JZAR JOURNAL OF ZOO AND AQUARIUM RESEARCH
www.jzar.org

Research article

Monkeying around on Twitter (now X): How big data and social media can be harnessed by zoos and other animal care facilities to examine public opinion trends

Heather J.B. Brooks

Department of Psychology, University of Tennessee, Knoxville, Tennessee, USA

Correspondence, Heather J.B. Brooks, email; hbrooks9@vols.utk.edu

Keywords: aquariums, big data, circuses, public perception, safari parks, social media, wildlife parks, zoos

Article history:
Received: 10 Apr 2023
Accepted: 12 Jul 2024
Published online: 31 Jul 2024

Abstract

Animal care facilities typically collect opinions from the people who attend their facility but measured perceptions of these institutions may be biased if they only survey people who have already chosen to visit. This study explores a different perspective by examining public opinion of five types of animal care facilities across all Twitter posts between July 2010 and July 2020. Analyses were completed with the use of an artificial intelligence (AI) tool by Brandwatch, which uses large-scale qualitative content analysis to detect behavioural trends by social media users. Zoos, aquariums, wildlife parks and safari parks are viewed positively on Twitter but sentiment is becoming more negative. Circuses are generally disliked and sentiment continues to decline. These perceptions from Twitter users may be indicative of an increasing disconnect between these facilities and the public. Using big social media data would increase the ability of animal care facilities to tailor their outreach efforts to the needs of the public, reduce the resources needed to conduct some visitor studies and provide methods for facilities with limited resources to compare data from other institutions.

Introduction

Thousands of animal care facilities exist around the world, both accredited and unaccredited, that are visited by hundreds of millions of people every year (AZA n.d.; EAZA n.d.). While there is a range in quality of animal care facilities, many of these institutions have admirable qualities in common: they work hard to promote education and conservation efforts, manage declining animal populations and provide lifelong care for animals unable to return to the wild. Indeed, these goals are often standardised through accreditation organisations like the European Association of Zoos and Aquaria (EAZA) (Williams-Mitchell 2021), Association of Zoos and Aquariums (AZA 2020) and the Global Federation of Animal Sanctuaries (GFAS 2019). But even with these helpful missions, there are still many vocal campaigns against animal care facilities by groups who have experienced facilities that do not prioritise animal welfare or individuals who believe that there are never reasons for animals to be in human care (Keith 2020; Rabb and Saunders 1999). These negative views are often applied to all animal care facilities without consideration of the differences between animal care style, facility regulations or institutional goals, perhaps because it is confusing for laypeople when facilities with very different missions share the same name like 'zoo'. Understanding and countering these adverse ideas is important for animal care institutions because the work depends on public support.

Audience research or visitor studies has been an important part of tourism research for around a century, although for a long time the primary focus of the research was museum visitors (Gilman 1916; Loomis 1988; Robinson et al. 1928). In the 1980s other institutions including zoological facilities started expanding into the field of visitor studies (Loomis 1988). Visitor studies are not just to help animal care facilities examine the demographics of who is visiting but also to understand why people are visiting. Often animal care facilities focus their audience research on how visitors affect the animals and vice versa (Davey 2006; Miller et al. 2020; Swanagan

2000). Research related to the institution's mission statement (e.g. learning outcomes, conservation actions) and studies on how visitors are affected by animals are less common and frequently are only collected by larger institutions with greater staffing capabilities (Luebke and Grajal 2011). Broader visitor studies may also be outsourced to marketing companies due to lack of staff availability (Davey 2006; Luebke and Grajal 2011). Current popular methods for visitor studies include surveying guests through programme evaluations, observational studies and interviews (Luebke and Grajal 2011; Luebke and Matiasek 2013). The results of these surveys may be confounded by the participant pool.

Survey participants are commonly zoo visitors or guests who are paying for a membership or programme. These surveys may have an inherent bias because people who are actively visiting the facility or paying to maintain a membership are more likely to look favourably upon the facility (Reade and Waran 1996). The AZA states that zoos and aquariums are exceedingly popular and "93% agree their family enjoys seeing animals up close at zoos and aquariums" (AZA n.d.). This statement may be true for zoo visitors attending AZA institutions, but it does not consider viewpoints of individuals who do not visit zoos and aquariums including people who refuse to visit any animal care facility or people who primarily choose to visit different types of facilities like wildlife parks or safari parks. Another flaw in the current visitor studies at animal care facilities is that they mostly focus on their own campuses, activities and services instead of comparative studies with other institutions (Luebke and Grajal 2011; Moss 2016). Comparative studies can inform animal care facilities whether the results of a study are similar to other institutions of comparable size, composition, location and other measures. Using big social media data could facilitate these comparative studies, a tool that could be especially useful for smaller institutions that do not have the resources to conduct broad visitor studies.

Social media is a crucial mode of connecting with the public. In 2022, there were around 435 million people on Twitter worldwide and over 2.9 billion people used Facebook (Statista Research Department 2022). AZA-accredited facilities have a large following on social media including over 230 million views on YouTube, 16 million on Facebook and almost two million people on Twitter/X (AZA n.d.). That number often only includes people who follow these institutions on social media but more people will likely be exposed to the posts if they are shared. Zoos and other animal care facilities mostly use social media to share marketing and educational information (Rose et al. 2018). Recently there have also been a handful of studies using targeted social media data particularly during COVID-19 closures, including an examination of visitor interactions (Macri and Wells 2023) or changes to animal behaviour (Hunton et al. 2022). Big data from social media posts has been underutilised by animal care facilities but this resource can be used to ask pointed research questions that could inform future functions of the facility.

Marketing data collection software is increasingly being used for research questions outside the original use of the software. It has increasingly become a valuable tool in the medical community; large data from social media allow researchers to track diseases in real time, getting the full spectrum of patient experience without the need to go through a doctor's office (Sarker et al. 2015; Urso et al. 2018). Likewise, social media can be used to view a new perspective on discourse about animal care facilities (Moss 2016).

This study uses marketing data aggregation software to pull 100% of Twitter posts over a decade to examine the reputations of not just one specific institution but five broad groups of animal facilities: zoos, aquariums, wildlife parks and related facilities, safari parks and circuses. Twitter was chosen for this study because it was open access and did not place restrictions on which posts could be viewed. By reviewing social media posts over a decade, without specifying individual events or facilities, it is possible to analyse the overall trend in the general public's opinions about animal care facilities. This study is intended to provide animal care facilities with a new perspective to consider when developing public outreach campaigns that extend beyond the facility itself.

