

Case Report

Does the Absence of Zoo Visitors during the COVID-19 Pandemic Impact Gorilla Behavior?

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Abstract: Whether or not primates are behaviorally affected by the presence of visitors in a zoo setting is a question of great relevance to zoo animal well-being. The situation imposed by the COVID-19 pandemic provided an unusual opportunity to examine how the absence of visitors impacts behavior. We took advantage of this opportunity to study the behavior of a gorilla troop during periods of no-visitors compared to our long-term database on gorilla behavior during normal zoo operations. While there were notable individual differences in response to visitors, we found no significant relationship between presence of visitors and behavior. These results suggest that the presence of visitors does not have a significant impact on behavior and well-being of zoo-housed gorillas.

Keywords: COVID-19; pandemic; research; gorilla; visitors; zoos; behavior



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1. Introduction

More than 700 million people visit zoos and aquariums each year, making visitors a significant feature of the zoo environment [1]. Because visitors are ubiquitous in zoos, it is nearly impossible to systematically evaluate how or whether visitors impact the behavior and well-being of zoo animals. The study of human-animal relationships in zoos has highlighted that humans may be positive, negative, or neutral stimuli. Differences based on the humans (for example, familiar keepers versus unknown visitors) and the animal species (for example, predator or prey species) influence the nature of this relationship [2–5]. The COVID-19 pandemic resulted in the temporary closure of the majority of zoos world-wide. As a result, animals have had to go about their daily routines without visitors present. This has led to a unique opportunity to study the impact of visitors' presence or absence on animals in zoos.

A number of studies have attempted to explore the relationship between visitors and animal behavior. Wells [6] studied visitor effects on gorillas (*Gorilla gorilla gorilla*) and found that a low density of crowds caused the gorillas to rest more often than at times of high visitor density. High crowd densities caused the gorillas to exhibit higher degrees of auto-grooming, conspecific aggression, and abnormal behavior, therefore showing that visitors have a significant impact on gorilla behavior. Another study provides evidence that visitors have an effect on the HPA axis of spider monkeys (*Ateles geoffroyi rufiventris*) [7]. Increased visitor numbers led to increased levels of urinary cortisol (accounting for diurnal fluctuations) within the spider monkeys, ultimately demonstrating that visitors have a significant impact on some zoo-housed primates. A study on the impact of crowd density on lowland gorilla behavior found that high levels of visitors affected the behavior in a gorilla troop, causing changes in the troop's enclosure use, activity, and anxiety-related behaviors [8]. Similarly, a study on chimpanzees (*Pan troglodytes*) in Nigeria showed a significant change in behavioral patterns related to relaxation behaviors in response to tourists' presence, absence, and interactions [9].

However, other studies have shown that visitors do not have a significant effect on apes. For example, a study conducted on zoo-housed gorillas focused on the impact of crowd size on behavior [10]. Crowd had no effect on most of the behaviors they focused on and those that did change (aggression and undesirable behaviors) did not do so in a consistent manner [10]. This contrasts with Well's study [6], which found that high crowd levels significantly impacted the behavior of zoo-housed gorilla populations. In contrast, Kuhar [11] found that there was relatively little difference in behavior between groups of zoo-housed gorillas and their reactions to large crowds. More broadly, some studies have shown that visitors may have a range of effects, from minimal to detrimental, on the behavior of apes in managed care depending on the size of the crowd and/or the level of noise caused by visitors [12]. Ross et al. [13] compared the behavior of apes on-exhibit and their behavior in temporary holding areas and found that crowd size did not impact overall ape behavior. Finally, Bonnie, Ang & Ross [14] found that the behavior of gorillas and chimpanzees was not affected by crowd size and/or visitor density.

