Exploring species-typical behavior patterns of giraffes (*Giraffa camelopardalis*) housed across US zoos (#102930)

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Exploring species-typical behavior patterns of giraffes (*Giraffa camelopardalis*) housed across US zoos

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Interpreting animal behavior in the context of welfare can be inherently challenging given our limited knowledge of what constitutes “normal” behavior for many species housed in zoos. Describing species-typical behavior patterns may help animal managers by providing additional background when assessing the individuals in their care. Although valuable, these efforts require a large, collaborative approach and have, consequently, been rare. Here, we share the species-typical behavior pattern of giraffes, an iconic and commonly housed megafauna in zoos. Behavior data were evaluated for 66 giraffes living across 18 AZA-accredited zoos using the ZooMonitor Community platform. Data were recorded for approximately one year at each zoo. The most common behaviors observed were feeding/foraging behaviors, which accounted for 38.5% of the mean visible time budget across giraffes. Time spent in these behaviors varied by individual and ranged from 14.3% to 69.5% of visible time. Stereotypic behaviors occurred in all study individuals, with oral stereotypic behaviors being most common. Although prevalent, stereotypic behaviors varied considerably across giraffes, with some individuals performing these behaviors only on a few occasions to an individual that performed these behaviors once every few minutes. This study is the largest evaluation of giraffe behavior across zoos and provides the most complete picture of their species-typical behavior patterns in managed care to date. We hope these multi-institutional behavior patterns can provide perspective to aid animal managers in evaluating giraffes in their care.

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Abstract

Interpreting animal behavior in the context of welfare can be inherently challenging given our limited knowledge of what constitutes "normal" behavior for many species housed in zoos. Describing species-typical behavior patterns may help animal managers by providing additional background when assessing the individuals in their care. Although valuable, these efforts require a large, collaborative approach and have, consequently, been rare. Here, we share the species-typical behavior pattern of giraffes, an iconic and commonly housed megafauna in zoos. Behavior data were evaluated for 66 giraffes living across 18 AZA-accredited zoos using the ZooMonitor Community platform. Data were recorded for approximately one year at each zoo. The most common behaviors observed were feeding/ foraging behaviors, which accounted for 38.5% of the mean visible time budget across giraffes. Time spent in these behaviors varied by individual and ranged from 14.3% to 69.5% of visible time. Stereotypic behaviors occurred in all study individuals, with oral stereotypic behaviors being most common. Although prevalent, stereotypic behaviors varied considerably across giraffes, with some individuals exhibiting these behaviors only on a few occasions to an individual that exhibited these behaviors once every few minutes. This study is the largest evaluation of giraffe behavior across zoos and provides the most complete picture of their species-typical behavior patterns in managed care to date. We hope these multi-institutional behavior patterns can provide perspective to aid animal managers in evaluating giraffes in their care.

Introduction

Understanding what is "normal" or typical behavior for an individual animal in managed care is likely a central question asked by many animal care managers, as a departure from typical patterns may have welfare implications. However, defining normal behavior can be challenging. First, what is meant by "normal" may differ between people. Specifically, is "normal" synonymous with *average* using a statistical interpretation of the word (e.g., Ivy, 1945) or does it refer to *proper* functioning (e.g., King, 1945)? Although we consider both views below, we generally use "normal" throughout to describe common behaviors, thereby drawing from a statistical interpretation without additional reference to whether the behavioral expression indicates good or poor welfare. Second, collecting relevant data to make inferences on the normalcy of a behavior pattern can be challenging. Behavior, by definition, is a dynamic process that enables animals to respond to changes in their environment and is reinforced through individual experiences (Gomez-Marin & Ghazanfar, 2019; Levitis, Lidicker, & Freund, 2009). Thus,

behavior patterns may vary between individuals and can change over time. Systematic monitoring of animal behavior at a single institution can help shed light on an individual animal's behavioral repertoire and patterns. However, classifying these individual behavior patterns as normal from a species perspective requires the additional context of the behavioral patterns of other individuals.

One approach to interpreting "normal" behavior patterns is to compare the behavior of an individual in managed care to their wild conspecifics (e.g., Veasey, Waran, & Young, 1996a; Melfi & Feistner, 2002; Miller, Chas, & Hacker, 2016; LaDue et al., 2022). This approach largely draws from a philosophical view that the performance of natural behaviors is fundamental for welfare and the presence of behaviors not occurring in the wild are "abnormal" and detrimental to welfare (Hill & Broom, 2009 ; Browning, 2020). This view has remained a central tenet in animal welfare science since the introduction of the Five Freedoms and the fifth freedom of "Freedom to express normal behavior". As Hill & Broom (2009) state, normal behavior in this view describes those behaviors occurring in healthy animals living in environments that provide unrestricted behavioral opportunities appropriate for the species. Unfortunately, animals in the wild do not live in a utopia and face corresponding challenges, albeit different ones than typically faced in captivity. Therefore, animals in the wild are unlikely to express this idealistic conception of normal behavior. Although these comparisons to wild animals may provide some insight into the potential range of behavioral expression for a species, their use as a benchmark for welfare in captive settings has been challenged (Veasey, Waran, & Young, 1996b; Spinka, 2006; Browning, 2020; Cronin & Ross, 2020; Bartlett, Grinsted, & Freeman, 2023).