Methods

Ethics statement

The University of Tennessee, Knoxville's Institutional Review Board approved the methods used in this study as secondary research of public information (UT IRB-23-07345-XM). The study was deemed exempt from needing informed consent.

Data collection

Data were examined by creating search strings for five broad types of animal facilities: zoos, aquariums, wildlife parks and related facilities, safari parks and circuses (Table 1). These were chosen because all terms except for circus are common names in English for facilities accredited by EAZA and AZA. Circuses were used as another facility type that historically have displayed exotic animals but are now experiencing a decline in popularity. The search terms for each subcategory were amended to exclude irrelevant posts containing colloquialisms or unrelated entities (Table 1). The keywords were only in English. The data were collected with the data aggregating software interface Brandwatch (2022). The

Table 1. Search strings used in Brandwatch

Facility Type	Search terms
Zoos	"zoo" AND -"like a zoo" AND - "what a zoo" AND -"fucking zoo" AND -"its a zoo" AND -"it's a zoo"
Aquariums	"Aquarium" AND -("aquarium filter" OR "aquarium heater" OR "aquarium glass" OR "my aquarium" OR "our aquarium" OR "pump" OR "your aquarium" OR "fish tank" OR "pet" OR "game" OR "home" OR "fishtank" OR "aquarium cleaner" OR "zodiac")
Circuses	"circus" AND ("animal" OR "animals") AND -("my circus" OR "what a circus" OR "whole circus" OR "animal crackers" OR "animal cookies")
Wildlife parks	("wildlife park" OR "wildlife sanctuary" OR "wildlife rescue" OR "exotic animal park" OR "animal park") AND -"college major"
Safari parks	"Safari park"

search results were limited to all public Twitter posts including retweets from a ten-year span—1 July 2010 to 1 July 2020. Tweets were limited to a word count of 140 characters until 7 November 2017 when they switched to a 280-character maximum (X n.d.). Tweets could include words, letters, emojis, hashtags and media. Retweets did not need to add anything to the original tweet to be included in the analysis.

Throughout data collection, subsets of 10,000 tweets selected by Brandwatch for each facility type were examined to make sure that the content of the tweets matched the search terms and that the tweets were relevant to the study. For example, in August 2018 there was a large influx of tweets about Mondelez International redesigning boxes of Barnum's Animals Crackers to remove the bars and "free" the animals printed on the box (Haag 2018). This news while somewhat relevant does not actually pertain to live animal care in a real facility, so "animal crackers" and "animal cookies" were removed from the search string.

The Brandwatch software used in this study is a proprietary artificial intelligence (AI) program that produces graphs and spreadsheets for each search string including graphs of volume data, sentiment, emotion, gender, age, topic wheels and word clouds. The Brandwatch AI uses Transformer Architecture Language Models to understand sentiment and a proprietary statistical classifier using logistic regression to understand the emotion within social media posts (Marwyn 2024). Both methods work by differentiating between key words like 'happy', 'sad', 'afraid' and other more complex words and phrases. (Bannister 2018). Sentiment is classified into positive, negative and neutral sentiment; and emotion is classified into Ekman and Friesen's (1971) six universal emotions: happiness, surprise, sadness, fear, anger and disgust (Marwyn 2024). The sentiment and emotion accuracy for Brandwatch is estimated to be between 60% to 75% compared to the accuracy between two humans which is around 80% (Marwyn 2024).

In this paper, analyses are limited to volume, sentiment and emotion. For each type of facility, spikes in the volume data were manually examined by using both a 10,000-tweet subset from the spike's time frame and Brandwatch's Iris software. Iris is an AI that is designed to detect changes and examine the source material to see why changes are occurring (Agnew 2018). The AI determines peaks (hereafter called spikes to differentiate between the spikes and the true peak of the data) by comparing the volume of tweets for each unique driver to the median volume for the entire time frame (Brandwatch n.d.). Iris only determines spikes for the volume data (Table 2). The sentiment and emotion graphs were manually labelled to mark the corresponding Iris spikes from the appropriate volume graph. Basic linear models were created and tested with analyses of variance (ANOVAs) for the volume and net sentiment data to examine the statistical significance of the observed trends. The ANOVAs were run with the base *stats* package in R (R Core Team 2021). For some of the facilities a second model was tested with extreme outliers (spikes) removed to see if the significance remained the same. Eta-squared effect sizes for each model were calculated with the package *effectsize* in R (Ben-Shachar et al. 2020) and can be found in Supplementary Information.

Results

Volume

Zoos are the most talked about animal care facility with monthly tweet totals regularly in the 500,000-tweet range and about 60.71 million total tweets (Table 3). The other animal care facilities in descending order of total volume are aquariums, circuses, wildlife parks and safari parks. Aquariums had 12.39 million tweets over the search period with an average monthly volume of around 100,000 tweets. Each of the other three types of animal care facilities had below two million total tweets in the search period

Table 2. List of spikes designated by Brandwatch's Iris software

Facility Type	Spike letter	Annotation in text	Percent above the median	Number of tweets
Zoos	A	ZA	85%	923,162
Zoos	B	ZB	61%	806,003
Zoos	C	ZC	80%	900,812
Aquariums	A	AA	422%	525,638
Circuses	A	CA	309%	35,728
Circuses	B	CB	364%	40,570
Circuses	C	CC	446%	47,640
Circuses	D	CD	1058%	101,060
Circuses	E	CE	1493%	139,057
Wildlife parks	A	WA	1351%	151,666
Safari parks	A	SA	771%	49,472
Safari parks	B	SB	209%	17,549
Safari parks	C	SC	1390%	84,613
Safari parks	D	SD	206%	17,423
Safari parks	E	SE	291%	22,215