With the COVID-19 pandemic came zoo closures and the absence of visitors. Although several studies have been published recently based on data collected during these unprecedented times, most do not have data prior to the COVID-19 shutdown to which they can compare their shutdown data in order to determine the effects of visitors' sudden absence. To do this, pre-existing data must exist to allow comparisons before, and during COVID-19. A study in Nile crocodiles (*Crocodylus niloticus*) [15] demonstrated small, but significant behavioral differences related to visitor presence and temperature (dependent on the month-before and during COVID shutdown), with patterns varying by individual. A study on red kangaroos (*Macropus rufus*) examined visitors' effects on behavior using data collected during and after the COVID-19 shutdown, but no data were collected prior to the start of the pandemic [16]. Williams et al. [17] studied the impact of zoo closures and reopenings in eight different large mammals but similarly did not include analysis of data collected prior to the shutdown. Studies on primates have demonstrated similar results. A study on macaque welfare and the impact of zoo closures [18] compared cognitive testing data during the shutdown to data when the zoo reopened, and found no impact of the absence of visitors, but also did not compare it to data prior to the shutdown. This absence of pre-COVID data is not surprising, as it requires that routine behavioral monitoring be in place in order to have a basis of comparison [19]. Consequently, many of these studies are missing an important piece of the puzzle. Our research team has been monitoring gorilla behavior at the Buffalo Zoo for over twelve years. This provided us with the unique opportunity to evaluate behavior when visitors were excluded from the zoo and compare this to our long-term data.

Previously, we demonstrated that early in the pandemic (summer 2020), when the zoo was completely closed, gorilla behavior showed little change when visitors were absent. We did, however, find individual variation, with several animals showing higher levels of auto-grooming (a behavior often linked to stress) and inactivity when visitors were present [20]. Now, we evaluate additional data that permits us to make a similar comparison during the winter months. Thus, here we compare the data collected from November 2019 through January 2020, prior to the pandemic, with data collected while there were no visitors present, from November 2020 through January 2021.

Our goal of this study is to determine if there is any significant difference in pre-pandemic behavior compared to behavior during the COVID-19 pandemic. Based on our previous findings [20], we hypothesize that we will see similar patterns during the winter. We predict overall no substantial impact of the absence of visitors on behavior. We also predict that individual gorillas are likely to show different patterns, with some individuals showing more auto-grooming when the zoo was open to visitors. Overall, we predict that there will be no consistent significant differences in gorilla behavior during the COVID-19 pandemic.

2. Materials and Methods

2.1. Study Site and Subjects

The study was conducted at an indoor gorilla exhibit at the Buffalo Zoo in Buffalo, NY, USA. The irregularly shaped exhibit measured approximately 185 m² and included a climbing structure and two alcoves that allowed the gorillas to be out of view of the public if they chose. These alcoves also contained shift doors that led into an off exhibit holding area. These doors were usually closed during the open hours of the zoo. Four viewing windows surround the exhibit, allowing visitors to observe from four different locations, but there were no viewing windows into the alcoves.

At the time of our study, the Buffalo Zoo's gorilla troop consists of five gorillas: one adult male silverback (Koga), two adult females (Sidney and Lily), one sub adult female, daughter of Lily (Nyah), and one juvenile male (Kayin), son of Sidney. These five gorillas are the subject of our study. Our research was purely observational and did not alter the normal husbandry routines of the animals.

2.2. Procedures

Our research team is comprised of undergraduate students in the Animal Behavior, Ecology, and Conservation program at Canisius College. All observers must pass their inter-observer reliability assessments with a minimum of 90% agreement. One observer at a time (a different observer each day of the week) engaged in instantaneous focal sampling [21] of one gorilla at a time (randomly selected) for a twenty-minute observation period. In most cases, all five gorillas were observed sequentially during a session. Occasionally, husbandry and management events prevented us from observing all five gorillas during a session. Individuals' state or activity was recorded at one minute intervals based on the ethogram presented in Table 1. Observations were conducted three to five times per week, either in the morning (between 1000 h and 1230 h) or the afternoon (between 1245 h and 1600 h). Keeper and observer presence were not considered to be visitor presence; we were focusing only on outside visitor presence or absence, as opposed to human presence in general.

