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Research article

Isolated to the internet: which Facebook posts from zoological collections generated greater community engagement during lockdown closures when society was isolated to their homes?

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'I hereby declare that this thesis is the results of my own investigations, except where otherwise stated. All other sources are acknowledged by bibliographic references. This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree unless, as agreed by the University, for approved dual awards.

I confirm that I am submitting this work with the agreement of my Supervisor(s).'

Abstract

Zoological collections have relied upon social media as a valuable platform to communicate their values and self-advertise to an interested public audience. Zoo visitation was prohibited during periods of COVID-19 lockdown restrictions, resulting in social media becoming the primary avenue for zoos to connect with the public. Consequently, there has been much research offering technical insight to businesses about improving their social network marketing strategies through optimising post publication time, post media type and post character count. Similarly, there has also been some zoological research into the factors affecting which animal species are most popular online. However, these two areas of research have often remained mutually exclusive and there is limited guidance for how zoological collections can most effectively use social media to communicate values and promote visitation – something for which lockdown restrictions offered zoos a golden opportunity. This study aimed to provide a comprehensive review, specific to the zoological attraction industry, of which factors affect the public engagement with a social media post. The data were collected from the Facebook pages of 30 UK zoological attractions for 4 months from both 2019 and 2020. The results support much of the existing zoological literature surrounding social media, as well as highlighting novel predictors of social media engagement which offer alternative insight into how zoos can boost the popularity of their posts. In particular it was found that: identifying the photographed species within the post narrative; including photographs of forward-facing animals; featuring photographs of zookeepers and avoiding infographics were all ways in which zoos could maximise the engagement of their Facebook feed. These findings justify the need for a strategized approach towards social media communications and provide a wide-ranging breakdown linking different creative post variables to their effect upon levels of public engagement.

Introduction

The advent of the 21st century has seen the explosive growth in people registering accounts on social media sites (Figueiredo *et al*., 2011; Giannakos *et al*., 2013; Liu *et al*., 2014; Komljenovic, 2019) especially because of its increasing accessibility through mobile 'apps' (Bellman *et al*., 2011; Du *et al*., 2019). In a recent survey by the Pew research centre, Auxier and Anderson (2021) found that roughly seven-in-ten American adults use social media, with the most popular sites being YouTube and Facebook with userships of 81% and 69% respectively. Such sites aim to provide a digital platform for users to: construct their own public profile, share multimedia content and direct message other users in order to give users a sense of close community even when not physically present with others (Farnham and Churchill, 2011; Lee and Cho, 2019; Tiwari *et al*., 2019).

Social media's function in increasing feelings of social capital (Burke *et al*., 2010) became particularly important during the COVID-19 national lockdowns. Whilst staying at home, many turned to social media sites as the predominant way to maintain social relationships (Sun *et al*., 2020; Lemenager *et al*., 2021; Nandy, 2021; Talbot and Briggs, 2022) through direct interaction with others such as liking, commenting and sharing posts made by their contacts (Burke *et al*., 2010). Social media also became an avenue for people to keep abreast with news developments (Raacke and Bonds-Raacke, 2008; Laato *et al*., 2020), although this also led to some people withdrawing from social media in order to avoid COVID-19 information overload (Wiederhold, 2020; Liu *et al*., 2021). Additionally, periods of lockdown have been associated with increased public engagement with businesses on social media to make product purchases whilst high-street shops were shut (Huang *et al*., 2021; Mason *et al*., 2021; Naeem, 2021).

Hospitality and tourism businesses have successfully exploited social media communities to cultivate positive digital relationships with their customers and generate high-reaching word-of-mouth advertising (Zeng and Gerritsen, 2014; Moro and Rita, 2018). There have been studies investigating the marketing potential of social media for many tourist attractions including: theme parks (Widmar *et al*., 2020), botanical gardens (Gaffar *et al*., 2018), the cinema (Yee *et al*., 2021) and zoological collections (Addo, 2020). Furthermore, a professional social media presence has been found to increase membership and donations for non-profit organisations (Waters *et al*., 2009). Most studies evaluate how attractions can use social media to influence consumer behaviour (Nzeku and Duffett, 2021). A defined social media strategy, developing emotional connection with potential visitors, increasing online advertising expenditure and holding social media competitions have all been touted as ways for tourist attractions to use social media effectively to increase revenue (Rothschild, 2011; Besana *et al*., 2018; Thompson *et al*., 2018; Rui, 2019).

