Comparative Analysis of Temperature Effects on the American Black Bear (Ursus americanus) Subspecies

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Abstract

This study investigates the influence of temperature on stereotypic behaviors in two subspecies of American Black bears (Ursus americanus), the Louisiana black Bear (Ursus americanus luteolus) and the Kenai black bear (Ursus americanus perniger), housed at the Audubon Zoo in New Orleans, Louisiana. Using focal animal sampling, we observed the bears' behaviors over several sessions, recording temperature data before each observation. Results indicate a significant positive relationship between temperature and stereotypic behaviors in the Kenai black bear, suggesting that this subspecies is acclimatized to cooler climates and exhibits stress responses when exposed to warmer environments. In contrast, the Louisiana Black Bear showed no significant changes in stereotypic behavior with temperature fluctuations, reflecting its adaptation to the warmer, subtropical conditions of the southern U.S. The interaction between temperature and location was also significant, highlighting the compounded effects of environmental stressors and subspecies-specific adaptations. These findings underscore the importance of phenotypic plasticity in shaping how these bears respond to temperature, with the Louisiana black bear demonstrating greater resilience. The study also discusses broader implications for the conservation of cold-adapted species in the context of climate change, suggesting that species like the Kenai black bear may face heightened vulnerability due to warming global temperatures. Overall, this research emphasizes the need for tailored management practices in zoos and conservation efforts to mitigate the effects of environmental stress on both captive and wild bear populations.

Keywords: American Black Bear (Ursus americanus), temperature, stereotypic behavior, subspecies, zoo, animal behavior

Introduction

Stereotypic behavior, which refers to repetitive, invariant behaviors with no apparent goal or function, is a common phenomenon observed across the animal kingdom, particularly in captive or semi-captive environments. Such behaviors are often linked to signs of distress, frustration, or boredom and are indicative of an animal's response to unmet natural needs (Garner, 2005). These behaviors can manifest in various forms, such as pacing, head bobbing, or other repetitive actions

(Shih et al., 2016). The onset of stereotypic behaviors is generally influenced by a range of factors, including limited space, lack of stimulation, and environmental stressors. Large roaming animals, for instance, may experience heightened levels of frustration due to restricted space that does not align with their natural roaming habits, while shy or reclusive species can become stressed by excessive human interaction around their enclosures (Mason, 2010). Such conditions often result in what is colloquially known as "zoochosis"—abnormal behaviors that are prevalent among animals in captivity (Yasmeen et al., 2023).

Bears, members of the family Ursidae, exemplify a group of large, highly adaptable mammals that are distributed across a wide range of ecosystems on all continents except Africa, Oceania, and Antarctica (Mclellan, 1994). Each bear species and subspecies has developed unique evolutionary adaptations that enable survival in specific environmental conditions, from the polar ice of the Arctic to temperate forests and tropical regions. These adaptations encompass variations in physiology, foraging strategies, hibernation cycles, and reproductive behaviors, intricately linked to the bears' natural habitats (Kumar et al., 2017). However, ongoing climate change is disrupting these delicately balanced ecological relationships, potentially altering the natural behaviors of bear populations worldwide. This presents a growing concern for conservationists and researchers as the effects of climate change accelerate (Togunov et al., 2022).

Environmental temperature plays a critical role in shaping the behavior and welfare of large mammals in captivity. For instance, studies on captive Asian elephants have revealed that lower temperatures are associated with an increase in stereotypic behaviors, which are commonly linked to stress and poor welfare (Mason et al., 2003). This observation raises questions about whether similar patterns occur in other large mammals, such as Black bears, when exposed to non-native or unfamiliar climates. While phenotypic plasticity—the capacity of an organism to adjust its behavior or physiology in response to environmental changes—may buffer these effects, the specific responses of Black bear subspecies to varying temperatures remain underexplored. Investigating these responses, alongside findings from other species, could provide valuable insights for improving captive bear management and developing more effective conservation strategies for wild populations (Vogt, 2022).