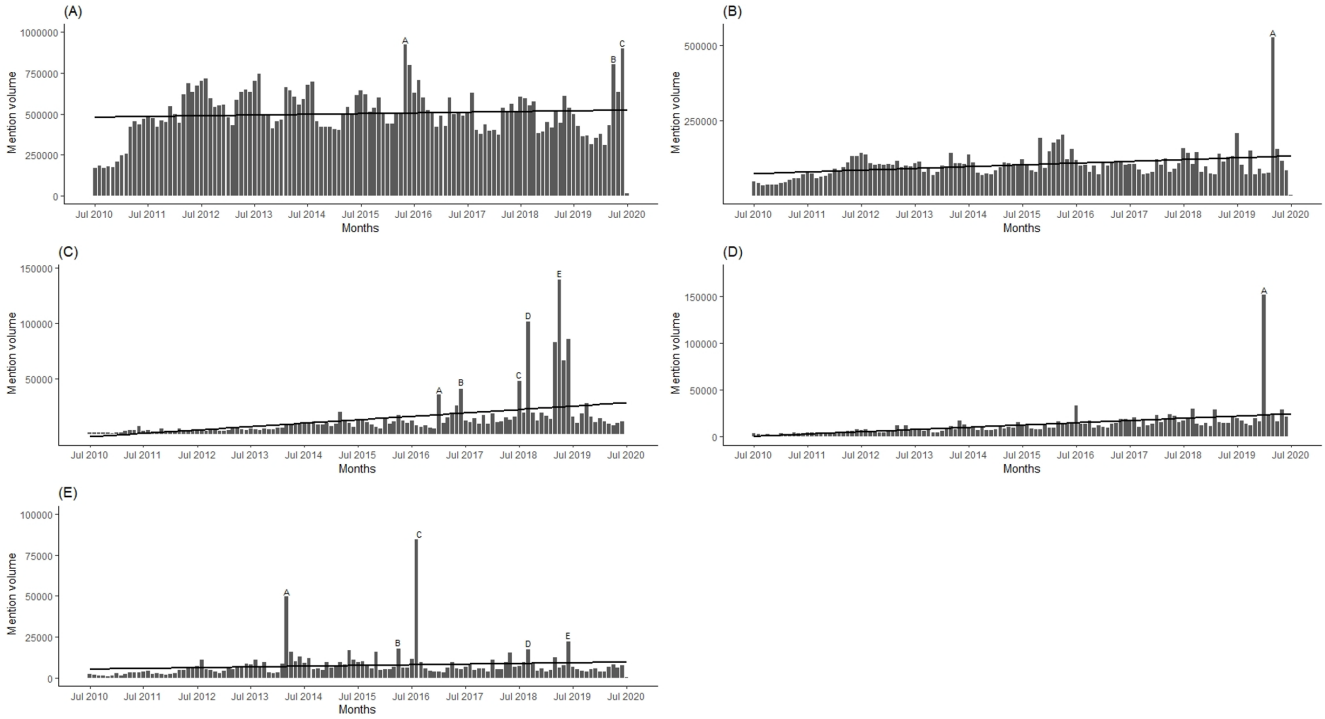

Figure 1. Total volume of posts on Twitter over time for (A) zoos, (B) aquariums, (C) circuses, (D) wildlife parks and (E) safari parks—from 1 July 2010 to 1 July 2020—broken down into month-long increments. The black line reflects the simple linear regression line. All facility types increased significantly in volume over the sampling period except for zoos

and had monthly averages between 5,000 and 10,000 tweets (Table 3). The different types of animal care facilities have varying numbers of spikes (outliers) in their volume graphs with some having as many as five spikes (safari parks and circuses) and others as few as one (aquariums and wildlife parks) (Figure 1).

The peak of the zoo volume trend graph is spike ZA with over 920,000 tweets (Figure 1; 84% above zoo median). This spike was identified as reactions to the death of Harambe the gorilla *Gorilla gorilla gorilla* after a child fell into his exhibit at Cincinnati Zoo. The smaller zoo spikes include a tiger at the Bronx Zoo testing positive for COVID-19 (spike ZB; 61% above zoo median, ~800,000 tweets) and the responses to a history article about a Belgian zoo that used people of colour as exhibits (spike ZC; 80% above zoo median, ~900,000 tweets; Figure 1A). The only other animal facility that has a comparable spike in the volume of tweets is aquariums with over 500,000 tweets (spike AA; 522% above aquarium median; Figure 1B). Aquarium spike A was caused by penguins and other animals exploring their aquariums and other museums at the beginning of the United States' COVID-19 lockdown. The number of tweets about aquariums increased over time ($F_{(1,118)}$=14.44,

Table 3. Total volume of tweets per facility type from 1 July 2010 to 1 July 2020 and median number of tweets per month over the search period. Retweets were included in these values

Facility type	Total volume of tweets over the search period	Median number of posts per month over the search period
Zoos	60.71 million	~500K
Aquariums	12.39 million	~100K
Circuses	1.55 million	~8.7K
Wildlife parks	1.51 million	~10K
Safari parks	0.90 million	~5.7K