An emerging area of research investigates whether social media can be used beyond marketing purposes to communicate other values that tourist attractions may have. Social media platforms have been found to be an effective interface for engaging in public debate over contentious conservation issues (Pavelle and Wilkinson, 2020) including: keeping primates as pets (Bockhaus, 2018; Chua, 2018; Norconk *et al*., 2020) and palm oil use (Ruggeri and Samoggia, 2018; Teng *et al*., 2020). An educational campaign co-ordinated by Melbourne zoo on the theme of palm oil was delivered in part via social media. It was found to increase awareness, intention (support for palm oil product labelling) and action (self-reported conservation behaviour) of the wider public (Pearson *et al*., 2014). During a negative social media backlash in response to the euthanasia of a giraffe, Copenhagen zoo used their social media platforms to communicate their professional zoo values and to scientifically correct public misinterpretation of the event as a result of emotionally-charged international media reporting (Rydén *et al*., 2020). This highlights how zoos can use their social media as a forum to engage in transparent dialogue with the public, communicating their work and responding to the viewpoints of non-professionals.

The potential for social media to be used as an educational vector has also been explored in the literature. In her study of museum social media pages, Russo found that social media can take a central educational role within informal learning environments as it allows individuals to engage in a participatory manner (Russo *et al*., 2009). This work was then developed further into the zoo industry through analysing the scientific authority of zoo social media accounts and the way in which the information they share then gets disseminated more widely through public retweeting (Light and Cerrone, 2018). During COVID-19 lockdowns several zoos delivered online Summer school programs which were found to have a positive effect on participants' appreciation of nature (Cozens-Keeble *et al*., 2021). These were most effective when livestreamed instead of being recorded which is explained by society's increased desire for connectedness to nature during lockdown isolation (Abd Rabou, 2020), but also fits with existing research about the visitor value of 'live' experiences (Carter *et al*., 2020; Miller *et al*., 2020). There is also evidence to indicate a public preference for receiving new information through an online format (Bakhtyari *et al*., 2018). Ballantyne and Packer (2016) also found that visitors valued online avenues, including Facebook groups, as effective methods for zoos to reinforce the conservation learning that visitors gain through wildlife experiences during a zoo visit (Kolb, 1984).

It is clear that the social media pages of zoos have the potential to function in a multi-faceted way, including: marketing, educational outreach and communication of missional values. Of course, the success of social media in fulfilling these purposes is underpinned by the extent to which it is able to attract the engagement of the public – commonly measured in similar studies by the number of likes, comments and shares (Lee *et al*., 2018; Rose *et al*., 2018; Ryder *et al*., 2021; Shaw *et al*., 2022). Principally, people choose to visit a zoological attraction for an entertaining day of watching wildlife (Ryan and Saward, 2004; Moss and Esson, 2010; Knežević *et al*., 2016), so it seems reasonable to predict that social media posts featuring animals will attract greater levels of public engagement. It is well-documented that social media posts need to be eye-catching as users will scroll through their 'feed' with hastily, only spending an

average of 1.7 seconds reading each post (Facebook IQ, 2016). Given that the human brain can understand and interpret images 60'000 times faster than it can text (Potter *et al*., 2014), it is anticipated that image-based social media posts will engage a larger audience. Therefore, this justifies further review of the existing literature surrounding specific creative photographic variables and public preference within wildlife photography.

