WEP Warwick Evans Publishing

International Journal of Natural Resources and Environmental Studies

ISSN: 3006-2012 (Print), ISSN: 3006-0834 (Online) | Volume 7, Number 3, Year 2025
DOI: https://doi.org/10.62051/ijnres.v7n3.09
Journal homepage: https://wepub.org/index.php/IJNRES/index

Environmental Factors that Shape the Behavior of White Rhinoceros in a Captive Setting in Yunnan, China

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ABSTRACT

Understanding the determinants of rhinoceros behavior is important in field and enclosure management, particularly during global climate change. In this study, the influence of five central environmental parameters (ambient temperature, relative humidity, temperature–humidity index (THI), light intensity, and wind speed behavior) on white rhinoceros (Ceratotherium simum) behavior was examined in captivity in Yunnan, China. Special attention was given to the rhino behavior walking, given it was the most frequently reported active behavior (e.g. excluding resting) and because this activity shapes intra and interspecific interactions and carries high energy costs. Results show there to be a highly significant positive relationship between THI and walking duration, while wind speed and light intensity contributed relatively weakly. The findings stress the importance of thermal environment in shaping locomotor activity. While future research is required to extrapolate these findings to more extensive populations and to understand the influence of seasonality on rhino behavior, this study presents the valuable quantitative evidence on environmental determinants of captive white rhinoceros behavior in China and offers guidance for future husbandry, welfare assessment, and restoration planning.

KEYWORDS

White rhinoceros; behavior; Environmental influences; Conservation strategies; Animal welfare.

1. INTRODUCTION

Over the past millennia, Earth's climate has been governed by natural factors, such as the carbon cycle, solar radiation variability, volcanic activity, and ocean circulation, resulting in the gradual variation of the climate [1]. However, over the past century, human activities like the combustion of fossil fuels, forest loss, and increased greenhouse gas emissions have significantly hastened climate change to an extent outside the natural variability range. Therefore, recent climate changes accelerated with the release of Grenn House Gases (GHGs), warming the Earth's atmosphere by an average temperature increase of over 1.1°C since 1900 [2]. Climate change at the global level has turned out to be one of the most severe natural disasters, posing an enormous threat to the environment, ecosystems, and endangered species alike. Rhinoceros, a highly endangered group of culturally and ecological important species, for example, are highly susceptible because climate-driven shifts in habitat cross with the confines of captivity habitats that may amplify physiological stress and welfare issues [3].

To address the urgent need to conserve endangered animals and maximize captive management, China has recently developed captive herds of white rhinoceroses (Ceratotherium simum) outside of their native range in Southern Africa

Past research conducted in some areas inside white rhinos native range in South Africa and outside of this range in Europe has shown that environmental factors, particularly temperature and humidity, have considerable influence on the behavior of white rhinoceros. Additional research is needed, however, on the influence of such factors in the context of China. Observations of the behavioral response on these newly established herds to Chinese environmental conditions 1) provides insight of ecological significance to conservation and management of this species globally in a changing environment, 2) has direct practical value in helping develop in-situ management practices such as those in zoological institutions; and 3) it offers some insight in the historical behavior ecology of this species as a proxy for now extinct lineages of rhino congeners that once existed in China.

The present study investigates the behavior of captive white rhinoceroses in Yunnan, an area of subtropical climate and montane edge environments. The site of the investigation is very different from the local savannas of the species in Africa, thus providing an unusual setting from which to examine the effects of climatic variables upon the behavior of the animals, like temperature, humidity, amount of light and wind speed, and, furthermore, by the opportunity which the confined environment supplies, to facilitate investigations into the individual and changing nature of daily behavior.

The value of the work lies, not only in that it is likely to elucidate certain important points concerned with the effects of climatic factors on the behavior of white rhinoceroses in a foreign environment, but that it will contribute to the general knowledge about the management of captive animals under conditions in which climatic factors are changing owing to change of climate and which has a friendly bearing on the management of other large mammals than rhinoceroses [4].

