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RESEARCH ARTICLE

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Zoo-housed mammals do not avoid giving birth on weekends

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Abstract

There is evidence that zoo visitor presence can influence the behaviour and, in some cases, adrenal response of zoo animals, and can sometimes compromise animal welfare. In some laboratory studies, significantly more primate births have been reported on weekends, when fewer people are working there, compared with weekdays when staffing levels are at their highest. Here, we investigate whether there is evidence of a "weekend effect" on births in zoo animals as a result of visitor numbers. Unlike laboratories, zoos are typically busier with visitors on weekends than on weekdays, although staffing levels remain fairly consistent across days of the week. If zoo animal parturition is sensitive to human presence, then fewer births would be expected on weekends compared with weekdays. We tested this using birth data and visitor numbers on the entrance gate from zoo records across 16 species representing artiodactyls, perissodactyls, carnivores and primates at four British zoos, to see whether there is an association between mean daily birth rates and average visitor numbers. We predict that, if there is a visitor effect, daily births should be lower on weekends than weekdays and should correlate with mean daily visitor numbers. Results showed that births for all 16 species were randomly distributed through the week, and there was no significant decline in births on weekends. We conclude that the "weekend effect", if such a thing exists, does not appear to be a feature of zoo births, suggesting that elevated weekend visitor numbers are not sufficiently stressful to trigger delayed parturition.

KEYWORDS

stress response, visitor effect, weekend effect, welfare, zoo visitors

1 | INTRODUCTION

It is now well known that the presence of zoo visitors can have an influence on the behaviour of zoo-housed animals (G. R. Hosey, 2000; Sherwen & Hemsworth, 2019; Ward & Sherwen, 2019). In the most recent review (Sherwen & Hemsworth, 2019), details are given of more than 60 peer-reviewed papers on the effects of zoo visitors and, although these include species from six mammalian and two avian orders, they are nevertheless heavily biased towards primates (35 studies). No clear overall effects are demonstrated in these studies. Some show what appears to be a negative effect on the animals (e.g., increased stereotypies, increased aggression, decreased social behaviour, increased faecal or urinary cortisol) when visitor numbers increase (e.g. Birke, 2002; Chamove et al., 1988; Mallapur et al., 2005; Mitchell et al., 1991), while others find little or no effect at all (e.g. Bonnie et al., 2016; O'Donovan et al., 1993; Ozella et al., 2017) and a small number show what is interpreted as a positive response (e.g. increased behavioural diversity, approaches to visitors and human–animal interactions; Bloomfield et al., 2015; Choo et al., 2011; Collins et al., 2016; Polgár et al., 2017). Even within a given zoo, individuals of the same species, housed in different groups in different enclosures, can show a range of responses to visitors (Stoinski et al., 2012), so it is apparent that other variables mediate the occurrence and type of response that zoo-housed animals have.

Because people are such a major feature in the lives of zoo-housed animals, and because there are potential welfare consequences (both positive and negative) implied by the behavioural and physiological responses to visitors that can occur, it is important to gain more understanding of the role that visitors play in zoo animal welfare. However, most of the studies published thus far show the immediate response (or lack thereof) to the concurrent presence of visitors; few studies have considered possible long-term effects of chronic exposure to the presence and activities of people within zoos. On the other hand, several studies have reported what appear to be long-term effects of human activity on laboratory-housed primates. For example, two different laboratories have reported that captive chimpanzees (*Pan troglodytes*) show a pattern of increased wounding events on weekdays compared to on weekends, and have attributed this to the reduced presence of people in the facilities on weekends (Lambeth et al., 1997; Williams et al., 2010). An investigation of this phenomenon in a zoo context using data from chimpanzees and ringtailed lemurs (*Lemur catta*), however, failed to find a significant difference between weekday and weekend woundings in either species (G. Hosey et al., 2016). It may be that this result implies that the human-generated disturbance in laboratory colonies is qualitatively (as well as quantitatively) different from that in zoos, and it is encouraging that aggression in zoo-housed animals does not appear to be affected in this way, at least for the species and zoos studied thus far.