Literature review

Facing the camera

Most of the research relating to the psychological effects of seeing a face relates to human social sciences with limited research examining the inclusion of faces in wildlife photography. Fundamentally facial recognition is a key component of human relationships and helps to promote mutual affection and dampen affinity (Walther *et al*., 2001). Bainbridge, *et al*. (2013) described human faces as having an intrinsic memorability and, although there are many traits which mean some faces are more memorable than others (Khosla *et al*., 2013), the inclusion of a face in a photograph makes it more memorable in the mind of the viewer (Sarno and Alley, 1997). There has also been some research conducted into the impact of facial occlusion, such as from wearing sunglasses (Roberson *et al*., 2012), which further exacerbates the ability to read facial expressions (Bassili, 1979). During the COVID-19 pandemic it was found that face coverings had a negative influence on communication, increased the chance of misinterpreting emotions (Carbon, 2020) both of which reduced trust and relational intimacy (Wiesmann *et al*., 2021). These findings strengthen the argument made by Bakhshi, *et al*. (2014) that photos featuring humans are more engaging, however it is possible that the same conclusions may apply to human perceptions of animal faces. At a fundamental level, one study found that forward-facing animal photos did better to elicit a response in the human's ventral temporal cortex (VTC) whereas photos of faceless animals produced minimal response in the VTC, similar to that elicited when

looking at photos of inanimate objects (Proklova and Goodale, 2022). There is little research into how humans perceive animal faces outside of a human-pet relationship. Nagasawa, *et al*. (2015) found that humans communicate frequently with pet dogs through facial expression. Moreover, mutual gazing increased the production of oxytocin for both dogs and their owners. In other words, humans feel happier when looking into the eyes of their dogs (Nagasawa *et al*., 2015). It is well evidenced that humans are drawn to other human faces with 'cute' features such as: a larger head, a round face, big eyes and a small mouth (Brosch *et al*., 2007; Glocker *et al*., 2009; Parsons *et al*., 2011). Ethologist Konrad Lorenz first described this proclivity as 'baby schema' and research has since shown that baby schema extends to animal faces (Sherman *et al*., 2009; Golle *et al*., 2013; Lehmann *et al*., 2013; Borgi *et al*., 2014; Borgi and Cirulli, 2016; Steinnes *et al*., 2019). Thus it is reasonable to conclude that humans feel more positive about forward-facing photos of their pets, yet it remains likely (but unclear) as to whether this preference extends to exotic wildlife.

Human-animal contact

There is a wealth of research which highlights the relational value in being able to see a human face (Shiota *et al*., 2003; Bainbridge *et al*., 2013; Wiesmann *et al*., 2021). This is something often cashed in on by celebrities seeking advertising work (Erdogan, 1999; Tomkovick *et al*., 2001; Jin *et al*., 2019; Jun and Yi, 2020). In a zoo context, Spooner and Stride (2021) found that images which included a zookeeper most encouraged viewers to donate to zoo conservation projects. In photography, photos which include humans have been found to better engage their audiences (Bakhshi *et al*., 2014). Research has also shown that photos (predominantly selfies) taken in close proximity to wild animals are also popular on social media sites (Lenzi *et al*., 2020), and that wildlife photos posted by Australian conservation organisations on Instagram were more popular if they showed humans physically interacting with the animal/s (Shaw *et al*., 2022). This may be because of the therapeutic value of viewing human-animal connection (Roenke and Mulligan, 1998) or because of the likening to wild animals as pets (Shaw *et al*., 2021). Green and Brock's (2000) transportation theory suggests that photos displaying human-animal contact may indeed receive higher levels of

engagement because the viewer can imagine themselves in place of the photographed human, experiencing the animal interaction themselves as if reality. It has been shown that connecting with animals benefits the viewer's physical health as well as improving mental wellbeing (Jorgenson, 1997; Virués-Ortega and Buela-Casal, 2006; Wells, 2009; McConnell *et al*., 2019). Given that zoo selfie photographs elicit a strong human connection to the focal animal/s (Spooner and Stride, 2021), it seems logical to assume that the public may engage more with human-animal photos than just animal photos alone.

