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Despite a long history in captivity, rhinos have been subjects of limited research and are thus poorly understood compared with many other captive species. This chapter provides an overview of research topics developed with the goal of improving captive management of all rhinoceros species. The following outline groups rhinoceros research topics under the headings of health, reproductive biology, behavior, and systematics and population biology. Table 26 provides a summary of captive rhino research priorities.

ANIMAL HEALTH



NUTRITION

Direct and indirect evidence to date suggests possible imbalances in dietary fats (particularly essential fatty acids), soluble and in-soluble carbohydrates, minerals and vitamins as underlying cause for many of the health problems identified in captive rhinos. Additionally, a different spectrum of nutritional problems are perceived to occur in free-ranging rhinos, a situation that will be compounded as more individuals are maintained in sanctuaries or intensive protection zones (IPZs).

RESEARCH OBJECTIVES:

- Develop optimal diets for rhinos under intensive management through the analysis of:
 - diets currently used in captive facilities,
 - fatty-acid composition,
 - carbohydrate content of natural browse,
 - trace minerals,
 - carotenoids and other antioxidants, and
 - amino acids.
- Develop nutritional standards for free-ranging populations under intensive management (i.e., sanctuaries or IPZs) through analyses.

STRESS

Various physiological and psychological stressors are believed to be underlying causal factors for many disease syndromes in rhinos. Identifying those stressors and their effects may help decrease or eliminate them, thereby helping prevent some diseases.

RESEARCH OBJECTIVES:

- Develop non-invasive methods of assessing stress levels;
- Develop baseline information and identification of stressors;
- Identify chronic stress as a factor in rhino morbidities and mortalities;
- Develop behavioral measures of stress and identify social and behavioral stressors.

COMPARATIVE CELL METABOLISM

Previous studies have established a number of unique biochemical, enzymological and hematological characteristics of rhinoceros red blood cells, yet it remains unclear whether these characteristics cause any or all of the observed disorders in these species. Further, it is

TABLE 26. Summary of captive rhino research priorities

Animal Health	Reproductive Biology	Behavior	Systematics and Population Biology
Nutrition	Characterization of the female reproductive cycle	Mate compatibility, courtship and aggression	Definition of subspecies distinctions and conservation units
Stress	Characterization of male reproductive activity	Behavioral indicators of estrus and parturition	Genetic and demographic management of populations
Comparative cell metabolism	Reproductive pathology	Social behavior and group structure	
Specific disease studies	Development of assisted reproductive techniques	Neonatal development and weaning	
Sample and data acquisition and storage		Behavioral measures of stress	

Research priorities identified by E. Blumer, research advisor to the Rhino TAG



unclear whether these or similar metabolic deviations exist in other tissues also and play a causal role in the genesis of other disease syndromes in rhinos.

RESEARCH OBJECTIVES:

- Establish intra- and inter-specific biochemical and enzymatic profiles of various tissues;
- Determine the effects of these biochemical and enzymatic characteristics on cellular processes;
- Assess the value of these variations on biomarkers of vulnerability to certain diseases;
- Identify potential therapies to modify the effects of these cellular processes.

SPECIFIC DISEASE STUDIES

The captive populations of several rhinoceros species have been limited by disease. Previous research has helped clarify the pathological processes involved in some of these diseases.

RESEARCH OBJECTIVES:

- Investigate specific causal factors and possible treatments for:
 - hemolytic anemia,
 - mucocutaneous ulcerative disease,
 - cholestatic hepatopathy,
 - encephalomalacia,
 - fungal pneumonia/immunological status, and
 - epidemiological processes and patterns.

SAMPLE AND DATA ACQUISITION AND STORAGE

Sample and data acquisition, storage and distribution are critical to the success of rhinoceros research programs. Adequate samples from captive animals are critical to understanding disease conditions in captivity. Field samples have inherent value for comparative purposes with the captive population.

RESEARCH OBJECTIVES:

- Establish regional "distribution points" for processing and redistributing samples;
- Develop blanket permits for movement of samples;
- Establish enhanced centralized storage facilities to make samples accessible to all interested parties;
- Develop a centralized database in conjunction with an epidemiologist for generation and maintenance of basic and specialized data on individual rhinos.

REPRODUCTIVE BIOLOGY



Although there has been much interest and considerable activity in reproductive research on rhinos, results have been desultory at best. The basic reproductive biology has yet to be adequately characterized in any of the species. Part of the difficulty has involved challenges inherent in rhinos themselves: large size, reproductive tract configuration and peculiarities of hormonal metabolism. Additionally, there has been an insufficient number of rhinos available for research. Finally, there has not been a systematic and coordinated program of research.



Research addressing rhino behavior, biology and management is needed. Priorities identified by the North American Rhino TAG include animal health, reproductive biology, behavior, and systematics and population biology.

(Photo: Knoxville Zoological Gardens)

FEMALE REPRODUCTIVE BIOLOGY

RESEARCH OBJECTIVES:

- Develop methods of determining reproductive status of individuals;
- Determine normal versus abnormal reproductive characteristics;
- Develop methods of estrus detection and ovarian activity, including time of ovulation by:
 - Developing methods of hormonal monitoring through regular collection and analysis of blood, feces and urine;
 - Developing methods of ultrasonic monitoring of ovarian activity, and
 - Developing methods of behavioral observation;
- Develop methods of determining and monitoring pregnancy.