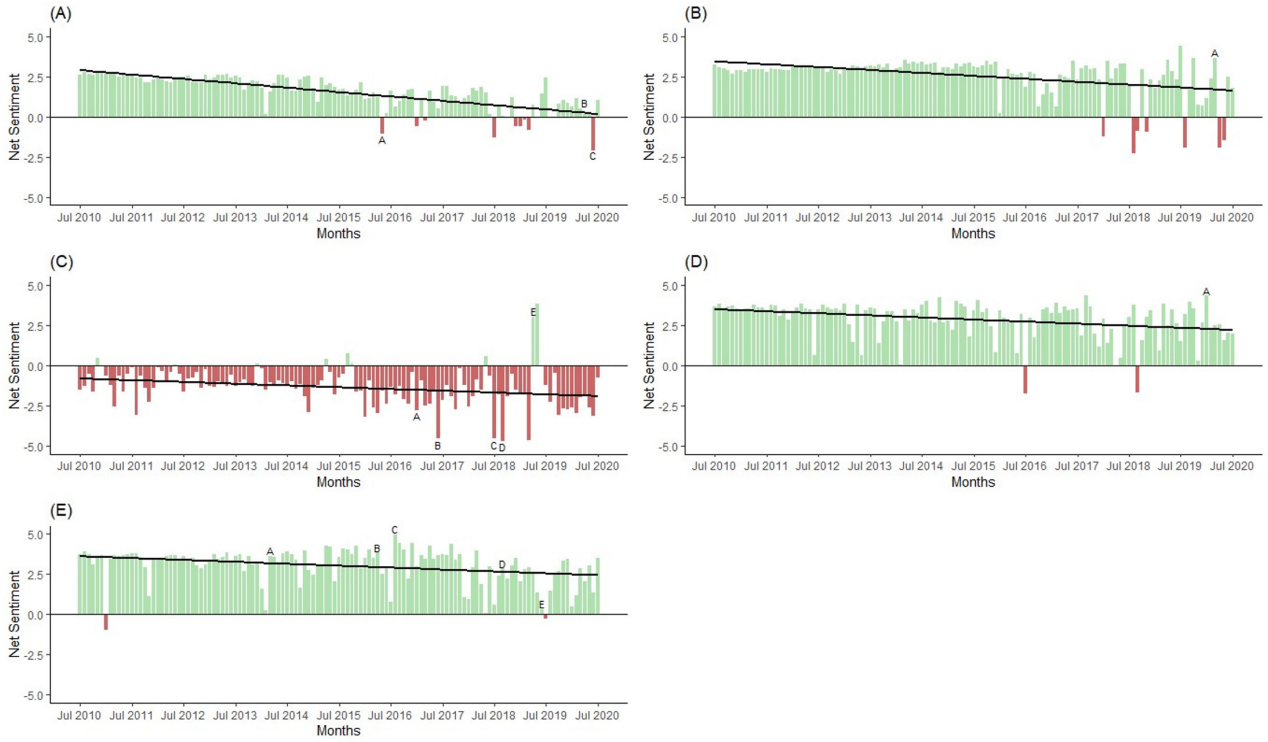

Figure 2. Net sentiment of posts on Twitter over time for (A) zoos, (B) aquariums, (C) circuses, (D) wildlife parks and (E) safari parks—from 1 July 2010 to 1 July 2020—broken down into month-long increments. The black line reflects the simple linear regression line. All facility types decreased significantly in net sentiment over the sampling period.

P=0.0002; extreme outlier AA excluded) but the number of tweets about zoos did not differ significantly throughout ($F_{(1,119)}$=0.878, P=0.351).

Circuses, wildlife parks and safari parks all have much smaller volume graphs. The peaks for these facilities reach a maximum roughly between 140,000 and 150,000 tweets (Figures 1C, 1D) and just under 85,000 tweets (Figure 1E) respectively. The peak and only spike in the wildlife park data occurred when wildlife rescuers saved koalas from the early 2020 Australian wildfires (spike WA, 1,451% above wildlife park median, ~150,000 tweets; Figure 1D). The total volume of tweets about wildlife parks increased over time ($F_{(1,118)}$=183.0, P<0.0001; extreme outlier WA excluded) with more people tweeting about wildlife parks monthly between 2017 and 2020 than prior to 2017. The safari park data have five spikes and also increased over time ($F_{(1,117)}$=11.88, P=0.0007; extreme outliers SA and SC excluded). Spike SC is 1,391% greater than the median and the peak of the safari park data. The driver of the spike was a video of two monkeys mating on a car in a safari park. The other smaller spikes are because of a picture of a monkey making a face (spike SA; 771% greater than the safari park median), two male lions mating (spike SB; 209% above the median), a video of a friendly lion trying to rub on safari park guests (spike SD; 206% above the median) and a video of an orangutan in a Ukraine safari park trying to touch grass through bars (Spike SE; 291% above the median) (Figure 1E).

The volume data for circuses also have five spikes. The driver of the peak of the circus data was a video from The Dodo of circus animals being rescued (spike CE; 1,493% higher than the circus median, ~140,000 tweets). The next highest spike was due to reactions to a People for the Ethical Treatment of Animals (PETA) video of bear cubs in the circus (spike CD; 1,058% higher than the median, ~100,000 tweets). Two of the spikes in the circus data stemmed from the same PETA video that was posted in two separate years (spikes CB and CC; 364% higher than the median and ~40,000 tweets, 446% higher than the median and ~47,000 tweets, respectively). The last circus spike is the smallest with ~35,000 tweets focused on the announcement that the Ringling Bros. and Barnum and Bailey Circus was closing (spike CA; 309% higher than the median). Like wildlife parks, circuses increased in total volume of tweets ($F_{(1,119)}$=32.6, P<0.0001) with more monthly tweets in the last three years of the timeframe (Figure 1C).

Sentiment

Sentiment was split into two graphs by the Brandwatch software. The first is total sentiment which shows the breakdown of positive, negative and neutral sentiments for each month during the timeframe. The second type of graph shows the net sentiment per month over time. The software calculated the net sentiment for each facility by plugging the volume of positive tweets and negative tweets into the following equation: (pos−neg)/(pos+neg)×5=net sentiment.

The net sentiment for zoos is declining sharply over time ($F_{(1,119)}$=163.8, P<0.0001) (Figure 2A). When removing the negative spikes ZA and ZC from the analysis the results remain very similar ($F_{(1,117)}$=178.7, P<0.0001). Net sentiment can be examined further with the total sentiment graph that is broken down into positive, neutral and negative sentiments (Figure 3A). Spike ZA, the death of Harambe the gorilla, appears to be an important date when

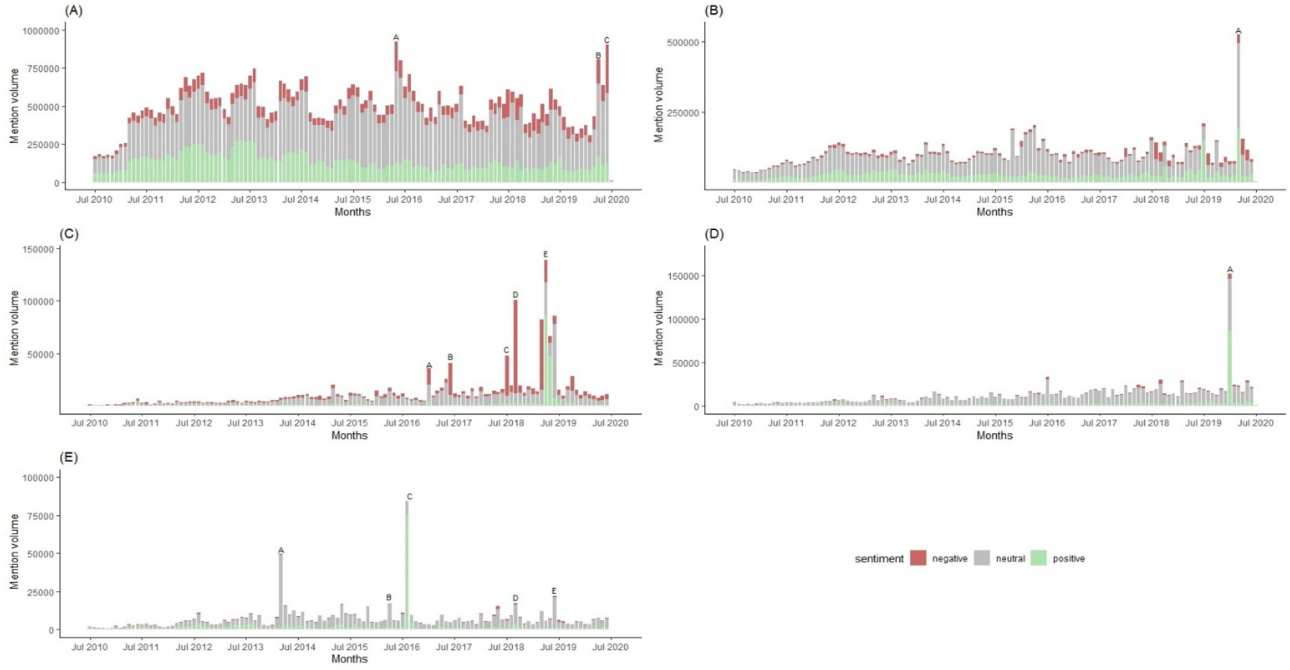

Figure 3. Total sentiment of posts on Twitter over time for (A) zoos, (B) aquariums, (C) circuses, (D) wildlife parks and (E) safari parks—from 1 July 2010 to 1 July 2020—broken down into month-long increments