Animal activity

As aforementioned, people predominantly visit zoos for the express purpose of watching wildlife and seeing exotic animals (Ryan and Saward, 2004; Moss and Esson, 2010; Knežević *et al*., 2016). In their work evaluating visitor interest in zoo animals, Moss and Esson (2010) identified the activity levels of an animal to be a significant predictor upon visitor holding time. Similarly, a study from Bitgood, *et al*. (1988) found that increased animal activity levels were associated with longer public viewing time of that animal. This is supported by the work of Altman's (1998) research of visitor conversation around bear enclosures as well as by the research of Margulis, *et al*. (2003) which evaluated visitor interest in felid activity. This trend is also true in safari parks as one study showed that visitors slowed down to watch animals that were displaying active behaviours whereas they drove faster when the animal was inactive or out of sight (Lloyd *et al*., 2021). Bitgood, *et al*. coined the term 'animal attractiveness' to describe the fascination of the public towards animals engaged in active behaviours, whereas Colléony, *et al*. (2017) names these species simply as being 'charismatic'. Furthermore, visitor interest in active animals is not an unconscious preference but an expressed intention, as evidenced in the survey responses to a zoo visit in social science studies (Puan and Zakaria, 2007; Godinez *et al*., 2013). There has however been limited research as to whether public preference for active animals translates into photography when the animal's activity is captured in a still image.

Taxonomic species bias

Taxonomic bias can be defined as the disproportional relationship between the representation of a species and its occurrence in nature (Clark and May, 2002). Taxonomic bias can exist on a large, taxa-wide level (Bonnet *et al*., 2002) but also between species (Roberts *et al*., 2016; Leandro *et al*., 2017). Such taxonomic preferences are not a new phenomenon as evidenced by a survey of visitors to London zoo in 1961 which highlights the favourability towards seeing mammalian species as opposed to other taxonomic groups (Morris, 1961). Extensive research has shown that taxonomic bias is pervasive within biological research literature across many scientific disciplines including: ecology (Pyšek *et al*., 2008; Culumber *et al*., 2019), animal behaviour (Shine and Bonnet, 2000), biochemistry (Herzig *et al*., 2019; Vickers *et al*., 2021), genetics (Kelly *et al*., 2017; Poulin *et al*., 2019) and citizen science (Ward, 2014). In their review of 4076 studies published in the zoological journal *Animal Behaviour*, Rosenthal *et al* (2017) highlights that studies focused upon chordates constituted 70% of all publications in the last 15 years, despite chordates forming only 7% of all animal species. Taxonomic bias is even more severe within conservation science literature (Cronin *et al*., 2014; Donaldson *et al*., 2016; Dos Santos *et al*., 2020). In a review of 15 years of conservation publications, Clark and May (2002) found an overrepresentation of vertebrates in conservation papers (69% of papers versus 3% of species) especially for birds (39% of papers versus 19% of species) and mammals (40% of papers versus 9% of species). Regrettably, the prevalence of taxonomic bias within the literature has translated into a further exacerbated favourability in the funding for wildlife conservation programmes (Czech *et al*., 1998; Seddon *et al*., 2005).

Bias towards certain species or taxonomic groups is not only commonplace within conservation science papers but is also notable in the dissemination of such publications on social media platforms amongst communities of conservationists (Papworth *et al*., 2015; Heathcote, 2021). It is therefore not surprising that similar taxonomic biases have also been observed in the social media output of zoological collections (Hunton *et al*., 2022) given that they partake in wildlife conservation programmes and actively engage with conservation science research (Rose *et al*., 2019; Hvilsom *et al*., 2020). In one study of the Facebook accounts from 9 different zoological

attractions, it was found that 82% of all posts featuring an animal photo focused on mammals (Rose *et al*., 2018). The collective disproportionate promotion of some species over others from both the research community and zoological collections means that popular interest in wildlife does not reflect extinction risk, as has previously been suggested (Carr, 2016a), but is instead a product of financial investment (Davies *et al*., 2018). On a societal scale, people now care much more about the conservation of some species such as polar bears or bison than they do about the conservation of other species like snowy plovers or Indiana bats (Roberge, 2014), partly as a result of a higher financial investment which has driven more public marketing towards the conservation of favoured species.