2. METHODS

2.1. Study Site

Data gathering took place in an enclosure for the white rhinoceros located in Yunnan Province, Southwestern China. In situ conservation at this safari arises from natural reserves or habitats for wildlife, this being an attempt to conserve reproduction of the species and original functions of ecosystems. Its aims are reached in maintain the natural functions in the more natural environment [5]. The conditions are subtropical with distinct seasonal differences. There is natural grass and forest cover, all the enclosures have access to a variety of fresh water supplies and there is plenty of shady cover. The two external sheds and an internal resting shed offer shade for the rhino which allows the animal the measure of thermoregulation in various weather conditions [6].

2.2. Subjects

The analysis was conducted on four captive white rhinoceroses, as identified during the study using their unique identification markers. All animals included in this study were males. Field observations were limited to diurnal behaviors.

2.3. Data collection

Behavioral data were recorded using focal animal sampling with continuous recording [7]. The observation was conducted in 2-hour bouts and the sessions were replicated twice a day (morning (i.e. approximately 09:30-10:30) and afternoon (i.e. approximately 14:30-15:30) for a total duration of two weeks. The same observer, who used binoculars and direct visual observation, collected the observations in an effort to minimize observer bias. In spite of visitors within the facility, their effect on rhinoceros behavior was considered to be negligible [8].

Behavior measurement was grouped into two categories:

Event counts – this category include two discrete behavior categories quantified as frequency (i.e. number of drinking events and number of aggressive interactions).

State durations – this category included timing five continuous behaviors quantified in terms of time in seconds (i.e. walking, lying down, wallowing, feeding, and seeking shade).

Operational definitions were created prior to observations for all recorded behaviors. For instance, "walking" was operationally defined as steady locomotion longer than two steps without a goal of feeding.

Environmental parameters were recorded simultaneously with behavioral data and included ambient temperature, relative humidity, temperature–humidity index (THI), light intensity, and wind speed. They were recorded using environmental monitoring equipment provided by the zoo.

All statistics reported in this analysis were computed in program R.

3. RESULTS

Standing was the most observed behavior during the period of observation, followed by walking, with other behaviors such as feeding, wallowing, and drinking rarely being observed (see Figure 1).

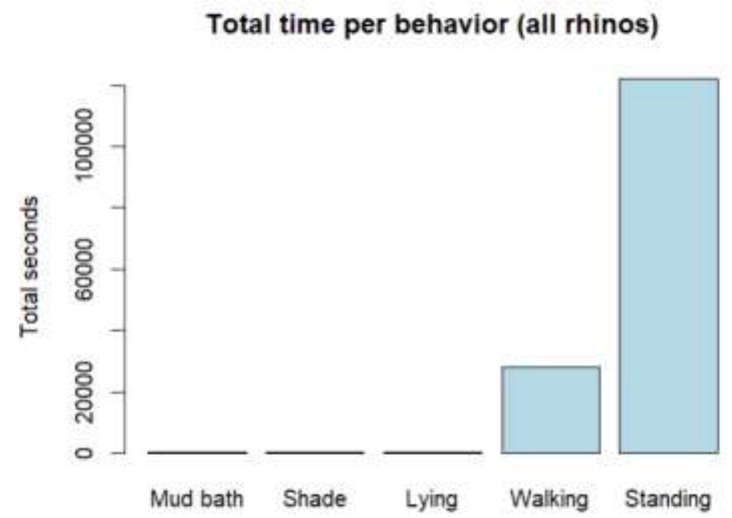

Figure 1. Total time (seconds) of five timed behaviors recorded over the course of the study; animals pooled and all time pooled.

There was a positive and significant relationship between THI and walking time for pooled data from the four rhinos we observed (Figure 2: r2= 0.872; p-value: 1.796e-09). Temperature is insufficient to evaluate heat load, as humidity influences the evaporative heat dissipation. Therefore, a combined indicator: the Temperature-Humidity Index (THI) is more effective to be introduced [9].