Despite a breadth of research on bear behavior, studies examining the relationship between weather—particularly temperature fluctuations—and stereotypic behavior in different subspecies of the American Black Bear (*Ursus americanus*) remain limited. To bridge this gap, this study will focus on Black bears housed at the Audubon Zoo in New Orleans, Louisiana, specifically two Black bears from Anchorage, Alaska, and one from Louisiana. Although these bears are housed together, they represent different subspecies of the American Black Bear: the Kenai Black Bear (*Ursus americanus perniger*) from Alaska (Audubon Nature Institute, 2022b) and the Louisiana Black Bear (*Ursus americanus luteolus*) from Louisiana (Audubon Nature Institute, 2022a).

Past research conducted at the National Zoo in Washington, D.C., found that Black bears exhibited increased docility during colder months, presumably in preparation for hibernation (Hughes et al., 2002). However, the applicability of this finding to southern climates, where temperatures remain warmer year-round, is uncertain. Anchorage, Alaska, experiences average summer highs around 18.3˚C (Hendricks, 2024), whereas New Orleans, where the Audubon Zoo

is located, sees summer temperatures that average 32.8°C (Williams, 2024). These stark temperature differences provide a unique opportunity to study how bears originally from a cooler, northern climate respond behaviorally when exposed to significantly higher temperatures in captivity. Such observations may also offer insights into how rising global temperatures could impact wild bear populations in the future (Kurth et al., 2024).

In this study I aim to expand on the existing body of knowledge regarding the response capabilities of the Kenai Black Bear and the Louisiana Black Bear in response to temperature variations. Specifically, I seek to answer which subspecies is more prone to engaging in stereotypic behaviors under different temperature conditions. The core research questions I asked include the following: Will the Kenai Black Bear exhibit more stereotypic behavior compared to the Louisiana Black Bear due to its unfamiliar, warmer environment when the temperature is above the normal it is accustomed to? Will the Kenai Black Bear's stereotypic behavior decrease during cooler periods, closer to its native climate conditions? Conversely, will the Louisiana Black Bear show any significant behavioral changes in response to temperature fluctuations?

I hypothesize that there will be a significant difference in the total amount of stereotypic behavior exhibited by each of the subspecies at different temperatures due to different evolved thermal acclimation. I predict that the Kenai Black Bear will display a higher frequency of stereotypic behavior overall than the Louisiana Black Bear due to its relocation to a warmer, non-native environment. Additionally, I expect that the Kenai Black Bear will show reduced stereotypic behavior when temperatures are cooler, aligning more closely with the conditions of its natural habitat. In contrast, I predict that the Louisiana Black Bear, being acclimated or adapted to warmer southern temperatures, will not exhibit significant changes in stereotypic behavior in response to temperature fluctuations.

Methods

Subjects

The subjects of this study were three female American Black Bears (Ursus americanus) housed at the Audubon Zoo's Black Bear enclosure. These individuals included one Louisiana Black Bear (Ursus americanus luteolus) and two Kenai Black Bears (Ursus americanus perniger). The bears were distinguished based on physical characteristics, as documented by the differences stated by the U.S. Fish & Wildlife Service (2024). Specifically, the Louisiana Black Bear (referred to as Bear L) was identified by its relatively elongated nose and smaller overall size compared to the Kenai Black Bears . The two Kenai Black Bears were distinguished by their size: Bear K2 was the smaller of the two, and Bear K1 was the larger. The Louisiana Black Bear weighed approximately 54.4 kg, Bear K2 weighed 72.6 kg, and Bear K1 weighed 90.7 kg. All three bears were approximately 2.5 years old at the time of the study, as confirmed by the zoo staff.

Experimental Design

This observational study employed the focal animal sampling method (Altmann, 1974). Observations were conducted during regular zoo operating hours, between 13:00 and 17:00, on Thursdays, Saturdays, and Sundays over a period spanning from September to November 2024. Prior to each observation session, temperature (in ˚C) was recorded using the iPhone weather app.

Each Bear was observed for 5 minutes per focal session, and the time spent performing stereotypic and normal behaviors was recorded. To minimize observer bias, I maintained a consistent position on the designated walkway that provided a clear view of the entire enclosure. A stopwatch was used to record the exact time each bear engaged in stereotypic behavior, allowing for the calculation of the percentage of time spent on these activities during the 5-minute focal period. A total of 16.5 hours of behavioral data, equating to 198 focal samples, were included in the final analysis. The pilot observations, totaling 4 hours, were not included in the main dataset but were essential for refining the ethogram and standardizing the observation protocol (Table 1).