An additional, and possibly more relevant, comparison is that between the behavior of a zoo-housed animal with many other zoo-housed animals of the same species. This approach still has limitations; the range of behavior observed will depend upon the individuals and the conditions in which they live. However, this perspective can shed light on the potential for behavioral expression in the managed population. This comparison necessitates a multi-institutional approach. Although others have raised the importance of multi-institutional research (Swaisgood & Shepherdson, 2005; Watters, Margulis, & Atsalis, 2009; Whitham & Wielebnowski, 2013), the logistical challenges of recruiting for and coordinating these studies to ensure systematic and reliable data collection have made them relatively rare, but some notable examples exist. In their expansive study on elephant welfare, Meehan et al. (2016) explored the impacts of the physical environment, social experience, and husbandry practice on Asian and African elephants that included behavior data from 89 animals housed at 39 zoos. One finding from their research was that stereotypic behaviors, which may be considered abnormal from a natural behavior view, were quite common in zoo-housed elephants, occurring in 85% of the animals studied (Greco et al., 2016). Stereotypic behaviors were also found to vary considerably across individuals, with some animals exhibiting these behaviors as little as 0.5% of their time while others exhibited these behaviors for up to 68% of their time. Findings from this study have been incorporated into the Association of Zoos and Aquariums (AZA) Standards for Elephant Management and Care, a set of guidelines required for AZA Accreditation. More recently, multi-institutional research in zoos and aquariums has revealed species-typical behavior patterns for bottlenose dolphins (Lauderdale et al., 2023) and chimpanzees (Whitham et al., 2023) as well.

Giraffes are one of the most commonly housed species of megafauna in zoos, with more than 500 individuals living across more than 100 zoos accredited by the Association of Zoos and Aquariums. Currently accepted taxonomy recognizes one species of giraffe with nine subspecies, although this has been disputed and some have argued for four species of giraffe to be recognized (Fennessy et al., 2016). Giraffe subspecies managed in the AZA include the Masai, reticulated, Rothschild, and resulting hybrids of these subspecies. Giraffes are browsers and, as the tallest animal, are adapted to feed on leaves and branches in the tree canopy, spending a majority of their day foraging and feeding in the wild (Pellew, 1984; du Toit & Yetman, 2005; but see Paulse et al., 2023; Deacon, Smit, & Grobbelaar, 2024).

There has been a long history of multi-institutional research on giraffes. In their pioneering work, Veasey, Waran, & Young, (1996a) were the first to conduct a multi-institutional study on zoo-housed

giraffes, comparing the behavior of individuals housed across four different zoos to each other and giraffes in the wild. Since then, more multi-institutional studies of giraffes have been conducted, including a review of oral stereotypic behavior (Koene & Visser, 1997); a comparison of female giraffe behavior (Bashaw, 2011), evaluations of guest feeding programs (Orban, Siegford, & Snider, 2016; Ramis et al. 2022), and an assessment of seasonal habitat changes (Razal, Bryant, & Miller, 2024). Despite this work, our understanding of species-typical behavior patterns remains incomplete as these past studies have been conducted at a small number of organizations (Veasey, Waran, & Young, 1996a; Koene & Visser, 1997; Bashaw, 2011; Razal, Bryant, & Miller, 2024), on a specific demographic group (Bashaw, 2011), or during a limited time of the year (Orban, Siegford, & Snider, 2016). However, past work has highlighted potential behavioral concerns for giraffes, including limited opportunities for browsing and the presence of stereotypic behaviors (Veasey, Waran, & Young, 1996a; Koene & Visser, 1997; Bashaw et al., 2001; Tarou, Bashaw, & Maple, 2003; Bergeron et al., 2006; Fernandez et al., 2008; Bashaw, 2011; Orban, Siegford, & Snider, 2016; Okabe et al., 2022; Depauw et al., 2023; Walldén, 2023; Razal, Bryant, & Miller, 2024).

Here, we contribute new information to the question of giraffe behavioral repertoires in North American zoos. Given previous research, we pay particular attention to feeding and stereotypic behaviors in giraffes housed across 18 AZA-accredited zoos over a one-year period. To our knowledge, this is the largest study of giraffe behavior in zoos. This exploratory study provides a holistic overview of species-typical behavior patterns in giraffes in managed care and provides important benchmarks for future inquiries regarding how individual behavior relates to population-level patterns.

Materials & Methods

Subjects and Housing

Focal subjects included 67 giraffes (26 males, 41 females) housed across 18 U.S. zoos that were accredited by the Association of Zoos and Aquariums (AZA). One female giraffe passed away shortly after the start of data collection and was excluded from analysis, resulting in 66 giraffes being considered in this study. This study was reviewed and approved by institutional research review boards at each zoo. These zoos represented organizations of varying size and were geographically located across the United States. Each participating zoo was asked to observe, where possible, a minimum of three giraffes from their herd. The selection of focal subjects was pseudorandomized such that the Primary Investigator (PI) provided an initial random selection of three focal individuals to each zoo who was then given the option to include additional individuals based on their monitoring capacity or swap individuals based on their management priorities. The number of focal animals at each zoo ranged from two to eight individuals.

Prior to the start of the study, surveys were administered to participating zoos to gather information on individual and habitat characteristics. Focal giraffes in this study ranged in age from 1 to 29 years, with a median age of 9 years. The total herd size (including non-focal individuals) ranged from 2 to 16 individuals, with a median herd size of 5 giraffes. Giraffes were primarily managed in a single social group (n=59) and housed socially overnight (n=61). During periods of the year with outdoor access, roughly half of the study giraffes were shifted into indoor areas overnight (n=32). Most giraffes in the study were not contracepted (n=43). Of the focal subjects, 49 giraffes were reported prior to the start of the study to exhibit a stereotypic behavior, with oral stereotypies being the most commonly reported (n=39), followed by locomotor (n=17), head rolling (n=9), and self-injurious (n=1).