MALE REPRODUCTIVE BIOLOGY

RESEARCH OBJECTIVES:

- Develop methods of determining reproductive status of individuals;
- Determine normal versus abnormal reproductive characteristics;
- Develop methods of processing sperm for artificial insemination or cryopreservation;
 - Develop reliable methods of collecting semen;
 - Evaluate electroejaculation versus artificial vaginas;
 - Document anesthesia considerations.

REPRODUCTIVE PATHOLOGY

RESEARCH OBJECTIVES:

- Determine a clear understanding of normal anatomy for males and females of each species;
- Evaluate the incidence of pathological conditions;
- Evaluate the impact of reproductive pathology on reproduction and population growth;
- If this impact is significant, evaluate medical or surgical methods to ameliorate the negative effects on reproduction.

ASSISTED REPRODUCTION TECHNIQUES

RESEARCH OBJECTIVES:

- Develop methods of manipulating female reproductive cycle through the use of various hormones or exogenous substances in order to develop protocols for estrus synchronization, ovulation induction and superovulation;
- Develop methods of safe and optimal semen collection, processing, storage and use;
- Develop methods of artificial insemination;
 - Determine best methods of sperm deposition in female tract: anterior vagina, cervix, uterus;
 - Develop modified artificial insemination guns;
- Develop methods of rescuing male or female gametes from gonads of recently deceased individuals;
- Develop specialized hardware and techniques for rhino reproductive work;
- Develop methods of determining and/or manipulating sex of offspring;

- Develop methods of collecting and using gametes or embryos via *in vitro* fertilization, embryo transfer or micromanipulation.

BEHAVIOR



MATE COMPATIBILITY, COURTSHIP AND AGGRESSION

The courtship behavior of rhinos is vigorous and often aggressive. Captive managers have had difficulty differentiating a truly dangerous situation (especially in smaller captive facilities where flight distance is limited) from the normal, and possibly required, amount of aggressive behavior during courtship.

RESEARCH OBJECTIVE:

- Identify "normal" behavior that delineates both the patterns that occur in the wild (how and when males and females come together) and the patterns and management practices that have occurred in captive facilities with successful rhino breeding programs.

BEHAVIORAL INDICATORS OF ESTRUS AND PARTURITION

Efficient reproductive management in captivity requires clear understanding of the timing and occurrence of several reproductive events. Currently, some managers can identify events such as estrus and impending parturition through changes in an animal's behavior. However, these indicators appear to have considerable variability among individual animals, and the ability to recognize them varies among managers.

RESEARCH OBJECTIVE

- Develop a reliable set of behavioral indicators of estrus and parturition for each of the rhino species currently managed in captivity.

SOCIAL BEHAVIOR/GROUP STRUCTURE

Little is documented about the behavior of extant rhinoceros species, either in the wild or in captivity. Attempts to integrate available information on rhino behavior have been hampered by the lack of standard methods of measurement and reliable ethograms to describe their behavior.

RESEARCH OBJECTIVES:

- Develop standard methods of measurement and reliable ethograms to describe behavior of rhinos;
- Examine husbandry practices, facility design, animal densities and sex ratios to determine the factors most critical for reproductive success.

NEONATAL DEVELOPMENT/WEANING

Of the rhino species maintained in captivity, only black and greater one-horned rhinos have enjoyed a significant degree of reproductive success. However, it has recently been suggested (Read & Smith, pers. comm.) that the interbirth interval may be significantly longer for captive individuals than for their wild counterparts and that this interval must be reduced if the captive population is to grow at the necessary rate (approximately 5% per year). Assuming consistent reproduction, the interbirth interval can best be reduced by returning females to a breeding situation as soon as possible after parturition and possibly weaning infants earlier.

RESEARCH OBJECTIVE:

- Develop a clearer understanding of neonatal behavior and maternal interactions, which is necessary for the identification of the periods critical for the development of normal socio-sexual and parenting behavior and an understanding of the effects of early weaning.

BEHAVIORAL MEASURES OF STRESS

Stress has been implicated as an underlying causal factor for many of the disease syndromes identified in captive rhinos (especially black rhinos).

RESEARCH OBJECTIVES:

- Identify and decrease these stressors, thereby reducing the causal factors of some diseases;
- Develop reliable behavioral measures of stress in conjunction with efforts to develop non-invasive, physical measures of stress;
- Evaluate the impact of facility design, management practices and social factors as primary stressors.

SYSTEMATICS AND POPULATION BIOLOGY



DEFINITION OF SUBSPECIES DISTINCTIONS / CONSERVATION UNITS

Definition of conservation units and confirmation of evolutionarily significant units have been issues of extreme importance in conservation and management of rhinos. Amid the crisis for rhino conservation, an optimal definition of conservation units has great significance in terms of demographic viability and economic feasibility. These issues are becoming particularly acute for the black rhinoceros, which is confronting a demographic crisis. Genetics is a critical tool in the definition process. However, the process must also integrate other areas of rhino conservation biology, including morphometrics, ecology and biopolitics.

RESEARCH OBJECTIVE:

- Use existing information or develop new information to confirm or modify current definitions of conservation/management units of rhinos.

GENETIC AND DEMOGRAPHIC MANAGEMENT OF POPULATIONS

As rhinoceros populations become smaller and more fragmented, the ability to measure and manage them genetically and demographically becomes more critical. A number of PHVAs have been initiated with workshops on various rhino species; however, PHVAs are a continuing process.

RESEARCH OBJECTIVES:

- Measure genetic variation within and between populations to assist in intensive management;
- Develop and apply biochemical measures of relatedness/pedigree construction and confirmation;
- Apply PHVA techniques to the management of *in situ* populations.