Stereotypic behaviors included but were not limited to self-licking, pacing, diving, head-tossing, and swaying, based on the ethogram developed during the pilot phase of the study and past studies. Normal behaviors included digging, climbing, eating, swimming and others (Shih et al., 2016; Mawah et al., 2021). The ethogram was constructed after conducting 4 hours of preliminary observations to ensure comprehensive categorization of behaviors (Table 1). Observations were performed sequentially, beginning with Bear L, followed by Bear K2, and concluding with Bear K1.

Table 1: Ethogram of Black Bear Behavior

Type of Behavior	Behavior	Behavior Description
Normal	Sleep	Bear is remaining in one place and not aroused by environmental conditions
	Eating	Bear is consuming some sort of food
	Swimming	Bear is propelling itself through the water using its limbs
	Digging	Bear is breaking up and moving dirt with paws inside of the enclosure
	Climbing	Bear is ascending different structures other than the enclosure itself
	Play	Bear engages in different types of play behavior
Stereotypic	Pacing	Bear walks back and forth from the same point, may or may not include head tossing
	Escape Behavior	Bear tries to escape the enclosure in any way possible, including but not limited to: climbing the enclosure, digging at the edge of the enclosure, scratching at the fences around the enclosure.
	Alert	Bear throws its head straight up
	Swaying	Bear moves left and right in a continuous pattern

	Diving	Bear moves quickly through the air in a downward direction into the water
	Licking	Bear licks itself or tongue licks at the air

Statistical Analysis

R-Studio (using the nlme and tidyverse packages) and Microsoft Excel were used to analyze the data. A mixed-effects model was created for each Black Bear subspecies to determine whether temperature significantly affected stereotypic behavior. In this model, temperature and location were included as interaction effects, while Bear ID was included as a random effect to account for multiple observations of the same individuals. A second model was constructed with the proportion of stereotypic behavior as the response variable and date and temperature as fixed effects. The data were analyzed using a 95% confidence interval to ascertain the significance of the findings.

Results

Behavioral differences between subspecies were notable. The Kenai Black Bears exhibited a markedly higher mean proportion of stereotypic behavior (0.396 ± 0.239) compared to the Louisiana Black Bear (0.041 ± 0.083), reflecting potential subspecies-specific responses to environmental conditions (Table 2). The statistical analysis demonstrated that temperature significantly influenced the proportion of stereotypic behavior in American Black bears.

Table 2: Bear Sample Statistics

	Louisiana Black Bear (*Ursus americanus luteolus*)	Kenai Black Bear (*Ursus americanus perniger*)
Mean (m)	.041	.396
Sample Standard Deviation (sd)	.083	.239
Number of Observations (n)	66	132

Specifically, for each 1°C rise in temperature, there was a 0.028-unit increase in the proportion of stereotypic behaviors, a relationship that was highly significant (t = 7.04, df = 193, p

< 0.001). While location had an observable effect on baseline stereotypic behavior, this effect was not statistically significant (t = 1.18, df = 1, p = 0.44). However, the interaction between temperature and location was significant, indicating that the effect of temperature on stereotypic behavior varied between locations (t = −3.70, df = 193, p < 0.001) (Figures 1, 2). The separate linear model examining the effects of date and temperature on stereotypic behavior did not yield significant results for date as a predictor (t = 1.20, df = 195, p = 0.46) (Figure 3); however it confirmed that temperature was a significant factor (t=2.86, df=195, p<0.001) This suggests that temperature, rather than date, played a more critical role in influencing stereotypic behaviors.