Habitat size varied widely across the zoos, with the smallest habitat measuring 464 m^2 and the largest habitat measuring 263,045 m^2. The median habitat size was 3,507 m^2. The percent of the total habitat space that was outdoors ranged from 4% to 100%, with a median of 90%. The percent of the total habitat space that featured soft substrate ranged from 75% to 100%, with a median of 92%. Most zoos housed giraffes with other species (n=14). This most commonly included other artiodactyl species (n=13) or birds (n=9).

143

144 *Data Collection*

145 Data collection and project coordination were conducted through the ZooMonitor Community collaborative
146 platform. A project was created in ZooMonitor (Version 5; Lincoln Park Zoo, 2024) and shared to the
147 Community platform prior to the start of data collection. Participating zoos were then able to view and join
148 the project in the Community and access the project's ethogram, behavior sampling methodology, and
149 training materials. After joining the project, participating zoos were then instructed to add their focal
150 individuals, animal habitat maps, and observers to their project. Each zoo also completed short surveys
151 on their individuals and habitats in ZooMonitor. Behavior data were recorded at each zoo using the
152 ZooMonitor app (Wark et al., 2019) and shared with the PI through the Community feature of ZooMonitor.

153 Data were collected for approximately one year at each participating zoo, starting in January, 2022 and
154 continuing to March, 2023. As several focal giraffes were added during the study and one individual
155 passed away near the end of data collection, a full year of data collection (i.e., minimum of 45 weeks of
156 data collection) was not possible for some individuals (n=6). These individuals were included in the
157 analysis to provide the most comprehensive view of giraffe behavior patterns possible. Behavior
158 observations were conducted during daytime hours (7:00 to 18:00) and were approximately balanced by
159 time of day.

160 Giraffe behavior was recorded during 10 min. observation sessions at each zoo. Observers were
161 instructed to record data for a single focal animal during observation sessions but, in a small number of
162 cases (3.5% of sessions), multiple focal animals were observed simultaneously. The ethogram of
163 behaviors observed in this study are shown in Table 1. All behaviors on the ethogram were recorded
164 using instantaneous point-sampling at one-min. intervals. In addition, all occurrences of stereotypic
165 behaviors were noted.

166 To ensure reliable and consistent observations within and across zoos, a three-part observer
167 testing process was conducted. This process relied heavily on video materials and was informed from
168 past research that identified potential gaps to live, in-person reliability testing (Wark, Wierzal, & Cronin,
169 2021). First, to familiarize observers with the appearance of ethogram behaviors, observers were
170 administered a 20-question online test that featured brief video snippets of different behaviors to identify.
171 After completing this test, observers then began inter-observer reliability testing. They were then asked to
172 complete two 10-min. video reliability tests, with a mean percent agreement of 85% or better required to
173 pass. Observers that did not pass initially were given two additional attempts (i.e., six total video reliability
174 tests maximum). If an observer did not pass video reliability testing (n=4), they were not permitted to
175 record data for this project. Observers that passed video reliability tests were then required to complete
176 two in-person reliability tests at the giraffe habitat with a project lead at each zoo. All project leads had
177 prior experience with research and/or giraffes had also completed the first two virtual testing parts. Given
178 logistical challenges, it was not possible for project leads to conduct in-person reliability tests across
179 institutions.

180 *Data Analysis*

181 To provide an account of the range of behavioral expression of zoo-housed giraffes, the percent of time
182 (i.e., percent of intervals) an individual was engaged in each behavior was first calculated for each
183 observation session. Then, an overall mean percent of time was calculated for each focal giraffe and
184 behavior across sessions. As the number of recorded intervals varied, sessions with less than five
185 intervals recorded were excluded from the analysis to prevent artificially inflated percentages (Wark et al.,
186 2023). Data are presented for both the individual behaviors and combined behavioral categories. To
187 illustrate the variability within behavioral categories, the standard deviation of the mean (SD), the
188 coefficient of variation (CV) (SD/ mean * 100), the range (max – min), and interquartile range (IQR; 75^{th} –
189 25^{th} quartile) were calculated. In addition to absolute measures of variability (i.e., SD, range, IQR), the CV

was included as a relative measure of variability to aid comparison between common and rare behaviors, as this metric standardizes the variability relative to the mean.

For stereotypic behaviors that were recorded on an all-occurrence basis, a rate was calculated by dividing the sum of the number of occurrences during each observation session by the number of visible intervals during a session These visible behavior rates per session were then averaged to calculate an overall mean rate of time for each individual. As with the analysis of interval data, sessions with less than 5 visible intervals were excluded from analysis. Rates were calculated for both individual behaviors and combined behavioral categories based on the type of stereotypy (i.e., locomotor, oral, motor).

Analyses and visualizations were performed using R statistical software (version 4.3.1; R Core Team, 2023).

Results

A total of 9,492 focal observation sessions were conducted. The mean number of weeks that focal individuals were observed was 50.3 and ranged from 13 to 58.1 weeks. The mean number of observation sessions per focal individual was 143.8 sessions and ranged from 22 to 373 sessions.

Species-typical Behavior Patterns

The range of behavioral expression observed in this one-year study of 66 giraffes is shown in Fig. 1, with summary statistics for each behavior category displayed in Table 2. Giraffes in this study spent the largest portion of their time visible engaged in a feeding or foraging behavior ($\bar{X}$ = 38.5%): browsing ($\bar{X}$=13.2, SD=9.7); other feeding/foraging ($\bar{X}$=13.0, SD=8.4); extractive foraging ($\bar{X}$=12.3, SD=8.5). Standing was the most common behavior observed ($\bar{X}$=17.4, SD=6.9) followed by ruminating ($\bar{X}$=15.6, SD=6.8). For most individuals, stereotypic behaviors constituted a relatively modest portion of the overall visible time budget ($\bar{X}$=10.4, SD=5.5): repetitive licking ($\bar{X}$=4.8, SD=8.6); tongue play ($\bar{X}$=4.8, SD=9.1); pacing ($\bar{X}$=0.5, SD=1.5); other stereotypy ($\bar{X}$=0.4, SD=0.9).