Body size

Several research papers have shown that, alongside taxonomic bias, the body size of a species plays a large role in its popularity. In a study conducted at London zoo and Zurich zoo, both adult and child visitors showed marked expressed preferences, actualised by the animals they chose to view during their visit, for larger-bodied species across all taxa (Ward *et al*., 1998). Similar public biases towards larger-bodied species have been recorded in studies at other zoological collections including: Chester zoo (Moss and Esson, 2010), Jersey zoo (Carr, 2016b) and the Smithsonian National zoo (Marcellini and Jenssen, 1988). However, there is a large degree of uncertainty surrounding the relationship between body size and popularity. Researchers have commonly used body mass as a measurement for size (Ward *et al*., 1998), yet Moss and Esson (2010) argue that thick fur can disguise the perceived mass of an animal, hence they chose to use animal length to measure animal size. There have also been studies which found no relationship between animal size and popularity (Da Silva and Da Silva, 2007), such as at Knowsley safari park - although it was suggested that the narrower diversity of species' body sizes within a safari drive-through may have limited the value of their findings in this regard (Lloyd *et al*., 2021). It is also worth considering the extent to which body size is secondary to other variables like animal activity (Berti *et al*., 2020) and taxonomic bias (Frynta *et al*., 2013) in determining species popularity, thus increasing the possibility for associations to

be a result of correlation and not causation. Nevertheless, larger-bodied animals often become valuable ambassador species (Keulartz, 2015) and have been found to generate much higher revenue from sponsorships and adoptions (Ward *et al*., 1998; Fančovičová *et al*., 2021). Moreover, a preference for larger-bodied species extends beyond the zoo environment, as large-bodied mammals constituted the most desired species that tourists often wanted to spot whilst on safari – it was these large-bodied species which most commonly featured in the photographs that tourists uploaded to social media after returning home (Hausmann *et al*., 2018). Indeed, it is often the largest individuals of a species which are seen as highly photogenic because of their impressive stature and power (McClenachan, 2009; Child and Darimont, 2015; Curtin and Papworth, 2020; Spooner and Stride, 2021). Small (2012) surmises it well when he states that "huge creatures elicit great respect, whereas the majority of species, which are small, tend to be ignored".

Study aims

The COVID-19 pandemic lockdowns put a spotlight upon the limitations of zoo social media communications. In one study at St Louis zoo, staff described the significantly-decreased ability of the zoo to engage with the public on conservation-related issues using social media (Fine *et al*., 2022). This study aims to analyse a plethora of different aspects of social media posts in order to examine which variables can be used as predictors to increase public engagement online. Through identifying which aspects of a social media post are associated with increased public engagement, it is hoped that zoological collections can collate a more informed approach to social media marketing strategies. It is anticipated that many of the results of this study will go to support existing literature about social media preferences. It is thought likely that zoos received increased levels of public engagement online during the 2020 COVID-19 lockdowns because more people were spending longer online. Photos and videos are more interactive content than text-based posts, so it is predicted that photos and videos will both receive higher levels of public engagement.

It is clear that whilst there is much research surrounding the public's favourability towards some wildlife species over others, there is little research which assesses how these public preferences translate into the social media domain. Taxonomic bias and baby schema are predicted to skew increased engagement towards posts relating to Mammalian species or juvenile animals. Marketing content is predicted to receive more online engagement than educational content or posts relating to the zoo's conservation/research work. It is predicted that photos displaying human-animal contact will receive higher levels of engagement due to increasing the viewers feelings of telepresence – the feeling of imagining oneself in a photographed environment despite not being physically present in that scenario.

Some of the variables recorded within the scope of this study have never been analysed in a zoo context before. Seeing a face is important in human relations and so it is hypothesised that Facebook posts with animal faces (or human faces) will receive higher levels of online engagement. It is suggested that photos showing animal activity may increase engagement as active animals result in longer public holding times at zoo enclosures. Furthermore, it was recorded whether the Facebook post identified the photographed animal within the text of the post, as it is predicted that people will engage more with a post if they know what species they are looking at. Celebrity endorsements are predicted to increase likes for zoos, as has been found in other industries.