Figure 1. Black Bear Temperature vs. Proportion of Stereotypic Behavior of each Bear Scatter Plot

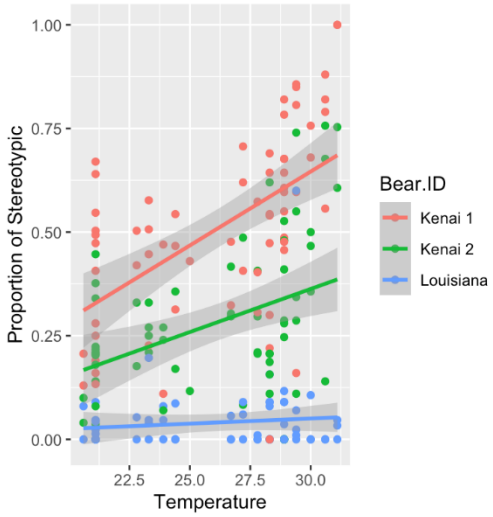


Figure 2. Kenai vs. Louisiana Black Bear Scatter Plot

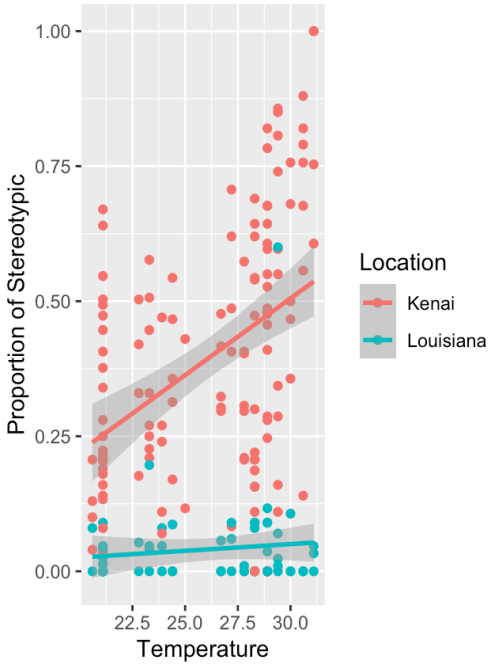
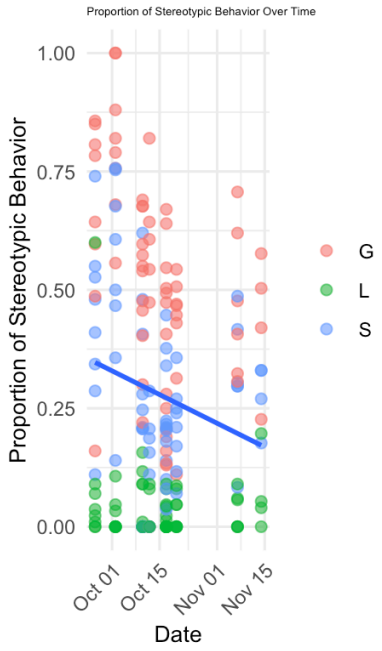


Figure 3. Proportion of Stereotypic vs. Date Scatter Plot



Discussion

This study highlights the intricate relationship between temperature and stereotypic behavior in two subspecies of American Black Bears: the Louisiana Black Bear (Ursus americanus luteolus) and the Kenai Black Bear (Ursus americanus perniger). The results reveal notable differences in how these subspecies respond to temperature changes, reflecting their distinct evolutionary histories and ecological adaptations or acclimatization s to different temperature regions.

The Kenai Black Bear exhibited a significant increase in stereotypic behaviors, such as pacing, swaying, and self-licking, with rising temperatures. These behaviors are well-documented indicators of stress in captive animals and typically arise when environmental conditions differ from those to which a species is naturally adapted such as higher ambient temperatures causing an increase in cortisol levels in Polar Bear blood (Leishman et al., 2022). The strong correlation between temperature and behavior in the Kenai Black Bear underscores its limited phenotypic plasticity, consistent with its evolutionary adaptation to the overall cooler environments typical of its native Alaskan habitat.

In contrast, the Louisiana Black Bear displayed a stable pattern of behavior across varying temperatures, with no significant changes in stereotypic activity. This behavioral resilience suggests a high degree of thermal adaptability, likely rooted in the subspecies' evolution in subtropical regions where exposure to high and fluctuating temperatures is common. Similar behavioral stability has been observed in other heat-adapted species, such as the sun bear, which show fewer stress responses under thermal variation (Mawah et al., 2021).