As a category, feeding and foraging behaviors showed the largest absolute variation across individuals, with an interquartile range (IQR) of 17.4% of visible time and range of 55.2% of visible time from the maximum to minimum observed per individual (Table 1). However, when evaluating the relative variability, adjusting for differences in the mean percent of time between behavior categories, feeding/ foraging behaviors had the lowest CV, as these behaviors were the most common. In contrast, stereotypic behaviors and social behaviors displayed large variation across individuals, with CVs over 100% (i.e., standard deviation was greater than the mean, Table 2). Inactive, locomotion, and ruminating behaviors showed a similar level of variation across study individuals, with CVs of 41.1%, 42.2%, and 43.5%, respectively.

Giraffes in this study were rarely out of view of the observers (not visible: $\bar{X}$=5.3, SD=5.8).

Feeding/ Foraging Behavior

The individual variation in visible time spent engaged in feeding or foraging behaviors is shown in Fig. 2. The maximum visible time spent feeding by a giraffe in this study was 69.5%. This individual was also observed to spend the most time browsing of any giraffe ($\bar{X}$=47.3, SD=36.3). The minimum visible time spent feeding or foraging by a giraffe was 14.3%. All giraffes were observed browsing or extractive foraging and most giraffes engaged in both behaviors (63/66 individuals).

Stereotypic Behavior

A total of 7,763 occurrences of stereotypic behavior were observed in this study. All giraffes in this study were observed to exhibit a stereotypic behavior at least once. Individual stereotypic expression ranged

from individuals that exhibited only one occurrence of a stereotypic behavior during the study (3 individuals) to an individual that exhibited 946 occurrences of stereotypic behavior.

The most common type of stereotypic behavior observed was oral, which accounted for 91.2% of the stereotypic behavior occurrences. Motor stereotypic behaviors were the next most frequent (5.6% occurrences) and locomotor stereotypic behaviors were the least frequent (3.2%). The majority of individuals exhibited more than one type of stereotypic behavior (41/66 individuals). However, of those individuals, most had a dominant stereotypy that accounted for more than 90% of their occurrences (27/41 individuals) (Fig. 3).

Although stereotypic behaviors were observed throughout the population, the time invested in stereotypic behavior varied greatly. Rates of stereotypic behaviors ranged from 0.0008 to 0.6 occurrences per minute, which corresponds to once every 1,250 min to once every 1.6 min of observation time.

Discussion

The goal of this study was to broadly describe typical giraffe behavior patterns in US zoos to better understand what "normal" behavior may look like in managed care and identify abnormal patterns that may signify a welfare concern. Through collaborative data collection across 18 zoos, this study provides the strongest insight yet into behavior patterns of zoo-housed giraffes. In addition to a general overview of behavioral expression, we examined foraging and stereotypic behaviors in detail, given the past attention towards these behaviors and their potential relationship to welfare (Bergeron et al, 2006).

For most maintenance behaviors, such as feeding and foraging, ruminating, inactivity, and locomoting, variation across individuals was low when considering the relative variability of common and rare behaviors (i.e., CV), presenting a clear picture of "normal" activity in AZA-accredited zoos. Social behaviors showed a high degree of variation when considering both absolute and relative measures of variability, however, overall rates were quite low despite differences in herd sizes across the study population. Stereotypic behaviors, on the other hand, showed a high degree of variation between individuals and were more common and observed to a varying degree in all individuals. The expression of stereotypic behaviors, therefore, may be considered "normal" for giraffes living in AZA-accredited zoos but their frequency may depend on individual- and organization-level factors.

Similar to past research, we found feeding behaviors represented a large portion of the visible time budget of giraffes (mean 37% of time and IQR of 29.1% – 46.5%). Notably, this estimate is generally higher than has been reported in previous multi-institutional studies (based on published values or extracted from graphs). For example, Veasey, Waran, & Young (1996a) found giraffes at four UK zoos spent between 17% to 26% of their time feeding and foraging, with the mean time across zoos of approximately 23%. Koene (2013) similarly reported giraffes at four Dutch zoos spent between 12% to 27% with a mean time across zoos of approximately 19%. Bashaw (2011) observed feeding behaviors by female giraffes ranged from approximately 17% to 41% across three herds, with a mean time feeding of approximately 27%. Similarly, Orban, Siegford, & Snider (2016) reported giraffes across nine zoos feeding for approximately 20% of time. Understanding the range of time giraffes in zoos spend feeding and foraging can be a valuable tool for animal managers evaluating individuals in their care and the potential for behavioral changes. It is generally agreed that more time spent feeding and foraging can support giraffe welfare (Rose, 2023); combining that background knowledge with the current data would suggest attention is warranted for individuals on the low end of these zoo-based estimates (i.e., feeding and foraging less than 30% of their visible time budget), and that it is within the potential of zoos to support more feeding and foraging time by resident animals.