Methods

Study population

A sample of 30 BIAZA-accredited zoological collections were identified for this study. This research focused exclusively on BIAZA member collections because they: invest in field conservation projects (Marshall and Deere, 2011); have an active educational outreach (Spooner *et al*., 2019; Counsell *et al*., 2020) and contribute towards cutting-edge zoological research literature (Hosey *et al*., 2019; Garcia-Pelegrin *et al*., 2022). Furthermore, a high standard of animal welfare forms part of the BIAZA accreditation criteria (BIAZA, n.d.) and it has been shown that BIAZA collections are significantly

better at providing good animal health care as well as protecting their animals from fear/stress (Draper and Harris, 2012). The 30 BIAZA collections were selected according to the number of mammal species that each collection held, with the 30 most mammal-rich zoos being chosen for the study. Mammal species richness was taken as a measure of collection size as this helped eliminate niche collections which specialised in a single taxa but might hold a higher number of species: aquariums, butterfly houses and reptile zoos. Some collections then had to be subsequently removed from the study because their Facebook pages contained too much data to allow earlier posts from February 2019 to be accessed without the webpage crashing. The eliminated collections were subsequently replaced by the 31st most mammal-rich collection, followed by the 32nd, then the 33rd and so on until 30 sample collections were decided. Conversely, zoos were also screened to check that they each demonstrated a regular pattern of social media output so that there would be a sufficient number of Facebook posts to make the content analysis representative and accurate – for months unaffected by COVID-19 lockdowns this was deemed to be a minimum of 5 posts per month, whereas zoos only had to post a minimum of twice a month during months where collections were affected by COVID-19 visiting restrictions. The vast majority of collections had a social media output considerably more than the aforementioned amounts, resulting in over 7500 Facebook posts being analysed within this research. Lastly, the 30 sample zoological collections were screened to check that they weren't all concentrated within a small geographical area as this might not have accurately reflected the array of regionally-specific lockdown restrictions across the country in the latter half of 2020. UK collections which weren't subject to mainland UK lockdown restrictions (such as Jersey and the Isle of Man) were eliminated from the study. The study sample included collections from all 4 UK nations as well as 11 of the 12 UK regions (Office for national statistics, 2022).

Data collection

One of the aims of the study was to determine whether public engagement with zoological collections' social media had increased during the COVID-19 pandemic. Therefore, the Facebook data collection evaluated posts published during the

following months: February 2020 (unrestricted public visitation to zoological attractions), May 2020 (COVID-19 national lockdown and complete zoo closures), August 2020 (re-opening from COVID-19 lockdown with reduced zoo visitation restrictions) and October 2020 (return of regionally-selective local lockdown conditions). Additionally, Facebook post data was recorded in the same way for the same month groupings in 2019 to allow for comparison before the impact of COVID-19 upon social media engagement. These months were chosen to represent distinct phases of the UK COVID-19 pandemic which reflect as best as possible the dynamic and unprecedented challenges that visitor attractions faced in 2020. Additionally, these months coincide with school holiday periods when zoo visitor numbers are typically higher (Aylen *et al*., 2014).

Another aim of this research was to evaluate how frequently zoological collections used their social media accounts to highlight each of the different values of the modern zoo. As aforementioned, BIAZA zoological collections contribute to wildlife conservation research projects (Marshall and Deere, 2011; Garcia-Pelegrin *et al*., 2022), offer opportunities for learning (Spooner *et al*., 2019), as well as providing an entertaining day out for the paying visitor (Moss and Esson, 2010). Therefore, this research will record each Facebook post as belonging to one of the following categories: Zoo action, Education and Marketing. Zoo action describes posts which highlight the collection's engagement with wildlife conservation projects and/or research. Education posts use facts to teach the social media user about the species in their collection, or suggest ways that the user can 'learn more'. Marketing posts aim to promote zoo visitation and increase revenue. A more detailed breakdown of each category can be found in the classification table below (table 1).

Table 1: A detailed overview of the different types of Facebook post which were classified under each of the three post core value categories. Facebook posts from a collection announcing site closure as a result of COVID-19 restrictions were not classified under any core value.

