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Editorial

An Introduction to the Special Issue: "The Animals Will Play While the Visitors Are Away: What Happens When Zoos and Aquariums Are Closed to Visitors?"

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Zoos and aquariums are cultural institutions that rely on a steady stream of paying visitors, whose patronage comes in the form of admission fees or product sales, for their financial health, a condition that is vital to their continued delivery on the modern zoological mission, one that includes not only recreation but also conservation, education, and research [1,2]. Visitors are therefore a permanent feature of the environment of zoo and aquarium animals, presenting a range of visual, auditory, olfactory, and other stimuli [3]. Nevertheless, when one considers that even ancient zoos had at least a basic interest in keeping animals alive, and perhaps in breeding them successfully, zoos and aquariums have been interested in animal welfare for centuries and have been considering animal welfare explicitly for at least 70 years (see [4]).

At face value, it is not clear whether we should assume that visitors represent a positive, negative, or neutral stimulus to zoo animals. One might suggest that the non-domesticated species in zoos did not evolve in close contact with or under direct selection by humans, and thus the animals have not evolved any natural adaptations for mitigating this potential stressor and thus humans must naturally be a negative stimulus (see [5]). Alternatively, humans might be considered part of a broader category of stimuli including other species or events the animals do not understand but have nonetheless evolved a response to that involves observation or inspection, and possible approach or retreat protocols to obtain more information in order to develop an appropriate response, as is the case in predator inspection behavior [6–8]. What also complicates predictions about how zoo animals perceive humans is the fact that for most of these animals, humans have been a constant part of their environment since their day of birth or hatching (Powell, unpublished data). As such, as long as human behavior remains generally predictable (e.g., visitors either do or do not typically enter the enclosure with the animals), the animals have likely become habituated to them or have developed behavioral mechanisms with which to mitigate their proximity.

Although recent reviews of visitor effects studies conducted on a wide range of taxa have reinforced the notion that the response to humans by zoo animals ranges from negative to positive [3,9], how animals will respond to visitors remains hard to predict. As would be expected based on the phylogenetic diversity of species housed in zoos, there is considerable interspecific variation in visitor effects. However, there is also variation in responses to visitors between different groups of the same species and sometimes between individuals within the same group, complicating even species-specific predictions. For example, meerkats (*Suricata suricatta*) at three institutions showed different responses in behavior and space use with and without guests [10], and the effect of visitor density on behavior varied between individuals in a group of polar bears (*Ursus maritimus*) at one zoo [11]. It also has been suggested that even within individuals, responses to visitors might vary based on visitor density [12] or have a cumulative effect over the course of a day or other time period [13,14]. Additionally, results from more recent studies tend to contradict those published earlier that commonly suggested visitors have a negative effect, likely due to the vast improvements in habitat design and management made in recent decades that may help mitigate the associated negative effects [9]. Given the spectrum of results reported in the literature, continued research is necessary to understand how visitors impact zoo-housed species and to allow for the continued monitoring and enhancement of the welfare of animals in human care.

As it can be difficult to discern to which visitor-related stimulus or stimuli animals are responding, visitor effect research often focuses instead on responses to visitor presence overall. One considerable challenge facing research investigating the effects of visitor presence is that zoos are infrequently closed to guests for long durations, leading to studies that may be biased or unrepresentative of general patterns. The global COVID-19 pandemic provided a (hopefully) rare opportunity to mitigate some key challenges in the study of visitor effects on zoo and aquarium animals. Hundreds of zoos and aquariums around the world closed their gates to the public for varying periods of time to slow the spread of the COVID-19 coronavirus. Thus, one of the key variables of interest, the presence versus absence of visitors, could be explored with some degree of experimental control, while other variables such animal species, individual temperament and history, and enclosure characteristics could be held constant. Animal keepers were still carrying out daily husbandry routines to a large extent and thus their influence on the animals should have been comparable between periods of zoo opening and closure, though in some facilities, keepers may have temporarily suspended regular practices involving close contact with certain taxa (e.g., training sessions), as we learned that humans could pass the coronavirus to certain taxa of zoo animals (e.g., [15]).