The greater time feeding observed in the present study compared to prior research may reflect greater attention to feeding behaviors in giraffes as a result of past research and husbandry recommendations (e.g., Bergeron et al., 2006; EAZA, 2006). In the present study, giraffes spent

approximately equal amounts of time engaged in each of the three feeding behaviors recorded: browsing, extractive foraging/ feeding, and other feeding. Many zoos have been striving to increase browsing and extractive foraging opportunities to prolong feeding bouts (Fernandez et al., 2008) and it is encouraging to see these behaviors well represented in the behavioral profiles of giraffes in this study. In a recent example, Depauw et al. (2023) evaluated changes in how giraffes were fed at a zoo that included an emphasis on increased browse and use of slow feeders, among other dietary changes, and found giraffes nearly doubled the amount of time spent feeding and foraging (24.5% of time before vs 43.4% after) and used their tongues more during feeding bouts. Some zoos in the current study may have already begun this journey and implemented similar changes, yielding higher estimates for time spent feeding and foraging.

Unfortunately, stereotypic behaviors, which are generally indicative of current or past welfare compromise, were observed in all the study animals. This prevalence is comparable to what has been reported in past behavior studies of giraffes (e.g., Orban, Siegford, & Snider, 2016: 93% of study animals) but higher than what might have been expected based on past survey research. In a previous survey that included 214 giraffes and 29 okapis, Bashaw et al. (2001) found stereotypic behaviors occurred in 80% of giraffes and okapis. In the present study, a survey conducted before data collection commenced found project participants reported stereotypic behaviors in 71% of the study animals. Although these reports broadly correspond and highlight the prevalence of stereotypic behaviors in giraffes, it is important to note that specific estimates of behavior prevalence may vary based on the study methods. Similar discrepancies between surveys and data collection have been observed in reports on the prevalence of stereotypic behaviors in chimpanzees (c.f., Birkett & Newton-Fisher, 2011; Jacobson, Ross, & Bloomsmith, 2016), emphasizing the value of systematic data collection over retrospective reports when possible. Surveys may often be chosen for their simplicity, however, even short-term data collection may be sufficient and superior to surveys, as the prevalence in stereotypic behaviors observed by Orban, Siegford, & Snider (2016) from three days of data collection was comparable to the year of data collection from the present study.

The stereotypic behaviors observed in the current study were primarily oral stereotypies, corresponding to what others have previously reported in giraffes (Bashaw et al., 2001; Bergeron et al., 2006; Orban, Siegford, & Snider 2016). In the present study, giraffes spent approximately 10% of their time budget performing stereotypic behaviors, a similar amount to what has been reported previously (Bashaw, 2011: 9-14%; Orban, Siegford, & Snider, 2016: 13.9-18.3%; Razal, Bryant, & Miller, 2017: 3.5-8%; Veasey, Waran, & Young, 1996a: 10-21%;). However, the rate of stereotypic behaviors varied greatly across giraffes, with some individuals rarely exhibiting stereotypic behaviors, most exhibiting them at a moderate level similar to what has been reported previously (Orban, Siegford, & Snider, 2016), and several individuals exhibiting these behaviors regularly.

Taken together, these results suggest some signs of progress in addressing concerns surrounding giraffe behavior. Encouragingly, the overall time spent feeding appeared higher than most past reports in zoos. However, given the widespread prevalence of stereotypic behaviors, additional work is needed. As past studies have found the rate of oral stereotypies may be related to overall time spent feeding and foraging (Koene & Visser, 1997; Orban, Siegford, & Snider, 2016), continued and increased efforts to promote browsing and extractive foraging may be warranted (e.g., Depauw et al., 2023; Fernandez et al., 2008; Walldén, 2023). Ultimately, this may suggest that giraffes in zoos would experience better welfare, at least as measured by stereotypic behavior, if they spend a similar amount of time feeding and foraging as their wild conspecifics, which has been estimated at 50-75% of the time budget (Pellew, 1984; du Toit & Yetman, 2005; but see Paulse et al., 2023; Deacon, Smit, & Grobbelaar, 2024). Unfortunately, as others have noted, stereotypic behaviors, once established, can be difficult to eliminate (Garner, 2006). Thus, it will be important to determine a realistic goal for individuals currently expressing stereotypies and it may be prudent to focus on avoiding the emergence of stereotypic behavior in recently born individuals. For example, although Depauw et al. (2023) observed a large increase in time spent feeding by giraffes after a series of husbandry changes, only one individual was

observed to significantly decrease their time performing repetitive licking behaviors. In another study, increasing the hay-to-grain ratio in the diet of giraffes was found to decrease tongue play oral stereotypies but did not change repetitive licking oral stereotypies (Monson et al., 2018). More work is needed to understand the perseverative nature of stereotypic behavior in giraffes and their responsiveness to husbandry changes.

While this study makes a valuable contribution to our understanding of giraffe behavior, and behavioral potential, across US zoos, it raises several important questions about how behaviors are impacted by husbandry and environment, as well as how behaviors are impacted by one another. For example, did habitat size impact behavior, as the largest giraffe habitat in this study was 566 times bigger than the smallest? Was there an effect of sex on time spent feeding, as others have found (Young & Isbell, 1991)? This work is currently underway and will hopefully shed light on specific predictive factors influencing behaviors of interest that can aid managers in making evidence-based decisions to enhance welfare.

This was the first study of the ZooMonitor Community platform. This collaborative feature in ZooMonitor introduces new tools for facilitating multi-institutional research, making it possible for researchers to publish their projects to a shared space visible to ZooMonitor users around the world. Researchers can then manage their studies through built-in tools in the ZooMonitor Community. The need for multi-institutional research has been highlighted by others (Swaisgood & Shepherdson, 2005; Watters, Margulis, & Atsalis, 2009; Whitham & Wielebnowski, 2013) and, with the widespread use of the ZooMonitor app in zoos and aquariums around the world, the ZooMonitor Community has the potential to increase collaborative research and accelerate our collective knowledge of normal behavior patterns for the many species housed across zoos and aquariums.