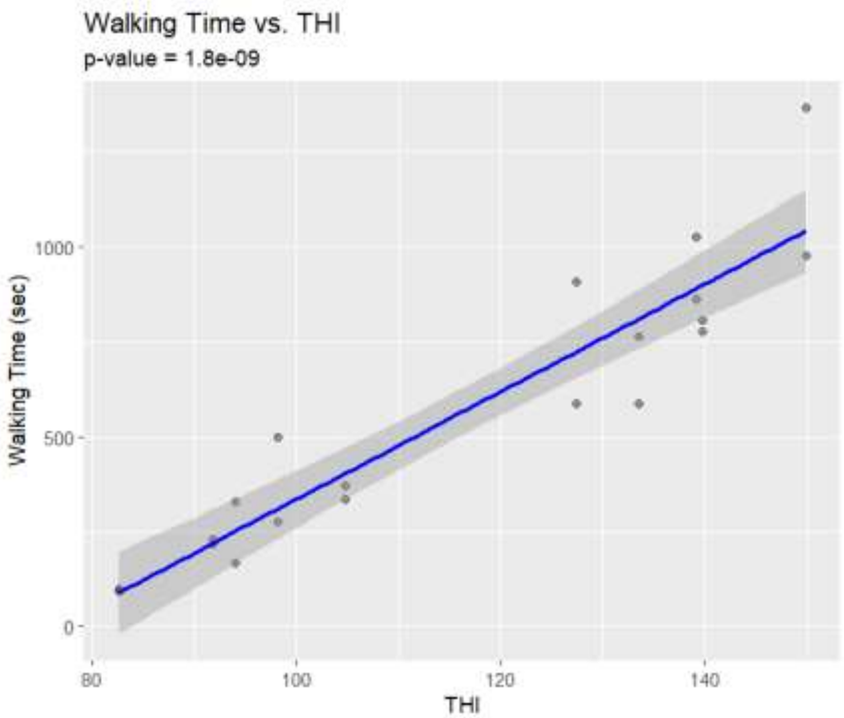

Figure 2. Correlation between temperature-humidity index (THI) and walking time (seconds) for all rhinos observed over the course of this study.

There was a slightly positive, but far less significant relationship observed between wind speed and walking time, suggesting a less important influence (Figure 3: r2= 0.2926; p-value: 0.01). There was no significant relationship observed between illumination and walking time (Figure 4: r2= 0.001; p-value: 0.86).), indicating no apparent relationship between these factors.