The interaction between temperature and location adds another layer of complexity to these findings. For the Kenai Black Bear, displacement from its native habitat appeared to amplify its sensitivity to temperature changes, resulting in pronounced behavioral shifts. This underscores the importance of environmental congruence in captive settings, as even moderate deviations from a species' natural conditions can significantly impact behavior (Mason, 2010). The linear model examining the effects of date and temperature suggested that short-term temperature changes, rather than seasonal variations, were the primary drivers of stereotypic behaviors. This reinforces the conclusion that immediate thermal conditions are a critical factor influencing stress responses in these subspecies.

The implications of these findings extend beyond the confines of captive settings, particularly in the context of global climate change. Rising global temperatures pose a significant threat to cold-adapted species like the Kenai Black Bear, which may face increased stress and disrupted behaviors in the wild. Studies on other cold-adapted species, such as polar bears, have shown that warming conditions can interfere with essential behaviors, including hibernation, foraging, and reproduction, ultimately threatening population viability (Togunov et al., 2022; Kurth et al., 2024). The Kenai Black Bear may encounter similar challenges as its native habitat becomes warmer, underscoring the need for proactive conservation measures. In contrast, the Louisiana Black Bear's resilience to thermal variability suggests a greater capacity to adapt to warming trends. However, even heat-adapted species are not immune to the long-term effects of climate change, which could disrupt food availability, habitat quality, and other ecological factors critical to their survival (Lawler et al., 2015). These potential impacts warrant continued monitoring and research to assess the resilience of Louisiana Black bears under changing environmental conditions.

From a captive management perspective, these results emphasize the need for subspecies-specific strategies to mitigate stress and promote welfare. For the Kenai Black Bear, environmental modifications that replicate its native thermal conditions—such as shaded areas, misting systems, and water features—could help reduce thermal stress and the prevalence of stereotypic behaviors. Enrichment activities designed to mimic natural foraging, climbing, or exploratory behaviors could further alleviate stress by providing mental and physical stimulation (Mason et al., 2006). For the Louisiana Black Bear, maintaining a diverse and engaging enclosure environment will remain critical to sustaining its overall welfare, although its thermal tolerance reduces the urgency for temperature-specific interventions.

Despite its contributions, this study has limitations that warrant consideration. The controlled environment of the Audubon Zoo, while ideal for systematic observation, does not fully replicate the complexity of natural habitats. Factors such as human interaction, enclosure size, and design may have influenced behavioral outcomes. Additionally, the small sample size of three bears limits the generalizability of the findings, though the focus on two distinct subspecies provides valuable insights into behavioral variability. Future research should address these limitations by expanding sample sizes, extending study durations, and incorporating a wider range of environmental and social conditions.

One promising avenue for future research is the integration of hormonal stress markers, such as cortisol, to complement behavioral observations. Measuring physiological indicators of stress would provide a more comprehensive understanding of how temperature and other environmental variables influence well-being. Additionally, exploring the effects of social housing versus solitary conditions on stress responses could yield critical insights for optimizing management practices. Research into sensory enrichment, such as olfactory or auditory stimuli, may also reveal novel ways to reduce stress and enhance welfare in captive bears. Finally, longitudinal studies that track behavioral and physiological responses to seasonal and climatic changes over extended periods could offer valuable insights into the long-term impacts of environmental variability. Such studies would be particularly relevant in the context of climate change, where understanding the adaptive capacity of both cold- and heat-adapted species is critical for developing effective conservation strategies.

Overall, this study highlights the significant influence of temperature on stereotypic behaviors in American Black Bears , with notable differences between subspecies. The findings emphasize the importance of considering evolutionary history, ecological adaptation, and phenotypic plasticity in understanding behavioral responses to environmental stressors. By addressing these challenges through targeted management practices and conservation efforts, zoos and wildlife organizations can better support the health and sustainability of bear populations in both captive and wild environments. In an era of rapid environmental change, such research provides essential guidance for ensuring the welfare and survival of vulnerable species.

Acknowledgements

I have no conflicts of interest to report. I would like to thank the staff at the Audubon Zoo, my peers in Experimental Animal Behavior for your continuous peer review, Ben VanDerHeyden for helping with corrections, Jordan Sztejman for help with Data Analysis, and finally Luke Anderson and Jordan Karubian for your initial guidance and mentorship on the process in creating this paper.

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