Conclusions

Understanding species-typical behavior patterns can aid zoos and aquariums in identifying normal and, consequently, abnormal behavior of animals in their care. Here, we evaluated the behavior of 66 giraffes across 18 zoos, providing the most complete picture of their species-typical behavior patterns to date. Consistent with past research, feeding and foraging behaviors were the most frequently observed behaviors. Given the focus of zoos on promoting these natural behaviors, it was encouraging to see they occurred more frequently than has been generally reported in past zoo research. Unfortunately, also consistent with past research was the prevalence of stereotypic behaviors, particularly oral stereotypies. Large inter-individual variation in stereotypic behavior was noted, suggesting there may be specific individual- or institutional-level factors in the housing or care of giraffes contributing to these behaviors. Additional research is underway to explore these factors in more detail. This study was conducted using new collaborative research features in the ZooMonitor behavior recording app. More multi-institutional research is needed to build our collective knowledge of normal behavior patterns for species housed in zoos and aquariums. We encourage others to consider these new tools and advance these efforts for more species.

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Figure 1

The species-typical behavior patterns of giraffes observed in this study.

The boxplot displays the percent of visible time for each individuals mean behavior value as boxes representing the 25th and 75th percentiles, the median indicated as a horizontal line, whiskers representing the largest value within 1.5 times the interquartile range, and dots to indicate individual outliers defined as values above and below 1.5 times the interquartile range.

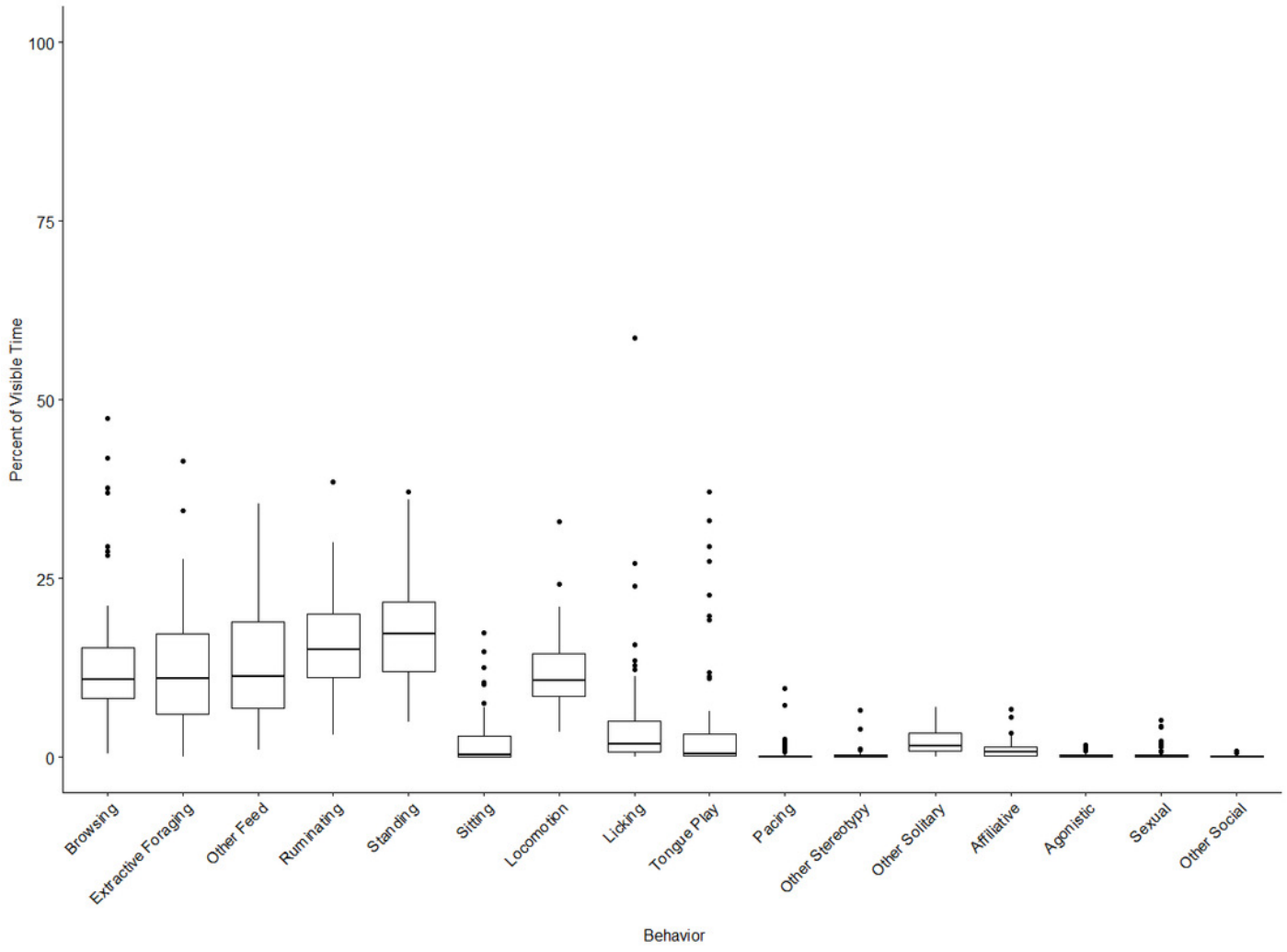

Figure 2

The percent of visible time spent in feeding or foraging behaviors across individual giraffes.

The X axis shows anonymized giraffe IDs.