Table 1. Ethogram of the gorilla behaviors analyzed during this study.

Behaviors:	Definitions:
Inactive	Sitting, standing, or laying while not active in physical activity
Locomotion	Moving across the ground, climbing either on the exhibit walls, or the climbing structure located in the middle of the exhibit.
Auto-groom	Scratching, itching, rubbing, or any other self-manipulations with the intention of cleaning
R/R	Regurgitation and re-ingestion, seen when a gorilla regurgitates a substrate for the intent of consuming it again.
Pluck	An individual pulling their own hair out.
Forage	Actively searching for, or eating substrate, or other food materials.
Out of view	The focal individual gorilla is beyond the observer's field of view.
Manipulate Object	Grabbing, moving, or touching, an inanimate object within the enclosure.

2.3. Statistical Analysis

The number of observations for each gorilla during each period is summarized in Table 2. Data were analyzed with R [22]. We conducted nonparametric Wilcoxon rank sums tests to evaluate individual differences in behavior between the 2019–2020 data (visitors present) and the 2020–2021 data (visitors absent). For simplicity, we have designated data collected during the 2019–2020 period as “2019” and the data collected during the 2020–2021 period as “2020”. We conducted another Wilcoxon test on all data combined to evaluate overall changes in behavior across the two study periods. Alpha was set at 0.05.

Table 2. Total number of twenty-minute observation sessions.

Visitors	Subject					Grand Total
	Kayin	Koga	Lily	Nyah	Sidney	
Absent	32	32	33	33	32	162
Present	26	26	25	24	24	125
Grand Total	58	58	58	57	56	287

3. Results

We found no significant differences when comparing the whole-troop's frequencies of each behavior during the two study periods (Figure 1). While not significant, several patterns are notable. Though it was a rare behavior, RR was almost twice as frequent in 2019 (visitors present) compared to 2020 (visitors absent), and gorillas were out of view more often when visitors were absent in 2020 (28.16% of the time) as compared to 18.18% of the time in 2019 when visitors were present. Object manipulation occurred more often in the presence of visitors.