sentiments for zoos started decreasing more rapidly. In the net sentiment graph, spike ZA is the first occurrence of a negative net sentiment for zoos and the sentiment does not return to previous levels (Figure 2A). The net sentiment from 2018 to 2020 stays much closer to zero or negative net sentiments than closer to the beginning of the decade. While it does appear that positive sentiments are declining and negative sentiments are increasing for zoos, many tweets included in the analysis each month are categorised as neutral (Figure 3A).

While still being mostly positive, the sentiment about aquariums, safari parks and wildlife parks are also heavily dominated by tweets categorised as neutral. Aquariums start to have more variance in the volume of positive and negative sentiment tweets in 2018 (Figure 3B). Comparing aquarium total sentiments to the net sentiments graph, the variance begins in 2016 after being relatively stable prior to January 2016 (Figure 2B). The trendline for aquarium net sentiments show that the number of positive sentiments is declining but not as rapidly as zoo sentiments ($F_{(1,119)}$=28.12, P<0.0001) (Figure 2B).

In contrast to the zoo and aquarium net sentiment graphs, instead of being stable for a few years and then declining wildlife parks and safari parks appear to have a small cyclical pattern where they will have an increase in positive sentiments and then the number of positive sentiments will decline (Figures 2D and 2E). Both facility types start to see an increase in negative sentiments between mid-2016 and 2017 and the net positive months do not remain as positive as earlier in the decade. There are spikes with a large increase in positive tweets that stand out from the rest of the graphs. Spike WA in the wildlife park data (wildlife parks rescuing animals from wildfires) is predominantly positive, even outnumbering the number of neutral tweets (Figure 3D). In the safari park data it is spike SC (monkeys mating on a car) that is extremely positive—with the positive tweets over eight times as numerous as the neutral tweets (Figure 3E). Even with the large positive spikes in the graphs, the trend of the sentiment of the tweets for both types of animal care facilities is declining from a more positive and neutral sentiment to more neutral and negative ($F_{(1,119)}$=13.29, P=0.0004, safari parks; $F_{(1,119)}$=14.3, P=0.0002, wildlife parks).

Circuses are on the opposite side of the spectrum from the other four types of facilities. The sentiments of tweets about circuses are mostly negative. Around 2017, the number of negative tweets starts to spike frequently (Figure 3C). Only spike CE (a video of circus animals being rescued) has a large influx of positive tweets. In the circus net sentiment graph, there is a steady decline in net sentiment over time ($F_{(1,119)}$=8.74, P=0.0038) (Figure 2C). Unlike the other facility types, instead of starting in the high positive net sentiments, the circus tweets begin with negative net

Journal of Zoo and Aquarium Research 12(3) 2024
http://doi/org/10.19227/jzar.v12i3.759

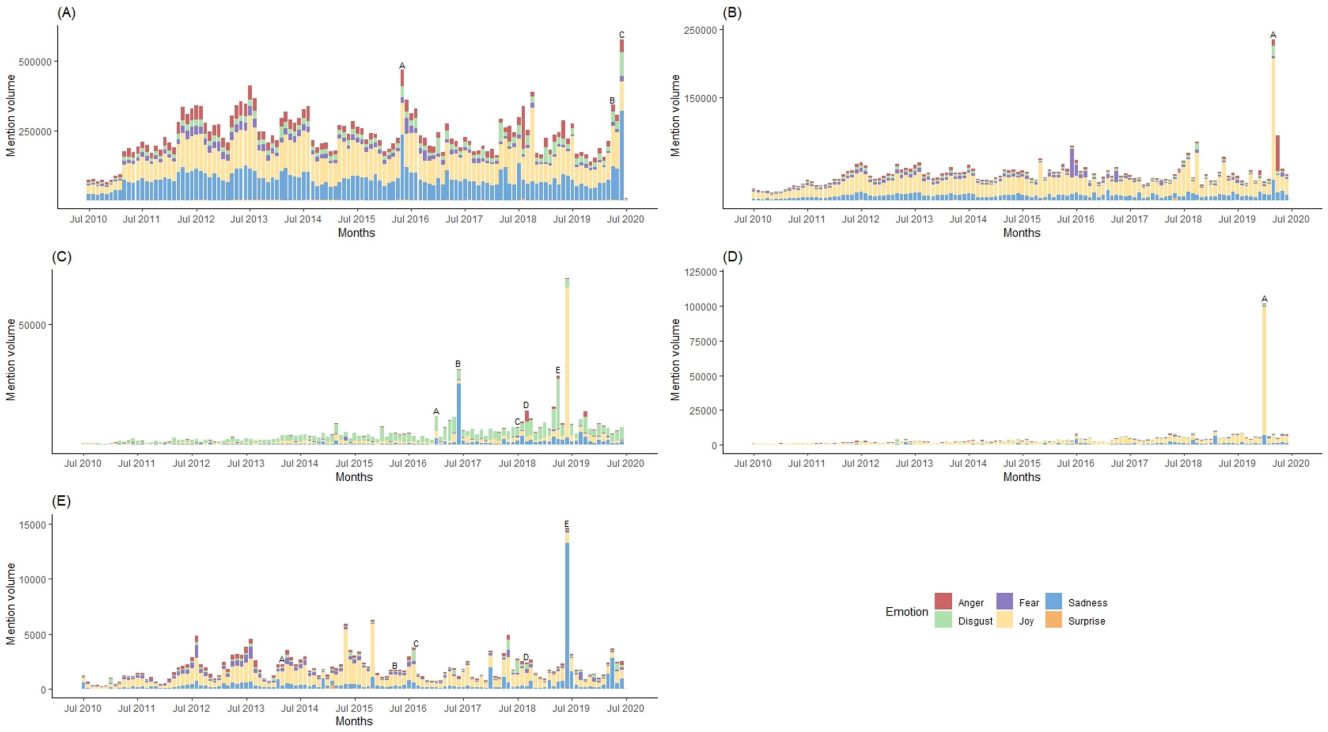

Figure 4. Emotion of posts on Twitter over time for (A) zoos, (B) aquariums, (C) circuses, (D) wildlife parks and (E) safari parks—from 1 July 2010 to 1 July 2020—broken down into month-long increments

sentiments. In 2015 the sentiments start to get more and more negative (Figure 2C). Many of the months still have a majority that are neutral sentiments but there are also more months where the volume of negative tweets compares to or outnumbers the volume of neutral tweets of the other facility types (Figure 3C).