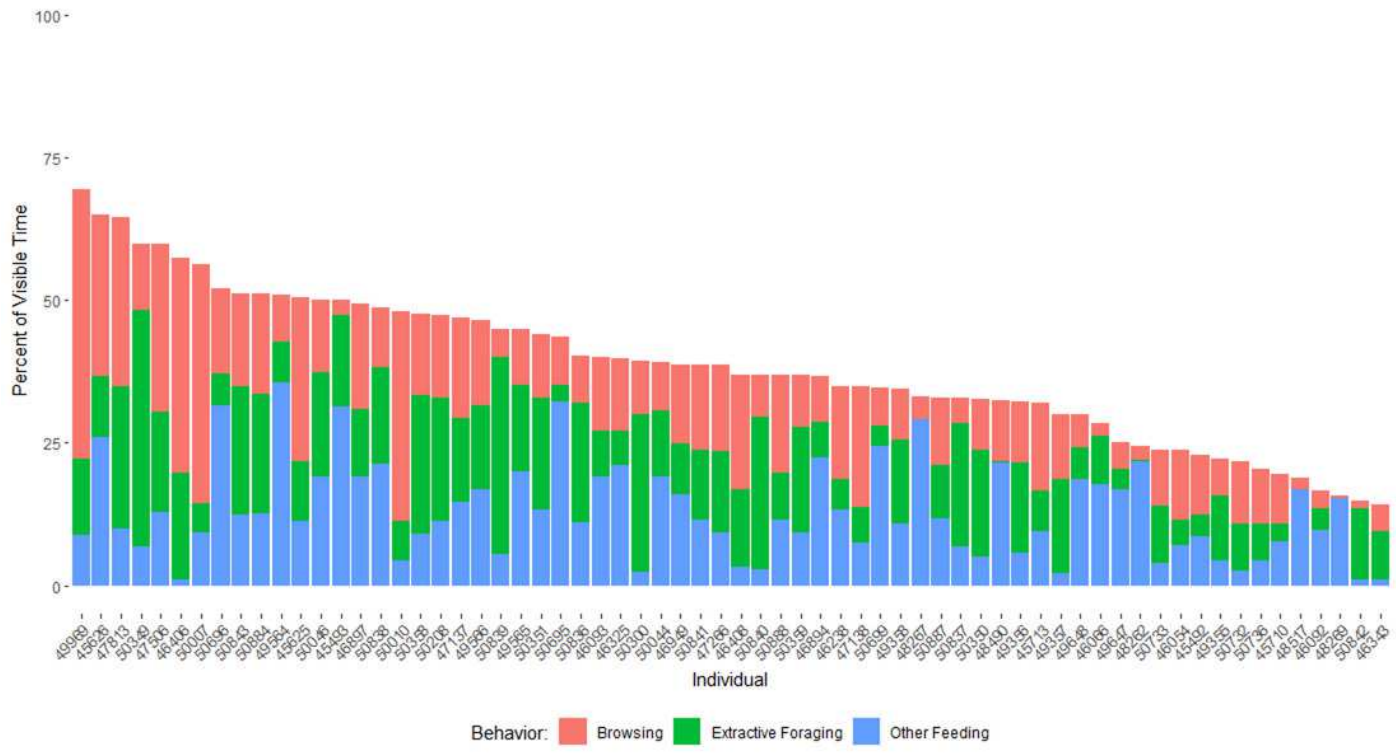

Figure 3

The mean visible rate of stereotypic behavior types across individual giraffes.

The X axis shows anonymized giraffe IDs.