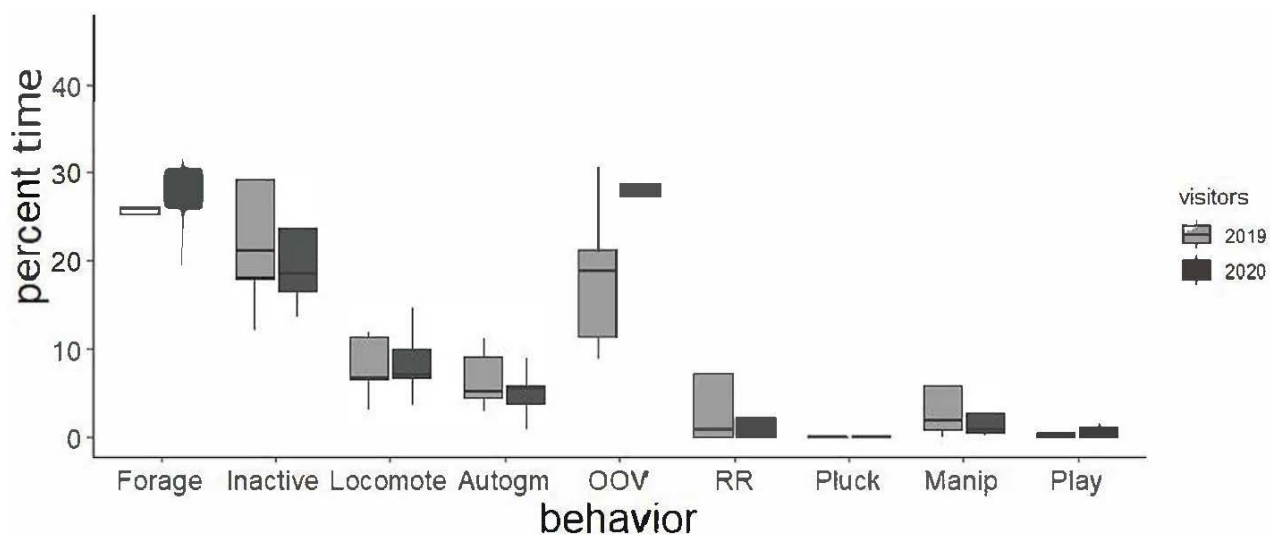


Figure 1. Percent time spent in each behavior for the troop overall in 2019 (visitors present; light grey bars) versus 2020 (visitors absent; dark grey bars). No significant differences were found. Bars represent quartiles, plus or minus standard error.

While there were no consistent patterns across individuals (Figure 2), there were several significant changes in behavior. Lily spent significantly more time out of view when no visitors were present in 2020 (Wilcoxon rank sum test, $W = 278$, $p < 0.03$). She auto-groomed significantly more often when visitors were present in 2019 ($W = 505$, $p < 0.035$). She manipulated objects significantly more—though still infrequently—when visitors were present ($W = 500$, $p < 0.016$). Though not significant, Lily also exhibited a trend towards more RR in the presence of visitors ($W = 518$, $p < 0.09$). While not significant, both subadults manipulated objects more often in 2019 with visitors present (Kayin: $W = 504$, $p < 0.16$; Nyah: $W = 486.5$, $p < 0.09$). Nyah also autogroomed more in the presence of visitors in 2019 ($W = 506.5$, $p < 0.054$). The silverback male Koga autogroomed significantly more in the presence of visitors in 2019 ($W = 548$, $p < 0.028$) and spent more time out of view in 2020 when no visitors were present ($W = 300$, $p < 0.053$). While relatively rare, Koga tended to engage in stereotypic plucking more often in the presence of visitors ($W = 468$, $p < 0.098$).