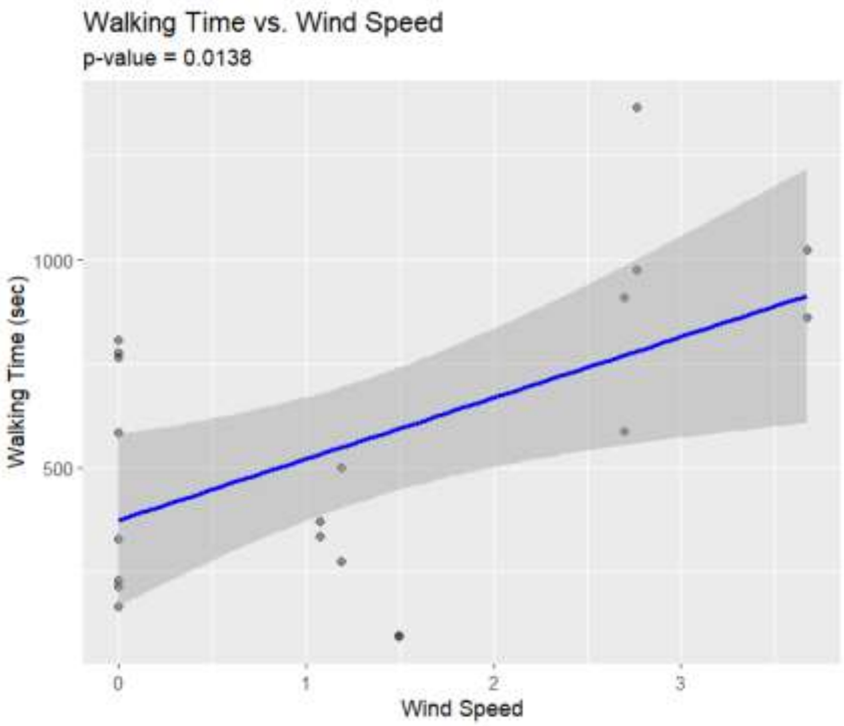

Figure 3. Correlation between wind speed and walking time (seconds) for all rhinos observed over the course of this study.

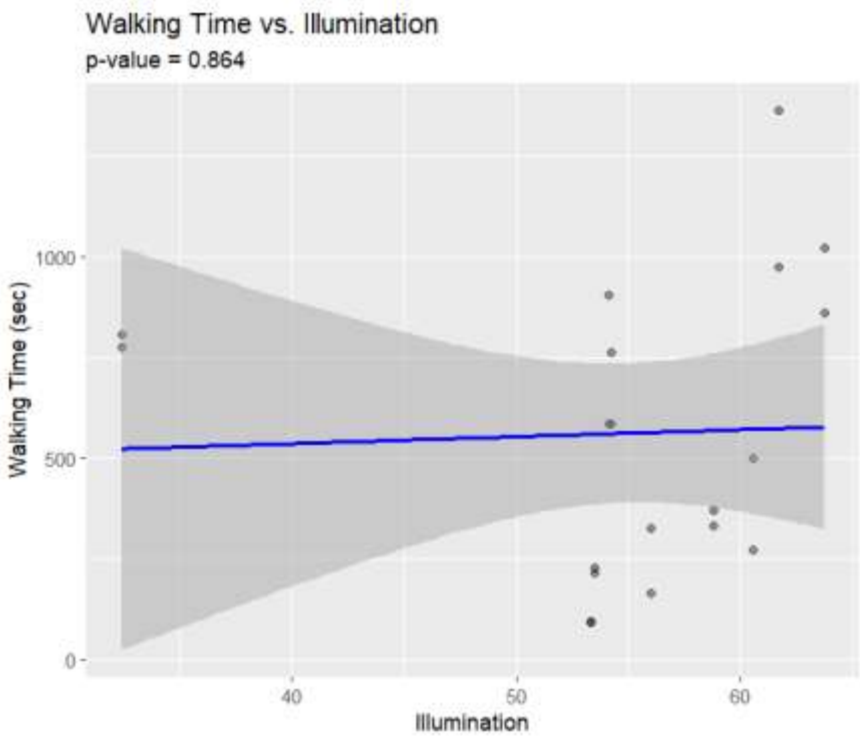

Figure 4. Correlation between illumination and walking time (seconds) for all rhinos observed over the course of this study.

4. DISCUSSION

4.1. Summary of Behavioral Trends

Standing as indicated in Figure 1 consumed the greatest proportion of total observation time followed by walking, with occasional cases of feeding, wallowing, and drinking. This standing behavior could be driven by severe light and heat, which are known to have a notable effect on trends in animal activities by the induction of low total activity and extensive use of shade. Additional research can help explore the factors controlling this behavior, whereas the focus of this study was on explaining the mobile behavior, walking.

4.2. Relationship Between THI and Walking Behavior

There was a statistically significant and positive relationship between walking time and the Temperature-Humidity Index (THI) (Figure 2). This indicates that white rhinoceroses spent longer time walking under conditions when humid heat was higher. Walking, the most energetically expensive of all behavior, is vital to thermoregulation, enabling animals to dissipate body heat via airflow and movement to shaded or cooler areas. The pattern revealed shows that rising humid heat loads invoke behavioral patterns in a bid to restore physiological balance.