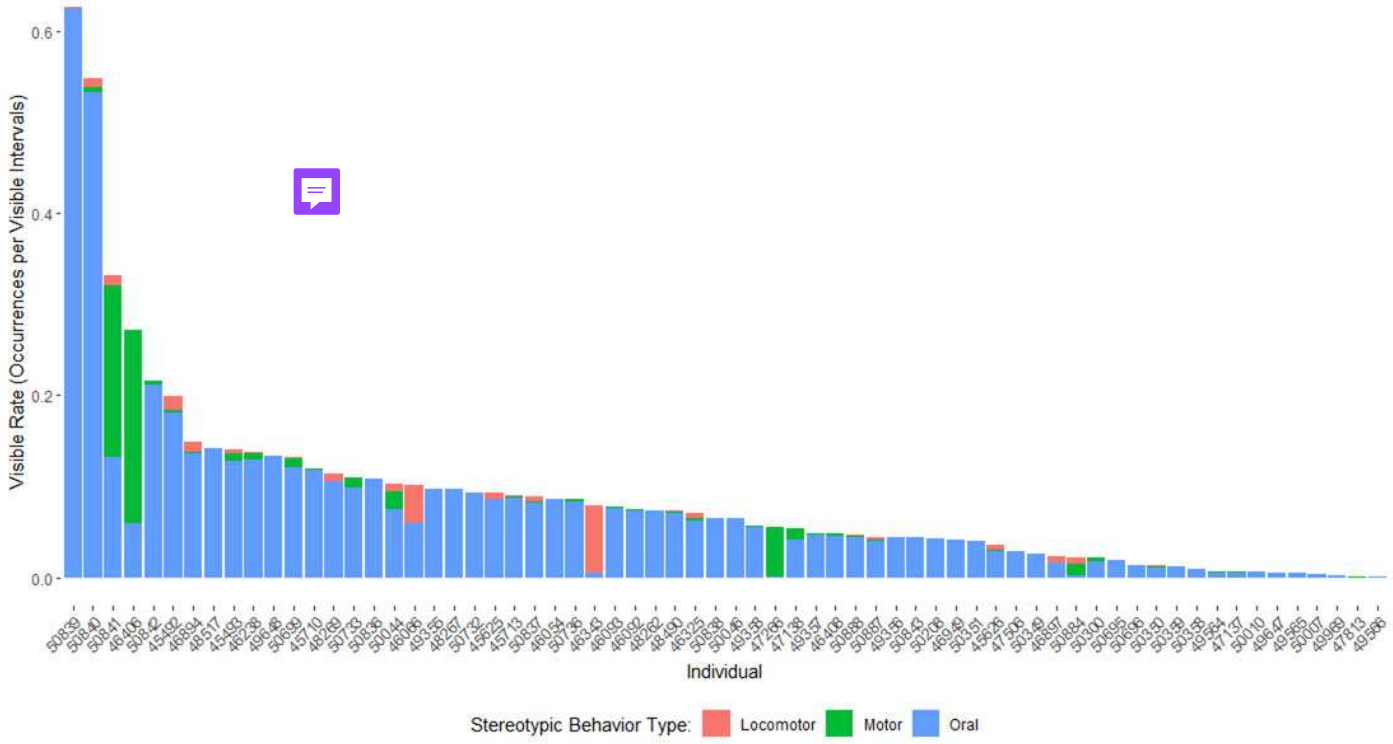

Table 1(on next page)

Ethogram

1 Table 1. Ethogram.

Behavior Name	Behavior Category	Definition
Standing	Inactive	Animal is upright with weight supported on feet and not performing another behavior listed.
Sitting	Inactive	Animal has weight supported on legs or ventral surface. May be alert with head elevated or sleeping with head resting on their body.
Browsing/ Feed	Feed/ Forage/ Drink	Animal is using tongue or mouth to strip or pluck leaves or bark from a branch (can include environmental foliage as well as diet items). This includes chewing and consumption of food items gained through browsing.
Extractive Foraging/ Feed	Feed/ Forage/ Drink	Animal is using tongue or mouth to extract food from within an enclosed object (e.g., hanging extractive feeding bags or buckets). This includes chewing and consumption of food items gained through extractive foraging.
Ruminating	Feed/ Forage/ Drink	Regurgitation and chewing cud of previously eaten food. Does not include periods of chewing which might accompany foraging and should be recorded as “Feeding.”
Other Feeding/ Drinking	Feed/ Forage/ Drink	Animal is performing any other feeding behavior (e.g., feeding from troughs, grazing on grass, foraging across substrate, guest hand feeding).
Locomotion	Locomotion	Animal is moving at least one body’s length in a non-stereotypical manner.
Tongue Play†	Stereotypy	Animal is moving tongue outside of mouth in a repetitive, twisting or rolling movement. May have food item present but not actively chewing food.
Repetitive Licking†	Stereotypy	Animal is repeatedly moving tongue across a non-food, stationary object (e.g., walls, fencing, or trees).
Pacing†	Stereotypy	Animal is walking in a repetitive manner along a fixed path without an apparent goal or function. The animal must move along the path three times to qualify as pacing. [Note: If an interval occurs during the first two transects and the animal continues into a pacing bout, score pacing].

Other Stereotypy†	Stereotypy	Animal is performing any other non-functional, invariant, and repetitive behavior not listed above (please score whether the stereotypy type is Oral, Motor, Locomotor, or Other).
Other Solitary	Other Solitary	Animal is performing any other solitary behavior, including but not limited to self-maintenance behaviors, exploratory behaviors, and elimination behaviors.
Affiliative	Social	Animal makes physical contact with another conspecific individual in an affiliative manner, including rubbing necks, heads, bodies, or muzzles or sniffing and licking the muzzle or non-anogenital area of the body.
Sexual	Social	Animal is physically mounting or attempting to mount a conspecific animal or investigating the animal or environment in a sexual manner (e.g., anogenital exam, urine investigation, flehmen).
Agonistic	Social	Animal performs any aggressive behavior, either with or without contact, or any displacement/ avoidance behavior.
Other Social Behavior	Social	Animal is performing a social behavior not previously listed.
Behavior Obscured	Not Visible	The behavior of the animal cannot be determined but the location of the animal is known and in the habitat spaces under observation (i.e., record a corresponding space use location).
Animal Not Visible	Not Visible	The animal is completely not visible and its location is unknown (i.e., do not record a space use location) or in an off-exhibit area not under observation.

† These behaviors were recorded on an all-occurrence and interval basis.

Table 2(on next page)

Summary statistics of the percent of visible time giraffes spent engaged in different behavior categories.

Table 2. Summary statistics of the percent of visible time giraffes spent engaged in different behavior categories.

Behavior Category	Mean (SD)	Median	Range	IQR†	CV‡
Feeding/ Foraging/ Drinking	38.5 (13.1)	37.8	14.3 – 69.5 (55.2)	29.1 - 46.5 (17.4)	34.0%
Ruminating	15.6 (6.8)	15.0	3.1 – 38.5 (35.4)	10.6 – 19.4 (8.8)	43.5%
Inactive	19.6 (8.0)	19.0	5.2 – 42.1 (36.9)	14.3 – 23.8 (9.5)	41.1%
Locomotion	11.7 (4.9)	10.7	3.5 – 33.0 (29.5)	7.7 – 13.7 (6.0)	42.2%
Stereotypy	10.4 (11.6)	5.5	0 – 59.6 (59.6)	0.05 – 11.0 (10.9)	111.4%
Other Solitary	2.2 (1.8)	1.6	0 – 7.0 (7.0)	0.4 – 2.9 (2.5)	79.6%
Social	1.9 (2.2)	1.0	0 – 11.0 (11.0)	0.05 – 2.0 (1.9)	112.0%

† IQR = Interquartile range

‡ CV = Coefficient of Variation