Emotion

The Brandwatch software takes sentiment a step farther by splitting tweets into six different emotions: joy, anger, disgust, fear, sadness and surprise. Tweets that cannot be classified as one of these six emotions are not included in the graph that is generated. Joy and sadness are the most used emotions, in that order (Dorronsoro 2020). For the most part that trend appears to be visible in the emotion graphs of all the animal care facility types (Figures 4A, 4B, 4D and 4E). Circuses have less joy and more disgust (Figure 4C).

There are many joyful tweets for zoos, aquariums, wildlife parks and safari parks which reflects the results of the sentiment graphs. The peak of the zoo sentiment and volume graphs was spike ZA (death of Harambe Gorilla) but in the emotion graph spike ZC (people of colour in zoo exhibits) was the peak (Figure 4A). Both of these spikes are dominated by sadness, anger and disgust. Starting in 2016, there are also more months in the aquarium data that have large influxes of negative emotions. This trend is less pronounced, especially when there are large spikes that are driven by joyful tweets like aquarium spike AA (penguins during COVID-19) which may explain why the sentiment for aquariums is declining less rapidly (Figure 4B). Similarly, the peak of the wildlife park data (spike WA, rescued animals from wildfires) has a large number of joyful tweets (Figure 4D). Outside of spike WA, there are an increasing number of months that have more tweets categorised as sad after July 2016. In contrast to aquariums and wildlife parks the largest safari spike in the sentiment and volume graphs, spike SC (monkeys mating on a car), is not the largest spike in the emotion graph. The peak of the safari emotion graph is spike SE (orangutan trying to reach grass through bars) which has a large volume of sad tweets (Figure 4E).

As with sentiment, circuses stand out from the rest of the other animal care facilities when it comes to the types of emotions that dominate the conversations. The emotions that had the greatest volume of tweets were disgust and sadness which reflects the overwhelmingly negative sentiments found for circuses (Figure 4C). The peak of the circus emotion graph is a large, unlabelled spike in the graph just after spike CE. It is unlabelled because it does not correspond with any of the spikes from the volume graph. Iris does not provide information about spikes in graphs other than volume data, but manual analysis of tweets from June 2019 indicates that this spike may be caused by a news article

about circuses using holograms instead of live animals. The unlabelled spike consists of many joyful tweets, which contrasts starkly with the rest of the emotions per month for the rest of the decade-long time frame. Spike CB (a bear urinating on itself), which generated predominantly sad emotions, had the greatest volume of tweets that were classified as an emotion among the labelled spikes (Figure 4C). In the volume and sentiment graphs spike CB is one of the smallest labelled spikes (Figures 1C, 2C).

Discussion

The general sentiments for zoos, aquariums, wildlife parks and safari parks on Twitter were neutral or positive but overall the net sentiment is declining. The net sentiment of zoos is declining the most rapidly. Circuses are set apart from the others by an overwhelming amount of negative emotions. This implies that while many animal care facilities may individually have positive reactions, people on Twitter/X may be becoming more critical of these institutions as a collective entity. All these facility types seem to have the origin of their sentiment decline in the past three or four years of the study period with most declines starting around 2016. These declines may be compounded by media showcasing animal captivity while not emphasising animal welfare efforts (Rank et al. 2018). An example of an event that gained critical international attention from the public and the media—and became a meme used for months and even years after—was the death of Cincinnati Zoo's western lowland gorilla Harambe (spike A; Figure 1A).

In February 2014, another public death of a charismatic animal occurred that caused a critical outpouring: the death of Marius the giraffe at Copenhagen Zoo. When people are angry at an institution they tend to take one of two approaches: acts intended to make the organisation change in favour of a goal or acts that discredit the organisation and cause a loss of business (Romani et al. 2013). In animal care facilities, these actions manifest in sharing online frustrations and even in pressure to tourism companies to reduce promotion of these zoological institutions (Keith 2020).

Social media allows for consumers to voice their discontent in massive and rapid increases in negative emotion towards the institution, sometimes called social media storms or collaborative brand attacks (CBAs) (Rauschnabel et al. 2016; Rydén et al. 2020). These social media storms are echo chambers that are difficult to break into; however using an already existing support network of social media followers may allow an institution to prevent real damage from social media storms (Pfeffer et al. 2014). Thus, constant dissemination of educational information by animal care facilities is crucial particularly when the information can be spread throughout social media by science communicators.

Science communicators, as defined by Light and Cerrone (2018), are interested in collecting and sharing science on social media and being part of a larger conversation about science topics. Young science communicators in particular are important to reach on social media. Teens aged 13 to 17 are ubiquitous on the internet and the majority of them see social media as a way to expand their world views and show support for causes they care about (Anderson and Jiang 2018). When prejudices and limited views are prevalent and given as truths on social media, it can create a spiral of misinformation that spreads throughout large groups on the internet (Andersson and Öhman 2017; Light and Cerrone 2018). While myths and falsehoods should be targeted and dispelled, it is important to note that not everyone on social media with a negative opinion of care facilities will be willing to learn and understand more about conservation/welfare efforts.

It has been shown many times that when people see live animals or videos of live animals, they learn more and feel more strongly about conservation practices (Ballantyne et al. 2011; Falk et al. 2007; Godinez and Fernandez 2019; Jensen et al. 2017; Miller et al. 2020; Randall 2011). Social media posts can also increase empathy and understanding of nature (Rose et al. 2018). All animal care facilities should maximise their outreach on social media platforms to engage with as many people as possible. More information should be available about animal welfare practices to counteract the large negative focus on welfare in the media (Rose et al. 2018). In some cases there may be a disconnect between what the public and the zoos understand to be conservation priorities (Shaw 2011). Fortunately, many institutions like EAZA are striving to take a step in the right direction by working to maintain transparency and foster a strong public understanding of the issues that can occur in a zoological setting (EAZA 2018).

