remains fairly stable ecologically, other factors threatening the rhinos' survival are directly related to the species' small population size, their susceptibility to infectious disease carried by domestic livestock entering the Park, and their vulnerability to cataclysmic environmental disasters, such as cyclones, tidal waves, or volcanic eruptions. Another clear insidious threat is from poachers, looking to kill the rhino for its horn.

Twenty years ago the Javan population of rhinos in Ujung Kulon was on the thin edge of extinction. Authorities figured there were about 20 animals left. Protection measures allowed the population to crawl up to its present level of about 60 animals. The sudden death in 1982 of five animals (an alarming 8% of the total) punctuates the fragility of this small isolated population. Since then, two animals were killed by poachers, one in 1985, and another in 1987.

What I find most intriguing is the question of how many Javan rhinos are there in the Park? Present estimates are based on measurements of footprints in the mud, collected by teams of field observers. No individual identities of rhinos have been established (although there currently is a remote photography project in place just to do this), yet all the arguments and conflict about what should be done to protect the rhinos are based on these highly questionable field censuses.

As pointed out by Kathy McKinnon, WWF advisor to Indonesia, greater investment in Ujung Kulon and more effective management of the Park will benefit not only the Javan rhino, but hundreds of other species. Ujung Kulon is one of the best known and most beautiful of the Javan parks, a national refuge of global importance. It protects one of the last remaining fragments of lowland forests on Java and more than 50 species of rare plants, some recorded only from this locality. The Park also harbors such rare and endangered species as the wild dog, leopard, banteng and three endemic primate species which occur only on Java: the Javan gibbon and two Javan leaf-eating monkey species. More than 250 bird species are recorded in the Park, as well as numerous rare amphibians, fish and reptiles. Using the Javan rhino as a "flagship" species attracts attention and funds to the Park and helps to conserve a unique area of Javan wildlife.

For anyone interested in supporting the "Adopt-A-Park" program in Ujung Kulon National Park or in selecting a park of their choice where Indonesian endangered wildlife could be protected, please contact the author, Ronald L. Tilson, Ph.D., Director of Conservation, Minnesota Zoo, Apple Valley, MN 55124 USA.

RHINO INFRASOUND STUDY

By Elizabeth von Muggenthaler

A number of papers report studies of the auditory vocalizations of rhinoceroses (Tembrock 1963, Frame & Goddard 1970, Spellmire 1991). These note the existence of low frequency sounds in the animal's repertoire, but none present data regarding vocalizations in the infrasonic (below human hearing) range. A study conducted by Elizabeth von Muggenthaler, Dr. Joseph Daniel, and John Stoughton, during the spring of 1991, presents preliminary evidence that rhinos, in addition to auditory vocalizations, produce infrasound.

Von Muggenthaler, while trying to duplicate infrasonic studies with elephants, discovered a unique vocalization pattern. The analysis that was used distinguished between the elephant's signatures and this new pattern. Two white rhinos, housed next to the elephant's enclosure, were recorded and determined to be the originators of the new pattern.

A total of 25 rhinos, representing all four captively held species, were recorded at various institutions across the United States. Equipment consisted of a Bruel & Kjaer portable FM recording system and a Sony Hi-8 video recorder. Generally recording sessions lasted from twenty minutes to two hours. Oftentimes, the best results were achieved when rhinos that were usually together were reunited after having been temporarily separated.

After each rhino recording session, the tapes were analyzed using a Macintosh computer with real-time spectrum and amplitude graphing software, and a Bruel & Kjaer spectrum analyzer. The vocalizations were first graphed and then run through the spectrum analyzer using a fast Fourier transform analysis.

Results from this study indicate that all four captive species of rhinoceros produce infrasounds. Typically these range between 10 and 75 hertz. Audiologists generally consider the lower limit of human hearing to be between 16 and 20 hertz, and this may be only detectable as vibrational sensations without distinct pitch. White rhinos produce vocalizations with spectral energies at 14, 20-24, 30-38, and 40-50 hertz. Black rhinos have spectral energies ranging 6-16, 21-28, and 32-50 hertz; Indian rhinos are at 8-10, 16-22, and 42-52 hertz; and Sumatran rhinos are 8-53, and 76-96 hertz.