This Special Issue includes eight articles incorporating data on visitor effects research related to the COVID-19 closures. Masman and colleagues [16] present a follow-up to their original study of gorillas (*Gorilla gorilla*) at the Buffalo Zoo [17] by comparing the group's behavior before and after the COVID-19 closure. Using behavioral and spatial data as well as novel object tests conducted during the COVID-19 closure and after reopening, Podturkin [18] emphasizes the importance of choice and control in how grizzly bears (*U. arctos*) respond to visitors. Hunton and colleagues [19] quantified social media and news reports to investigate how zoos communicated the effect of the closures on animals and used questionnaires to understand how keepers perceived animal behavior and keeper–animal interactions during the closures. Using zoo records, Salak and Cloutier Barbour [20] investigated wounding prior to and during the COVID-19 closure in chimpanzees (*Pan troglodytes*) housed at three institutions. Our research group measured space use and fecal glucocorticoid levels to examine visitor effects during and after the COVID-19 closure on banteng (*Bos javanicus*), grizzly bears, a polar bear, and gorillas [21]. Finch and colleagues [22] used 24-h video footage to investigate the behavior of Palawan binturong (*Arctictis binturong whitei*) before and during the COVID-19 closure. Behavioral data from Bennett's wallabies (*Notamacropus rufogriseus*), meerkats, macaws (red and green: *Ara chloropterus*; blue and yellow: *A. ararauna*; military: *A. militaris*), and rabbits (*Oryctolagus cuniculus domesticus*) housed at four different zoos were used by Frost and colleagues [23] to compare three separate COVID-19 closures and corresponding reopening periods. Rounding out the Special Issue is another study in gorillas by Cox and colleagues [24] investigating behavioral variation before, during, and after two separate zoo closures and in relation to increasing maturity within the groups.

While these zoo closures provided natural experiments to study visitor effects on animals, there were still challenges in the research. Many facilities strictly limited the number of staff and volunteers who were allowed on site during the early stages of the pandemic, and trained observers were sometimes considered non-essential staff, as was the case at our facility. Even when trained observers were permitted on site, safety protocols may have limited the amount of data they were able to collect. The rapid onset of facility closures also prevented a classic A-B-A experimental design in most cases, although some facilities were able to capitalize on research already in progress prior to the closures.

Moreover, many facilities re-opened in stages characterized by mandatory attendance caps that reduced visitor density; thus, the "post-closure" phase of these studies might not have been ideally comparable to a "pre-closure" phase or to archival data collected previously. Additionally, projects that limited "post-closure" phases of projects to time periods with reduced visitor density may have obtained results that do not generalize to when attendance caps were removed. Finally, varying durations of closures and scheduling of data collection meant that, in some cases, data collection periods spanned different seasons which may have an impact on behavioral (e.g., [25]) or physiological parameters (e.g., [26]).

Despite these challenges, we believe the papers in this Special Issue and other studies investigating visitor effects during COVID-19 closures [10,17,26–35] represent an important contribution to our understanding of visitor effects on zoo animals because the key variable of interest—the presence of visitors—could be manipulated while keeping many other variables, such as time of day and management strategies, constant. The articles in this Special Issue cover 78 animals from 12 different species across 14 zoos in the United States, the United Kingdom, and Russia. The authors of the studies presented here were able to harness long-term behavioral data sets, the availability of surveillance cameras in animal habitats, records kept by keepers, hormone monitoring, and even social media posts to generate testable hypotheses and gain useful insights. The studies herein are a representative compendium of results that are consistent with those from other studies conducted during this unique period. Based on the body of work that has been published thus far, while visitor effects may be classified as negative in some cases (e.g., European glass lizards [*Pseudopus apodus*] spent less time visible and near glass when the zoo was open compared to when closed [31]), the presence of visitors was neutral and not associated with concerning effects in a wide variety of taxa. Evidence from several species even supports the suggestion that visitors can provide an enriching or beneficial stimulus. Our impression of the literature on visitor effects studied during COVID-19 closures is that, while some studies may find changes in certain metrics in the presence or absence of visitors or due to certain aspects of visitors, to date, there are no studies that demonstrate dramatic impacts on overall welfare, positive or negative.

While scientists may want to pick apart different aspects of "visitor effects"—for example, the impact of visual vs. auditory stimuli provided by visitors, the composition of crowds, the behavior of the visitors—the fact is that many of these aspects are not likely to be controllable in a practical setting. We would never limit visitation to primate exhibits to women, for example, or require that children be absolutely silent when seeing a giraffe. Visitors, and all of the characteristics they bring with them, are part of the in situ environment for zoo and aquarium animals. We therefore suggest that, going forward, this field consider visitor effects more holistically with an eye towards what management changes are actually realistic when serious, negative impacts of visitors on animal welfare are established. For example, while visitor noise itself will likely never be manageable, sound dampening features in indoor spaces can be evaluated (e.g., [36]). In some exhibits, cost effective modifications to alter visitor field-of-view [37] or proximity to animals [38] can be evaluated when concerns arise. Thus, while we may not be able to change the visitors, we may be able to change some of the ways in which they interact with animals and improve habitat design to increase the likelihood of positive effects and minimize the frequency or intensity of negative effects [3].

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