Limitations

One of the limitations of this study is that the search strings only used English words. Considering how global animal care institutions are, future studies should examine similar keywords in other major languages. It is also important to note that Brandwatch only provides information for the spikes identified by the AI in the volume data. There may be cases like the circus emotion data where an important spike is unlabelled because it does not register with the AI in the volume data. Caution should also be used when analysing the results of the data. Brandwatch does not always capture the complexity of the topic. For example, circus spike CE is predominantly positive in sentiment but the underlying cause is negative for circuses (i.e., Twitter users were happy that animals were removed from circuses). Researchers may be able to correct for these potential errors by manually examining the data or cross-referencing with other systems but this will be more time-consuming. The scale of the study was very large by looking at broad categories of institutions rather than individual facilities. Finer details were likely lost because downloading 77 million posts was not feasible for detailed analysis, leading to a reliance on summary statistics for a high-level view.

Other limitations from this study can likewise be expanded upon in future studies. For example, Twitter was the sole social media website used to collect the data. As a blogging website, Twitter/X has fewer restrictions on who can see posts, making most tweets public; other companies like Facebook have more privacy settings controlling what people can and cannot see. Facebook is one of the primary ways that zoos and other animal care facilities connect with their visitors over social media (Rose et al. 2018) so future studies could integrate Facebook and other social media posts for a more comprehensive view. Twitter/X tends to amplify negative posts more than Facebook does likely due to the more public nature of the site (Zimmerman et al. 2014). This implies that replications of this study using data from other social media sites may result in different trends.

Retweets were included in the data, showing the total number of people who were sharing posts about the facilities. Another metric that could be explored is identifying the volume of original authors. It is also very important to note that the AI used in these types of data analysis may still have flawed data (Hayes et al. 2021). Researchers can guide the AI to focus on specific topics by manually training the AI to better recognise key statements and the sentiments behind them. Researchers can also look at subsections of AI-generated data to ensure that the software is accurate. Even after these quality control measures there may still be errors that are missed when considering millions of social media posts.

Conclusion

Animal care facilities are portrayed in both positive and negative lights in social media and many posts focus on animal welfare. There is an apparent disconnect between the favourability of animal care facilities between visitors and non-visitors and this is not being reflected in the literature. Posts on social media are reflective of a slow decline in the sentiments towards all animal care facilities. The current distrust of circuses on social media is a dire warning for all zoological institutions. A step toward improving the public's perceptions would be to practise transparency and to continue striving to educate and promote conservation in multiple modes. In the future, animal care facilities should consider using data aggregation software to analyse how well they are connecting with their audiences across multiple media formats and to perform cross-institutional studies.

Acknowledgements

Thanks to TF, IB, RB and the EEB writing group for their comments on earlier drafts. Thanks also to the Center for Health Informatics at the University of Illinois Urbana-Champaign for providing access to Brandwatch.

References

Agnew P. (2018) *Introducing Iris™: An AI-Analyst for Better Insights.* Available online at https://www.brandwatch.com/blog/introducing-iris-an-ai-analyst-for-better-insights/

Anderson M., Jiang J. (2018) *Teens' Social Media Habits and Experiences.* Pew Research Center. Available online at https://www.pewresearch.org/internet/2018/11/28/teens-social-media-habits-and-experiences/#fn-21827-1

Andersson E., Öhman J. (2017) Young people's conversations about environmental and sustainability issues in social media. *Environmental Education Research* 23(4): 465–485. doi:10.1080/13504622.2016.1149

Association of Zoos and Aquariums (AZA) (2020) *The Accreditation Standards and Related Policies 2020 Second Edition*. Silver Spring, Maryland: Association of Zoos and Aquariums.

Association of Zoos and Aquariums (AZA) (n.d.) *Visitor Demographics. AZA*. Available online at https://www.aza.org/partnerships-visitor-demographics

Ballantyne R., Packer J., Sutherland L.A. (2011) Visitors' memories of wildlife tourism: Implications for the design of powerful interpretive experiences. *Tourism Management* 32(4): 770–779. doi:10.1016/j.tourman.2010.06.012

Bannister K. (2018) *Understanding Sentiment Analysis: What It Is and Why It's Used*. Available online at https://www.brandwatch.com/blog/understanding-sentiment-analysis/

Ben-Shachar M.S., Lüdecke D., Makowski D. (2020) *effectsize:* Estimation of Effect Size Indices and Standardized Parameters. *Journal of Open Source Software* 5(56): 2815. doi:10.21105/joss.02815

Brandwatch (2022) *Brandwatch*. Available online at https://www.brandwatch.com/

Brandwatch (n.d.) *Iris*. Available online at https://support.brandwatch.com/hc/en-us/articles/360002524477-Iris

Davey G. (2006) Visitor behavior in zoos: A review. *Anthrozoös* 19(2): 143–157. doi:10.2752/089279306785593838

Dorronsoro S. (2020) *How Do We Express Our Emotions Online?* Available online at https://www.brandwatch.com/blog/react-research-online-emotions/

Ekman P., Friesen W.V. (1971) Constants across cultures in the face and emotion. *Journal of Personality and Social Psychology* 17(2): 124–129. doi:10.1037/h0030377

European Association of Zoos and Aquaria (EAZA) (n.d.) *About Us*. EAZA. Available online at https://www.eaza.net/about-us/eaza/

Falk J.H., Reinhard E.M., Vernon C.L., Bronnenkant K., Heimlich J.E., Deans N.L. (2007) *Why Zoos and Aquariums Matter: Assessing the Impact of a Visit to a Zoo or Aquarium.* Silver Spring, Maryland: Association of Zoos and Aquariums.

Global Federation of Animal Sanctuaries (GFAS) (2019) Operations Standards. Phoenix, Arizona: Global Federation of Animal Sanctuaries.

Gilman B.I. (1916) Museum fatigue. *The Scientific Monthly* 2(1): 62–74.

Godinez A.M., Fernandez E.J. (2019) What is the zoo experience? How zoos impact a visitor's behaviors, perceptions, and conservation efforts. *Frontiers in Psychology* 10: 1746. doi:10.3389/fpsyg.2019.01746

Haag M. (2018) *In a Victory for PETA, Animal Crackers Roam Free.* New York Times. Available online at https://www.nytimes.com/2018/08/21/business/animal-crackers-barnums-nabisco-mondelez.html

Hayes J.L., Britt B.C., Evans W., Rush S.W., Towery N.A., Adamson A.C. (2021) Can social media listening platforms' artificial intelligence be trusted? Examining the accuracy of Crimson Hexagon's (now Brandwatch Consumer Research's) AI-driven analyses. *Journal of Advertising* 50(1): 81–91. doi:10.1080/00913367.2020.1809576

Hunton V., Rendle J., Carter A., Williams E. (2022) Communication from the zoo: Reports from zoological facilities of the impact of COVID-19 closures on animals. *Journal of Zoological and Botanical Gardens* 3(2): 271–288. doi:10.3390/jzbg3020022

Jensen E.A., Moss A., Gusset M. (2017) Quantifying long-term impact of zoo and aquarium visits on biodiversity-related learning outcomes. *Zoo Biology* 36(4): 294–297. doi:10.1002/zoo.21372

Keith R. (2020) Animal welfare policies in the tourism providers sector. WAZA News Magazine 1: 14–16.