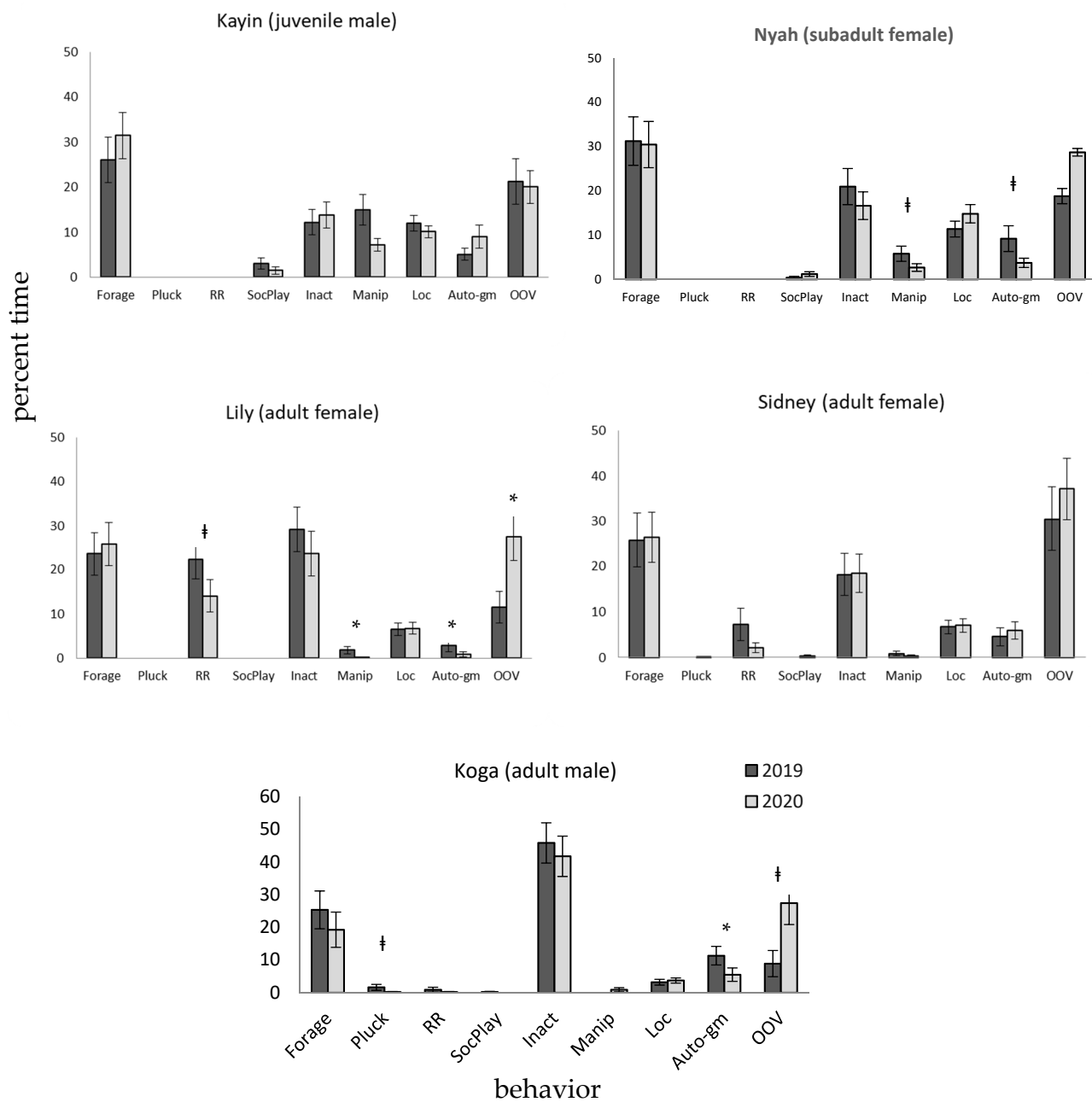


Figure 2. Activity budgets (percent time) for individual gorillas. 2019 (visitors present; light grey bars); 2020 (visitors absent; dark grey bars). Bars indicate mean \pm S.E. * $p < 0.05$; ‡ $p < 0.1$.

4. Discussion

When looking at the combined behavior of the entire troop, we found no significant differences in behavior before and following the COVID-19 shut-down, suggesting that visitors do not have a significant effect on the behavior of this gorilla troop. Keeper routines remained fairly consistent throughout this time allowing us to focus on visitor presence or absence as the most likely explanation for our findings. This comparison was only possible because of our long-term, routine behavioral monitoring.

Individual differences in behavior may obscure any broader patterns. For example, three gorillas showed greater levels of autogrooming in 2019 in the presence of visitors, while two gorillas showed the opposite pattern. Auto-grooming has traditionally been viewed as a displacement activity indicative of stress [23]. A recent study on a zoo-housed gorilla troop found overall no significant changes in behavior when viewing was

restricted, other than a decrease in auto-grooming [24]. It is interesting that the adult male, Koga, performed significantly more auto-grooming in 2019 when visitors were present. In addition, he exhibited a trend of plucking more in the presence of visitors (though this idiosyncratic stereotypy comprised only 0.32% of his activity budget). In contrast, the youngest individual, Kayin, performed more auto-grooming in the absence of visitors (though this difference was not significant). Similarly, he spent twice as much time engaged in social play and object manipulation in the presence of visitors. While these differences were not significant, we speculate that the lack of visitors resulted in boredom for the youngest individual, as interaction with visitors may be enriching. For some gorillas, visitors may serve as enrichment, while for others, they may be a stressor, and in some cases, visitors may be an entirely neutral stimulus. Indeed, anecdotally, we often observed the young gorillas in the troop engaging with visitors at the viewing windows. In contrast, we found the opposed pattern for the silverback, perhaps indicating that visitors may be perceived as a stressor for this individual, although our findings are preliminary and not statistically significant.

