certain edentates). The threshold for potential damage to organs and tissues is 104.2-106°F (40.1-41.1°C).

Conditions fostering hyperthermia

The causes of hyperthermia include high ambient temperatures, high humidity, muscular exertion, fever resulting from disease, dehydration, mycotoxins which inhibit thermoregulation, and drugs which depress thermoregulation. Factors contributing to
the production of body heat include breeding, fighting, transportation, prolonged restraint and flight on being chased (e.g. by dogs).

Clinical signs of heat stress

Body temperatures in hyperthermic animals rarely exceed 110°F (43.3°C) and, in fact, animals suffering from severe heat stress may have temperatures of only 106-108°F (41.1-42.2°C). Hyperthermia may damage every organ system in the body, but the central nervous system (CNS) and reproductive systems are the most sensitive. Signs of effects on the brain include impaired mental function, convulsions and coma. Heat stress may have a marked effect on the adult female; the more profound effects in pregnancy are fetal damage (including inhibition of embryonic cleavage and implantation), initiation of birth defects and abortion. If a pregnant female becomes hyperthermic, effects on the CNS of the fetus may be pronounced, possibly leading to any of numerous congenital defects and even death. The fetal CNS is most sensitive to development of congenital defects when the brain is forming, at 50-60 days after conception.

General effects on the fetus may result in reduced birth weight. Fetal effects have been noted, when the core body temperature of the dam rises above 104.2°F (40.1°C) for prolonged periods.

In the male, excessive heat kills sperm. Camelid males commonly become infertile during hot summer weather in much of the southern and western USA. Unlike most domestic livestock and horses, the scrotum of the llama is not pendulous, and thus core body temperature changes have a rapid and profound effect on developing immature sperm. Although the effect of heat stress on sperm development has not yet been studied in all species, between 35 and 60 days are required for new sperm to become mature and viable once heat stress is alleviated. Males suffering from heat stress frequently have an accumulation of fluid in the scrotum.

All organ systems may suffer from intense or prolonged hyperthermia. Effects on the respiratory system include rapid and open-mouthed breathing. Heart rate is increased and blood pressure decreases. The shift of blood away from the viscera causes decreased digestive tract function and possibly colic. Alpacas with severe hyperthermia may die within minutes.

Managers are responsible for the prevention of heat stress by providing shade and ample water, to prevent dehydration and for immersion and cooling. Maintaining cool temperatures for Arctic and Antarctic species may require air-conditioning.

NIDUS CONCEPT OF DISEASE

Disease agents, as part of a stable pristine ecosystem, have a nest, home or habitat which is called a ‘nidus’. The natural disease nidus exists under definite conditions of climate, vegetation, soil and favorable microclimate in localities where vectors, donors and recipients of the disease agent occur. In other words, the natural nidus of a disease is characteristic for a defined geographic landscape. Although a parasitic or infectious disease organism may be circulating through a population of free-ranging wild animals, overt disease is rarely observed, because the agent and host have established a balance. The most successful agent is not one which kills off the host, as the agent
then loses its home. Although this issue of the *Review* is primarily concerned with captive wild animals, it would be an error not to recognize the inter-relationship of captive and free-ranging wild animals (Fig. 2).

**Fig. 2**

**Inter-relationship of disease agents in captive and free-ranging wild animals**

It is well known that many animal species host one or more herpesviruses while incurring little or no overt disease, but that when certain other species are exposed the resultant herpesvirus disease may prove fatal, e.g. *Herpes simplex* (cold sores) in humans produces a fatal encephalitis in great apes. A similar herpes infection (herpesvirus B) causes a mild stomatitis in macaques, but a fatal encephalitis in humans. As more experience is gained of the intricate epidemiologies of parasitic and infectious diseases, this leads to a better understanding of the difficulty of housing various animal species safely in close association with other species.

It has become difficult to determine in which species the nidus of certain diseases resides, as animals have been moved from their native habitats into new environments for centuries, thus either being exposed to new agents or transmitting their quiescent disease agents to new susceptible hosts.
Agents which may have produced little if any disease in the nidus population may increase in pathogenicity due to decreased immune resistance (stress), agent buildup or greater exposure. In a study of the parasites of South African zebras, parasitologists harvested healthy zebras seasonally to ascertain parasite load. One such zebra harboured 30 million parasites from 14 different genera. This zebra, in captivity, may have succumbed to such a parasite load. Health requires a critical balance between challenge and resistance (Fig. 3). When challenge becomes intense or resistance is lowered, disease is also possible (Fig. 4). Zoo managers must be on continual alert for management practices which change the health balance of the animals in their charge.

**FIG. 3**
Healthy state of an animal, based on a balance between microorganism challenge and host resistance

**FIG. 4**
Disease state caused by heavy challenge or lowered host resistance

**CONCLUSION**

Wild animals in captivity are known to have a longer life span than their free-ranging counterparts. They should also have a life in captivity which may approximate to or improve on the free-ranging state. Zoos are improving, and it is hoped that the information contained in this volume will contribute to continued improvements in the well-being of wild animals in captivity.