Light D., Cerrone M. (2018) Science engagement via Twitter: Examining the educational outreach of museums, zoos, aquariums and other science organizations. *Visitor Studies* 21(2): 175–188. doi:10.1080/10645578.2018.1560747

Loomis R.J. (1988) The countenance of visitor studies in the 1980s. *Visitor Studies* 1(1): 12–24.

Luebke J.F., Grajal A. (2011) Assessing mission-related learning outcomes at zoos and aquaria: Prevalence, barriers, and needs. *Visitor Studies* 14(2): 195–208. doi:10.1080/10645578.2011.608013

Luebke J.F., Matiasek J. (2013) An exploratory study of zoo visitors' exhibit experiences and reactions. *Zoo Biology* 32(4): 407–416. doi:10.1002/zoo.21071

Macri A.M., Wells D.L. (2023) Connecting to zoos and aquariums during a COVID-19 lockdown. *Journal of Zoological and Botanical Gardens* 4(2): 476–489. doi:10.3390/jzbg4020035

Marwyn A. (2024) *Sentiment and Emotion Analysis*. Social Media Management. Available online at https://social-media-management-help.brandwatch.com/hc/en-us/articles/4555786479901-Sentiment-and-Emotion-Analysis

Miller L.J., Razal C.B., Luebke J.F., Matiasek J., Granger D.A., Brooks H.J.B., Maas K. (2020) The impact of in-person and video-recorded animal experiences on zoo visitors' cognition, affect, empathic concern, and conservation intent. *Zoo Biology* 39(6): 367–373. doi:10.1002/zoo.21565

Moss A. (2016) Can conservation education learn anything from 'Big Data'? *International Zoo Yearbook* 50(1): 23–33. doi:10.1111/izy.12107

Pfeffer J., Zorbach T., Carley K.M. (2014) Understanding online firestorms: Negative word-of-mouth dynamics in social media networks. *Journal of Marketing Communications* 20(1): 117–128. doi:10.1080/13527266.2013.797778

R Core Team (2021) *R: A Language and Environment for Statistical Computing.* Vienna, Austria: R Foundation for Statistical Computing. Available online at https://www.R-project.org/.

Rabb G.B., Saunders C.D. (1999) God, unicorns, and toilets: Mission-inspired evaluation. *American Zoo and Aquarium Association Annual Conference Proceedings* 354–359.

Randall T. (2011) *Assessment of Change in Conservation Attitudes Through Zoo Education*. Oklahoma City, Oklahoma: Oklahoma State University PhD thesis.

Rank S.J., Voiklis J., Gupta R., Fraser J.R., Flinner K. (2018) Understanding organizational trust of zoos and aquariums. *Iowa State Summer Symposium on Science Communication* 0–11. doi:10.31274/sciencecommunication-181114-16

Rauschnabel P.A., Kammerlander N., Ivens B.S. (2016) Collaborative brand attacks in social media: Exploring the antecedents, characteristics, and consequences of a new form of brand crises. *Journal of Marketing Theory and Practice* 24(4): 381–410. doi:10.1080/10696679.2016.1205452

Reade L.S., Waran N.K. (1996) The modern zoo: How do people perceive zoo animals? *Applied Animal Behaviour Science* 47: 109–118. doi:10.1157/13119978

Robinson E.S., Sherman I.C., Curry L.E. (1928) *The Behavior of the Museum Visitor*; New Series, Number 5. Washington, DC: American Association of Museums.

Romani S., Grappi S., Bagozzi R.P. (2013) My anger is your gain, my contempt is your loss: Exploring consumer responses to corporate wrongdoing. *Psychology and Marketing* 30(12): 1029–1042. doi:10.1002/mar.20664

Rose P.E., Hunt K.A., Riley L.M. (2018) Animals in an online world; An evaluation of how zoological collections use social media. *Journal of Zoo and Aquarium Research* 6(2): 57–62. doi:10.19227/jzar.v6i2.324

Rydén P., Kottika E., Hossain M., Skare V., Morrison A.M. (2020) Threat or treat for tourism organizations? The Copenhagen Zoo social media storm. *International Journal of Tourism Research* 22(1): 108–119. doi:10.1002/jtr.2322

Sarker A., Ginn R., Nikfarjam A., O'Connor K., Smith K., Jayaraman S., Upadhaya T., Gonzalez G. (2015) Utilizing social media data for pharmacovigilance: A review. *Journal of Biomedical Informatics* 54: 202–212. doi:10.1016/j.jbi.2015.02.004

Shaw A. (2011) *Public Perception of Conservation Work By UK Zoos*. London, UK: Imperial College London MSc thesis.

Statista Research Department (2022) *Most Popular Social Networks Worldwide as of January 2022, Ranked by Number of Monthly Active Users*. Available online at https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/

Swanagan J.S. (2000) Factors influencing zoo visitors' conservation attitudes and behavior. *Journal of Environmental Education* 31(4): 26–31. doi:10.1080/00958960009598648

Urso B., Updyke K.M., Domozych R., Solomon J.A., Brooks I., Burton V., Dellavalle R.P. (2018) Acne treatment: Analysis of acne-related social media posts and the impact on patient care. *Cutis* 102(1): 41–43.

Williams-Mitchell D. (ed.). (2021) *Saving Species Together With You*. Amsterdam, Netherlands: European Association of Zoos and Aquaria.

X (n.d.) Counting Characters When Composing Tweets. Available online at https://developer.x.com/en/docs/counting-characters#:~:text=This%20limited%20the%20original%20Tweet,brief%2C%20but%20enabling%20more%20expression.F

Zimmerman C., Chen Y., Hardt D., Vatrapu R. (2014) Marius, the giraffe: A comparative informatics case study of linguistic features of the social media discourse. *CABS 2014 - Proceedings of the 5th ACM International Conference on Collaboration Across Boundaries* 131–140. doi:10.1145/2631488.2631501