4.3. Wind and Irradiance Impact

In contrast wind speed and illumination showed relatively weak or no significant relationship (respectively) with walking behavior (figures 3 and 4). The less significant relationship between wind and walking may indicate that in enclosures wind speed might not be a good cause of behavioral change, perhaps because in enclosures spatial buffering is such that a changing air movement is of little effect. The absence of relation between illumination and walking may indicate that light intensity itself does not directly produce a stimulus for a change in behavior, but may be an indirect stimulus in Relation with other factors of environment such as temperature [10].

4.4. THI Significance as a Total Thermal Indicator

The significance of an evolving relationship between the Temperature-Humidity Index (THI) and walking behavior is noteworthy since the index provides a single parameter which incorporates both temperature and humidity and therefore expresses the overall thermal stress more accurately. The THI is high in conjunction with a high heat load, which can have an effect on physiological and behavioral processes the animals such as respiration, water balance mechanisms and metabolic rate. This becomes important with a larger animal such as the rhinos, with a low surface area to volume ratio and inefficient refrigeration by perspiration. It is critical therefore that this information be taken into account by management of animals where possible.

4.5. Significance for Animal Welfare and Building Design

The implications of these results show that the design of climate specific, species-specific enclosures have to be made in order to allow behavioral thermoregulation. More access to water bodies, mud wallowing and shade would allow for the expression of more natural behaviors and thus improve welfare. The shortcomings that have been shown in wallowing and drinking indicate that even currently designed facilities can be designed in such a way as to improve animal conditions [11].

4.6. Policy Context and Management Recommendations

At the policy level, while the National People’s Congress Standing Committee reform resolution has forbidden the consumption of wildlife for commercial purposes, exceptions have been made for non-food uses, which means medicines and displays. This creates a grey area between “rational utilization” and “protection” which can have a negative effect on the implementation of welfare-based practices. More transparent direction and enforcement of regulations would enhance animal protection and ensure ethical standards of conservation [12].

4.7. Broader Significance of the Study

This study provides China's additional quantitative evidence of the effect of environment on the behavioral ecology of Ceratotherium simum in captivity. Since earlier studies have been aimed mainly at the African and European populations, these local results establish the need for local management policies to be adopted in accordance with China's subtropical climate.

Secondly, it has been found that environmental conditions, notably thermal load, have a direct effect on the central activities of C. simum, such as walking, so that climatic adaptive design of zoos and thermal monitoring systems are of even greater importance.

4.8. Relevance to Climate Change and Future Directions

In the wider context of global climatic change, there is an increasing likelihood that captive animals will be subjected to progressively artificial climatic regimes which do not fulfil their behavioral or physiological needs. The present work supplies important data to facilitate the forging of climate-resilient, data-driven management recommendations and policy intervention in the near future. The inclusion of these findings in the assessment of welfare and the planning of facilities will be a key to protecting vulnerable species and permitting sustainable conservation measures which are also consistent with global development objectives.

Aside from the insights gained from this study, several limitations should be indicated with further improvements. First, the sample size was relatively small and limited to a single zoo or conservation area, which may constrain the generalizability of the findings to other populations or species. The major limitation of statistical methods is the need for a large sample size to even make valid assumptions for a predictive model [13]. However, the selected species can offer indications for tailored research and the importance of individualized animal welfare assessment. Moreover, behavioral observations were conducted over a relatively short period in a month. Observing for only two hours a day may miss more details of their behaviors.

In future investigations, continued video recording of rhinoceros behavior studied in this (and similar) experimental conditions for a full 24-hour period would show more accurate details of behavior on the specific experimental days. Observations were made in summer only and hence are subject to the specific seasonal and climatic conditions during summer which may have had an effect upon activity patterns which was not evident in other climatic conditions particularly during the cold weather prevalent in winter. Also, observations made in the different seasons would provide the opportunity to ascertain if and what possible seasonal variation may be effective in the results reported here.