Several laboratories have also presented results that appear to show a long-term change in the timing of births in primate colonies. This was first reported by McGrew and McLuckie (1984), who found that 69% of cotton-top tamarin (*Saguinus oedipus*) births and 73% of marmoset (*Callithrix jacchus*) births occurred at the weekend, the difference between these and weekday births being statistically significant. However, they also found that their stump-tailed macaque (*Macaca arctoides*) colony showed no such effect, and neither did another colony of the same two callitrichid species housed at a different facility. Two other laboratories have shown a similar change in birth pattern phenomenon. Alford et al. (1992) presented data on a total of 153 live births of laboratory chimpanzees housed in three different facilities and showed that births were significantly higher on Sundays and Mondays, and fewer on Wednesdays and Thursdays. They attributed this pattern to the stressful effects of routine laboratory procedures occurring during the week, which were greatly reduced on weekends. Finally, in a laboratory colony of Campbell's monkeys (*Cercopithecus campbelli*), analysis of 34 births again showed that significantly more births occurred on weekends than during the week, and this also was attributed by the authors to the disruption caused by laboratory procedures during the week (Lemasson et al., 2017).

Arising from these studies, the "weekend effect" hypothesis postulates that captive primates are more likely to give birth during times of low disturbance and reduced staff activity (Hopper et al., 2019). The hypothesis was tested by Hopper et al. (2019) using datasets from three species of laboratory-housed primates, each with larger numbers of births than in previous studies: squirrel monkeys (*Saimiri* sp., 2090 births), owl monkeys (*Aotus* sp., 479 births) and rhesus macaques (*Macaca mulatta*; 2047 births). Their data failed to support the hypothesis; the birth patterns being better explained by time of day and lunar phase. Similarly, time of day has been shown to influence birth events in other animals, such as Lipizzaner mares (*Equus ferus caballus*) on stud farms delivering over 90% of their foals between 18:00–06:00 h, and 63% between 21:00–03:00 h (Heidler et al., 2004), when human disturbance would be minimal. There is also an observed clustering of noninduced vaginal births of human infants between 01:00–07:00 h. This was deemed to be because of minimal disturbance and mother–infant bonding opportunities (Chaney et al., 2018).

Birth is recognised as being a stressful event in itself, and there is evidence from a range of domestic animal species to suggest that the release of catecholamines during early labour can occur if the pregnant female is experiencing particularly high levels of stress (e.g., Nagel et al., 2019). This seems to subsequently enable the delay of further onset of labour, presumably until environmental conditions are more favourable, but the endocrinology of parturition is still only partially understood. Nonetheless, building on some of the evidence from laboratory primates, it would be a concern if a "weekend effect" occurred in zoo-housed animals, as it would be likely to imply the elicitation of a stress response. However, in this case, we would expect the reduction in births to occur at the weekend, when visitor numbers are usually higher, than during the week. Using data from across a number of North American zoos, the putative effect was investigated in 231 chimpanzee births by Wagner and Ross (2008), and in 336 live births and 48 stillbirths in western lowland gorillas (*Gorilla gorilla gorilla*) by Kurtycz and Ross (2015). In neither study was a "weekend effect" found, the births being randomly distributed across days. As far as we are aware, these are the only two published studies on a possible "weekend effect" on births in zoo-housed animals. Notably, nobody has tested the "weekend hypothesis" in any nonprimate taxa in any captive condition, even though if the phenomenon has any reality we would expect that plausibly it could affect species of any mammalian order. Here, we test the "weekend hypothesis" in 16 different mammalian species from four different orders, using data from four UK zoos.