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Certainly, as elephants and rhinoceroses are both large land mammals and share the same environmental niche, the literature on elephants may be immediately relevant. Payne (1989) concluded that much of the "uncanny synchronization of elephant behavior", conducted over long distances, was explainable by their use of infrasound. Responses were identified over distances of up to 2.5 miles. Also, Berg (1982) systematically analyzed the vocalizations of African elephants. She discovered distinct patterns in the elephant's sound repertoire that could be attributed to specific behavioral contexts. Research into rhinoceros vocalizations and their correlated behaviors, could yield important information about rhinoceros group coordination and, most importantly, breeding.

The study *Infrasound from the Rhinocerotidae*, will be published in the proceedings of the 1991 International Rhinoceros Conference. The authors are grateful to Rhino Rescue USA, the Diane Baum St. Clair Fund, Virginia Zoological Park, Zoo Atlanta, Bronx Zoo, San Diego Zoo and Wild Animal Park, National Zoo, Knoxville Zoo, and to Dr. Zuckerwar for his technical help.

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from 5-8 cm/year. Field managers are already conducting routine horn tipping or horn removal operations in both Zimbabwe and Namibia in connection with most capture and translocation projects in an effort to decrease injuries sustained by both animals and personnel during those procedures.

Sustainable utilization advocates certainly face a number of problems, not the least of which is the public perception of those practices and the possible effect that could have on funding of conservation projects from outside sources. There is also the question of how horn would be marketed given the current CITES climate which forbids trade in rhino horn, and how the marketing of it might affect the credibility of those who are encouraging the use or horn substitutes.

In the session on evolution and genetics, new information was presented on the subject of subspecies differentiation. Conflicting data have been gathered as to whether there is a genetic basis for rhino species divisions at the subspecies level, particularly with the black rhino. Dr. Eric Harley found mitochondrial haplotypes that are unique markers for the *minor, bicornis*, and *michaeli* subspecies, but noted that the divergence among the three subspecies was small and did not in and of itself warrant managing them separately. He further added that genetic data should not necessarily preclude subspecies differentiation based on morphological, behavioral, or adaptive differences.

Dr. Oliver Ryder's karyologic studies of the *minor* and *michaeli* subspecies in Zimbabwe and Kenya show subspecies differences in the distribution of chromosome arm lengths. He added, however, that heterochromatin changes very rapidly, and that his measurements may be the result of a very recent lack of gene flow between the two regions.

Dr. George Amato is working on assembling the molecular genetic and karyologic data and manuscripts that currently exist on the black rhino subspecies question to determine if it is sufficient enough at this time to merit a gathering of scientists for the purpose of discussing and resolving the genetic aspects of this issue.

The session on the biology and conservation of the greater one-horned rhino provided an effective illustration of how adequate protection and sufficient habitat can lead to recovery. The Kaziranga population in India, which had fallen to less than 100 individuals in the early 1900's, is now at 1,080. The Chitwan National Park population in Nepal has gone from a low of 60-80 individuals in 1962, to a current population of around 400.

An added boost to this species is attributable to the recent startling discovery that their average heterozygosity is one of the highest ever recorded in free-ranging mammals. Dr. George McCracken credits the maintenance of this species' genetic diversity despite its serious decrease in population size, to its extremely large effective population size within its original range, and the fact that the bottleneck occurred recently and was of short duration.

There are a number of areas within the historic range of the greater one-horned rhino which are well protected and have adequate habitat for the re-establishment of populations. Dr. Sunder Shrestha described one such successful translocation/reintroduction process which occurred between 1986 and 1991 with rhinos moved from Chitwan to Royal Bardia. The ability to carry out a successful translocation project with greater one-horned rhinos becomes even more significant with the news of seven poached rhinos in Chitwan within the last 10 months. Dr. Esmond Bradley Martin attributes that to an unstable political situation in the region, and a loss of funding for maintaining the formerly effective intelligence system of informants who identify poachers.