Lastly, some behavioral patterns, such as social behavior, were not recorded completely by the observed behavior technique and hence their limitations indicate that the results recorded though providing important suggestions for animal conservation and management in zoos, must be interpreted with caution extrapolated into larger contexts. Future studies with larger numbers of animals, additional sites and behavior monitoring at the same times would further strengthen the data base [14].

5. ENHANCED POLICY RECOMMENDATIONS

5.1. Individual Animal Records System

Current animal management is plagued by fragmented short-term records that are inconsistent, making it hard to pick up health or behavior problems early, and inhibiting the scope for longitudinal research and evidence-based management decisions.

Institute a complete digital record system covering all animals such as ID, sex, age of animal, health condition, behavior characteristics, and the tolerance of the animals to changes in their environment. Include devices for automatic monitoring such as RFID devices, GPS collars and video monitoring, allowing for the uninterrupted collection of real time data [15].

This system of recording will provide a current scientific information storage of apparently fragmented bits of information, eliminating error in the manual recording of data and allowing for a more subtle tracking of behavioral and health changes. It will be a more continuous, accurate and effective method of collecting data than the present use of short term observation by humans, and allow the managers and researchers a more valid evidence base from which to work.

The utility of the system to the animals will facilitate increasing individualization of care, early detection and intervention to eliminate stress or ill health and will enhance welfare outcome. It will also facilitate long-term accumulation of standardized data covering individual animals, allowing sufficient information to study changes associated with long term treatment and categories of management procedures, circumventing many of the problems of long term observation by humans, and along with the continuity of standard data, lend itself to studies of a longitudinal nature, and allow refinements to evidence-based management practices, along with interesting contributions to studies impacting on the conservation of species and ecological studies.

5.2. Climate-Adaptive Facility Policies

Climate change is increasingly exposing zoo animals to heat stress and variable micro-environmental conditions which can lead to compromised welfare, reduced diversity of activity, and ultimately the elimination of natural behavior. Such a design has not traditionally lent itself to adaptive design mechanisms for coping with these environmental pressures.

Design or upgrade enclosures with climate responsive design features such as shady areas, mist or sprinkler systems, mud bathing areas, and additional water stations. Continuous monitoring of temperature, humidity, and light levels is important to ensure that buildings may respond dynamically to changes [16].

This solution actively counteracts environmental stressors by combining structural upgrade with real-time data monitoring and adaptive management. Whilst the traditional enclosure approach entails rigid enclosure design, the flexible approach of sensor-based systems works to ensure that welfare measures are effective under climates both expected and unexpected, enhancing the resilience.

The newly upgraded facilities will provide a considerable reduction in heat stress, and improve natural thermoregulatory and comfort behaviors and welfare in general, during periods of extreme or variable climatic conditions. Particularly, the flexible design framework, driven by data, provides a proactive approach to adapting zoo infrastructure to long term climate change effects and applies to wider sustainable animal management and conservation messages [17].

6. CONCLUSION

This study indicates a highly significant positive relationship between the THI and the walking activity of captive white rhinoceroses (Ceratotherium simum) in Yunnan and demonstrates thermal stress to be a principal environmental determinant of their activity. Other environmental effects (such as wind velocity and light intensity) showed relatively weaker effects; in the case of light intensity, the relationship was not significant. Thus, the importance of a wide indicator of thermal stress such as THI in animal management is emphasized since such indicators express with greater accuracy the constellation of pressures exercised on the animals from the surrounding environment. Though the present study has been carried out with a small sample of animals, and the period over which observations took place was limited, the results contained therein should serve to enrich our quantitative knowledge of the captive rhinoceros population in China. They emphasize also the urgent necessity which exists for enclosures and management plans for these animals with reference to seasons of climatic change. Future observations should, if practicable, be carried out on a wider sample basis, such that, for example, the observations extended over a longer yearly term of time in order that proper measures may be taken for formulating plans dealing with the problems of long-term continuation of the species under consideration amidst the troublesome background of climatic effects in various parts of the world.

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