2 | MATERIALS AND METHODS

We analysed birth records for 16 mammalian species, chosen if large ($n > 50$) numbers of births were available, and also to provide representatives from a range of mammalian orders. We took birth data from Transaction Reports for each taxon (ARKS/ISIS at that time, now ZIMS/Species360), provided by four individual zoos, all based in the UK (North of England Zoological Society [NEZS, Chester Zoo], ZSL London Zoo, South Lakes Wild Animal Park and ZSL Whipsnade Zoo). If more than one birth event was listed on the same date for a specific zoo and species, Taxon Reports were used to determine if the mother was the same for these; if so, they were counted as one birth event. We then used birth events as our data to test for weekday/weekend differences. Species were: Cetartiodactyla: Blackbuck (*Antilope cervicapra*; $n = 476$ birth events), Nilgau (*Boselaphus tragocamelus*; $n = 193$), Arabian gazelle (*Gazella cora*, referred to as *Gazella arabica* in the zoo records; $n = 220$), Giraffe (*Giraffa camelopardalis*; $n = 113$), Kafue Plains lechwe (*Kobus leche kafuensis*; $n = 267$), Nile lechwe (*Kobus megaceros*; $n = 93$), Guanaco (*Lama guanicoe*; $n = 119$), Sitatunga (*Tragelaphus spekii*; $n = 196$); Perissodactyla: Plains zebra (*Equus quagga*; $n = 82$); Primates: Ring-tailed lemur *Lemur catta* ($n = 394$), Sulawesi crested black macaque (*Macaca nigra*; $n = 111$), Chimpanzee (*Pan troglodytes*, $n = 164$), Hamadryas baboon (*Papio hamadryas*: $n = 62$); Carnivora: Ring-tailed coati (*Nasua nasua*; $n = 70$), Lion (*Panthera leo*; $n = 77$) and Leopard (*Panthera pardus*; $n = 82$). The time span over which data were available was different for each species and zoo, but collectively covered a period from 1935 up to 2015 (Table 1).

Visitor numbers were obtained from gate figures, from each participating zoo's records. As these data followed a normal distribution, means were calculated for each weekday (Mondays–Fridays) and weekend day (Saturdays and Sundays) and compared using *t* tests to confirm differences in visitor numbers between week and weekend days ($p < .05$). The numbers of birth events were pooled from different zoos for each species and tested by χ^2 goodness-of-fit tests against the Null Hypothesis that there would be no differences in numbers of birth events between days in the week and those at the weekend. Because any reduction in birth numbers could lag slightly behind high visitor numbers, for example, as a consequence of endocrine-induced delays to parturition, we also tested for a random distribution across all seven days using χ^2 goodness-of-fit tests. Because of the number of χ^2 tests being performed, we applied a Bonferroni correction, and therefore the Null Hypothesis was rejected if $p < .002$.

3 | RESULTS

Mean daily gate numbers were significantly higher for the two weekend days than for the other 5 days of the week for all four zoos (NEZS, Chester Zoo: $t_5 = -19.1$, $p < .001$; London: $t_5 = -3.66$, $p < .01$; South Lakes: $t_5 = -2.93$, $p < .05$; Whipsnade: $t_5 = -9.6$, $p < .001$).

Results of the comparison of birth events on weekdays and weekends are shown in Table 2. Birth events were not significantly different from expected in any species, indicating that for all species investigated there was no reduction in birth events on weekends compared to weekdays. Comparisons between birth events on each of the 7 days of the week also revealed no significant difference from expected in any of the species (Table 3). The pattern of birth events across the week was random, and so the Null Hypothesis was accepted.

TABLE 1 Time spans over which data on births were available from the different zoos

Species	NEZS, Chester Zoo (C)	ZSL London (L)	ZSL Whipsnade (W)	South Lakes (S)
Antilope cervicapra	1973–2005	1973–1988	1990–2009	N/A
Boselaphus tragocamelus	1970–1988	1977–2015	N/A	N/A
Gazella arabica (cora)	1967–2003	N/A	N/A	N/A
Giraffa camelopardalis	1962–2012	1954–1999	1992–2014	N/A
Kobus leche kafuensis	1959–2010	N/A	N/A	N/A
K. megaceros	N/A	N/A	1991–2008	N/A
Lama guanicoe	1977–2000	N/A	1978–1988	N/A
Tragelaphus spekii	1967–2012	N/A	1975–2015	N/A
Equus quagga	1953–2001	1972–1977	N/A	N/A
Lemur catta	1959–2011	1968–2014	2014–2015	1989–2013
Macaca nigra	1983–2011	1989–2015	N/A	N/A
Pan troglodytes	1956–2009	1935–1994	1946–2002	N/A
Papio hamadryas	N/A	N/A	N/A	1986–2013
Nasua nasua	1980–2005	2008–2009	1983–1990	N/A
Panthera leo	1939–2008	1971–2011	1976–2007	N/A
P. pardus	1958–1993	1962–1999	N/A	N/A

Abbreviation: N/A, not available.