We note that these gorillas performed more regurgitation and re-ingestion in 2019. However, the frequency of this behavior overall was quite low during both observation periods (comprising less than 10% of the overall activity budget) and driven largely by a single gorilla. If real, this behavior may have multiple root causes including diet, but it may be stress related [25,26].

Several behaviors showed significant but inconsistent changes between our two sampling periods, with tremendous individual variation. Four out of five gorillas spent more time out of view in 2020, in the absence of visitors (though this pattern was only significant for or approached significance for two individuals). It is possible that this pattern relates to the presence of keepers in the off-exhibit area (visible to the gorillas when the gorillas were in the alcove and not visible to observers). That is, the gorillas may have been seeking out human interaction—particularly with familiar humans—in the absence of visitors. These results suggest that human presence may serve as a positive stimulus for gorillas [2,5]. Four gorillas manipulated objects more when visitors were present. This is likely due to individuals, especially younger animals, engaging with visitors. When engaging with visitors, young gorillas within the troop would often manipulate objects in relation to their audience. This could include throwing handfuls of straw into the air or placing a blanket over their head whilst running back and forth at the window, all of which are instances observed by our researchers. In response, this behavior elicited a response from the crowd (e.g., clapping, videotaping, etc.). Previous studies have demonstrated variable effects of crowd level on gorilla behavior, sometimes impacting behavior and sometimes having no measurable effect [10–12]. One study on carnivores demonstrated that the activity of animals may influence visitor behavior, with active animals leading to higher levels of visitor interaction and activity [27].

Our results are largely consistent with our previous findings in that the gorilla troop as a whole was not affected by the presence of visitors. However, unlike our previous findings [20], we did not find an overall significant decrease in inactivity when visitors are present compared to when visitors are absent. We conclude that these gorillas do not appear to experience any consistent, significant negative impacts from visitor presence, and at least in the case of young animals, may view visitors as a positive, enriching component of the environment [20]. As visitor interaction is a normal part of zoo animals' lives, human interaction is inevitable and while the impact may be neutral or negligible, it may have a noticeable impact on their welfare [28], positively or negatively. Hosey [2] pointed out that visitors may be a positive, negative, or neutral influence on zoo animals. Indeed, during the pandemic, considerable popular press [29,30] suggested that zoo animals were bored due to the lack of visitor interaction. One published study found that meerkat (*Suricata suricatta*) behavior was indicative of a positive human-animal relationship, while African penguins (*Spheniscus demersus*) showed no effect of visitor presence, indicating a neutral relationship [1]. We interpret the limited significant impact of visitors on behavior

as a good sign. Our findings further highlight the importance of examining individual responses to visitor presence, as broad generalizations may obscure meaningful patterns. Continued research to explore additional changes post-COVID will serve more clearly to elucidate patterns.

5. Conclusions

The COVID-19 pandemic offered an unexpected and unique opportunity to examine the effects of zoo visitors on gorilla behavior. Because of our long-term behavioral monitoring, we were able to compare behavior before and during the pandemic. Following our work on changes in behavior during the first post-COVID summer, we found similar patterns, but note some differences that suggest the gorilla troop was beginning to acclimate to absence of visitors. In contrast to our previous work [20], we found no differences in the proportion of time spent foraging or inactive. Furthermore, RR was no longer more common in the absence of visitors, suggesting that the gorillas may have begun to acclimate to the absence of visitors. Our findings suggest that individual variation in response to visitors may be an important influence on animal welfare and should not be overlooked. We suggest that routine monitoring of behavior may serve as a valuable tool for assessing the impacts of unplanned and unexpected events. In this way, zoos will be better able to make evidence-based decisions with respect to behavior and welfare.

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Data Availability Statement: The datasets analyzed during the current study are available from the corresponding author on reasonable request.

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