TABLE 2 Total numbers of birth events during weekday and weekend periods (and expected values showing in italics) for 16 mammalian species at NEZS Chester Zoo (C), ZSL London Zoo (L), South Lakes Wild Animal Park (S) and ZSL Whipsnade Zoo (W)

Species	Zoos	Number of birth events (*Expected value in brackets*)		Comparison
		Weekdays (Mon–Fri)	Weekends (Sat–Sun)	
Antilope cervicapra	C, L, W	346 (*340*)	130 (*136*)	$\chi^2 = 0.38$, ns
Boselaphus tragocamelus	C, W	131 (*138*)	62 (*55*)	$\chi^2 = 1.17$, ns
Gazella arabica (cora)	C	160 (*157*)	60 (*63*)	$\chi^2 = 0.19$, ns
Giraffa camelopardalis	C, L, W	76 (*81*)	37 (*32*)	$\chi^2 = 0.95$, ns
Kobus leche kafuensis	C	213 (*191*)	54 (*76*)	$\chi^2 = 9.17$, ns
Kobus megaceros	W	67 (*66*)	26 (*27*)	$\chi^2 = 0.02$, ns
Lama guanicoe	C, W	84 (*85*)	35 (*34*)	$\chi^2 = 0.04$, ns
Tragelaphus spekii	C, W	144 (*140*)	52 (*56*)	$\chi^2 = 0.41$, ns
Equus quagga	C, W	62 (*59*)	20 (*23*)	$\chi^2 = 0.71$, ns
Lemur catta	C, L, S, W	283 (*281*)	111 (*113*)	$\chi^2 = 0.04$, ns
Macaca nigra	C, L	76 (*79*)	35 (*32*)	$\chi^2 = 0.47$, ns
Pan troglodytes	C, L, W	129 (*117*)	35 (*47*)	$\chi^2 = 4.23$, ns
Papio hamadryas	S	49 (*44*)	13 (*18*)	$\chi^2 = 1.77$, ns
Nasua nasua	C, W	54 (*50*)	16 (*20*)	$\chi^2 = 1.13$, ns
Panthera leo	C, L, W	53 (*55*)	24 (*22*)	$\chi^2 = 0.25$, ns
Panthera pardus	C, L	60 (*59*)	22 (*23*)	$\chi^2 = 0.13$, ns

Note: All χ^2 tests are for 1 degree of freedom and $\alpha = .002$.
Abbreviation: ns, not significant.

TABLE 3 Total numbers of birth events by day of the week for 16 mammalian species; data pooled from four zoo

Species	Expected	Number of birth events							Comparison
		Mon	Tues	Wed	Thurs	Fri	Sat	Sun	
Antilope cervicapra	**68**	85	56	78	73	54	74	56	$\chi^2 = 13.25$, ns
Boselaphus tragocamelus	**28**	28	18	18	40	27	27	35	$\chi^2 = 14.07$, ns
Gazella arabica (cora)	**31**	42	33	25	32	28	34	26	$\chi^2 = 6.26$, ns
Giraffa camelopardalis	**16**	15	23	13	13	12	20	17	$\chi^2 = 6.13$, ns
Kobus leche kafuensis	**38**	46	42	39	38	48	30	24	$\chi^2 = 11.28$, ns
Kobus megaceros	**13**	9	15	14	12	17	11	15	$\chi^2 = 3.32$, ns
Lama guanicoe	**17**	20	20	12	16	16	17	18	$\chi^2 = 2.58$, ns
Tragelaphus spekii	**28**	23	33	36	22	30	25	27	$\chi^2 = 5.66$, ns
Equus quagga	**12**	11	8	14	18	11	11	9	$\chi^2 = 5.67$, ns
Lemur catta	**56**	49	49	57	59	67	49	62	$\chi^2 = 5.21$, ns
Macaca nigra	**16**	11	9	14	19	23	20	15	$\chi^2 = 9.52$, ns
Pan troglodytes	**23**	30	32	18	21	28	18	17	$\chi^2 = 10.23$, ns
Papio hamadryas	**9**	13	9	6	12	8	5	9	$\chi^2 = 5.67$, ns
Nasua nasua	**10**	11	10	14	9	10	4	12	$\chi^2 = 5.72$, ns
Panthera leo	**11**	9	17	9	9	9	11	13	$\chi^2 = 5.01$, ns
Panthera pardus	**12**	15	15	13	8	9	16	6	$\chi^2 = 8.06$, ns

Note: All χ^2 tests are for 6 degrees of freedom and $\alpha = .002$.

4 | DISCUSSION

Our data do not support the "weekend effect" hypothesis. None of our 16 species showed a significant reduction in birth events on weekends, and births were distributed randomly through the week for all of the species. Furthermore, our results are consistent with those of Wagner and Ross (2008) and Kurtycz and Ross (2015), who showed that chimpanzees and gorillas respectively in North American zoos also showed a random pattern of births across the days of the week.

It is encouraging that there appears to be no "weekend effect" in zoo-housed animals. In domesticated animals, a temporary cessation of labour may be associated with acute periods of stress linked with fear or emotional disturbance (Silver, 1990). The domestic horse shows some ability to delay parturition; studies report approximately 80%–90% of foals are born at night when there is less human disturbance (Campitelli et al., 1982; Heidler et al., 2004; Meliani et al., 2011; Rossdale & Short, 1967; Sevinga et al., 2004). Older cows can avoid parturition around milking times (Edwards, 1979), and CF1 strain nulliparous mice who were exposed to experimental disturbance (2-min handling periods) upon the birth of their first pup experienced significantly longer labour time than the undisturbed controls, regardless of how much handling the experimental groups were previously accustomed to (Newton et al., 1966). From an evolutionary perspective, it would make sense for a biological mechanism to exist in which parturition can be delayed (up until a certain point, at least, as there may be survival advantages to expelling the foetus, should the threat occur when its delivery is imminent). If a pregnant female senses a threat to her and her foetus during labour, but when delivery is not imminent, the ability to regulate labour and delivery until the threat has passed may convey survival benefits to both mother and infant. It follows that a plausible mechanism may exist whereby zoo-housed animals could perhaps delay births due to occur on crowded weekends, but this does not appear to happen in our data. This suggests that the increased number of visitors on weekends is not sufficiently stressful to trigger this response.

The results in Artiodactyla and Perissodactyla are of note as, being prey animals, it could reasonably be expected to be more likely that species in these orders would respond to the "weekend effect". It appears the higher numbers of visitors on weekends are not perceived by the animals as a high enough threat to delay parturition, or else other aspects of these species' management (enclosure size, design, etc.) mitigate the perceived threat. Should larger datasets be available in the future, to enable comparison at the species level and across a range of types of enclosure and husbandry practices, it may be the case that more fine-tuned patterns begin to emerge.

Our results do not follow those of the laboratory primates. It could be that the interactions between laboratory staff and the primates were more influential than a passing visitor in a zoo. However, there are no written protocols included within these laboratory studies that may indicate the nature of the interactions and therefore it is difficult to distinguish if this impacted the results. The results from the laboratory studies are also not consistent. Of the three primate colonies examined by McGrew and McLuckie (1984), only one showed the weekend effect and both this colony and the one examined by Lemasson et al. (2017) had low sample sizes ($n < 50$). Of the two studies that had larger sample sizes, only the one by Alford et al. (1992) showed a weekend effect. The other study (Hopper et al., 2019) was an explicit test of the "weekend effect" hypothesis using large datasets, implying that these authors considered that the effect might be a statistical artefact due to low sample sizes. It may well be that the "weekend effect" does not exist, or at least is quite a rare phenomenon, and the observed pattern of births can be better explained through circadian and lunar timings than through human disturbance (Hopper et al., 2019). In this context, it is worth noting that whilst diurnal primates, including humans, characteristically give birth at night, captive pied tamarins (*Saguinus bicolor*) do not, and this could not be explained by whether or not animals were on display to the public, even though this species is more sensitive to human disturbance than other callitrichid species (Price et al., 2016). Clearly, there is a still much to be learned about the biology of birth timings, between and within species.

Zoo visitors are a major feature in the experiences of zoo-housed animals and can have a number of effects, both positive and negative, on the welfare of those animals. It is encouraging that we can probably discount disruption of birthing dates, therefore discounting negative implications on ex situ conservation efforts. Nonetheless, as part of a holistic approach to welfare monitoring, zoos should continue to address any challenges to welfare related to high visitor density should any be identified in the future.

5 | CONCLUSIONS

1. Birth events across sixteen different mammalian species representing four orders were randomly dispersed through the week.
2. There was no evidence that any species avoided giving birth when the zoos were most crowded with visitors.
3. It was concluded that visitors were not sufficiently stressful to bring about birth delays in any of the species and zoos studied.

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CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

DATA AVAILABILITY STATEMENT

Data subject to third-party restrictions.

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