Core value	Code	Classification definition

Zoo action	C1	Information on conservation work being done by the zoo within the physical site of the zoological collection (breeding programmes, building habitats for natural wildlife, etc…).
	C2	Content promoting conservation work (including fundraising action) being done by the zoo beyond the collection site.
	C3	Posts that relate to in-situ/ex-situ research projects, that the zoo is involved with or promoting.
Education	Ed1	Promotion of information or environmentally-friendly attitudes relating to a large-scale 'green issue' (plastic pollution, palm oil sustainability, illegal pet trade, carbon footprint…).
	Ed2	Q & A or other educational exercise (including zoo live videos) with a zookeeper or other appropriate professional.
	Ed3	Provision of learning resources/worksheets/materials.
	Ed4	Educational course, summer school programmes or student career-oriented placement/programme.
	Ed5	Information advising external groups (incl schools) to book a visit with the educational department.
	Ed6	Factual post about an animal species with significant educational information (minimum 2 facts or an educational link).
Marketing	En1	Photos/video/link of animals/zoo/wildlife park, perhaps with reference to where you can see them within the attraction.
	En2	Zoo visiting information including closure of facilities or changes brought in by COVID-19 restrictions or inclement weather conditions.
	En3	Promotion of seasonal zoo events such as a Summer concert or Halloween trail.
	En4	Promoting extra-cost animal 'experiences', zoo memberships, adoption packages, weddings or corporate events available at the attraction.
	En5	Promotional offer as an incentive to visit the attraction or a competition with a prize to be won.
	En6	Donation appeals.

This study focused exclusively on analysing the content of the Facebook post, so the language within any comments (made by either the zoo or by members of the public) were not recorded, thus anonymising the dataset. A maximum of 26 different data points were recorded from each Facebook post to assess the 5 areas of interest of this research. The data points which were recorded for each Facebook post included:

technical variables (time of post publication, whether a post was published on a weekday/weekend…), creative predictors (media type, focal species…) and public engagement metrics (number of likes, comments and shares). A summary of all predictor variables recorded from a Facebook posts as well as how they were recorded is detailed below (see table 2).

Table 2: An overview of the different predictor variables recorded for each Facebook post alongside the different categories under which each predictor could be recorded.

Predictor variable	How it was recorded
Zoological collection	The name of the zoological collection which managed the Facebook page
Year	[2019][2020]
Month	[February][May][August][October]
Content	[Education][Marketing][Zoo action]
Media type	[Photo][Text][Video]
Focal species	Species common name e.g. [Asian short-clawed otter]
Class of focal species	[Bird][Mammal][Other]
Order of focal species	Species order e.g. Carnivora
Was an animal visible in the photo?	[No][Yes]
Did the post identify the focal species?	[No][Yes]
Diet of focal species	[Carnivore][Herbivore][Omnivore]
Were juvenile animals visible in the photograph?	[No][Yes]
Was the photographed animal facing the camera (seeing both eyes)?	[No][Yes]
Was the photographed animal engaged in active behaviour?	[No][Yes]
How many individual animals were visible in the photograph?	The researcher recorded the number of individual animals seen in the photo. An estimate was given if the count exceeded 50 individuals.
Was a human visible in the photograph?	[No][Yes]
Was the photographed human facing the camera (both eyes visible)?	[No][Yes]
What type of human was photographed?	[Famous invited guest][Keeper][Someone not visiting the attraction][Staff, non-animal care][Visitor]
Was any human-animal contact visible in the photograph?	[No][Yes]
Is any aspect of zoo enclosure barriers or a non-animal zoo attraction visible in the photo of the surveyed Facebook post?	[No][Yes]
Can the photo of the surveyed Facebook post be best described as a poster,	[No][Yes]

animation, infographic or displaying a large logo?	
When was the Facebook post published?	[Afternoon = 13:00 – 18:59][Morning = 07:00 – 12:59][Night = 19:00 – 06:59]
What day was the post published on?	[Friday][Monday][Saturday][Sunday] [Thursday][Tuesday][Wednesday]
Was the post published on a weekend?	[No][Yes]

Data recording

For the purposes of this research, online engagement was quantified by the number of likes, comments and shares that each Facebook post received – an approach which has been used successfully in other zoological research (Rose *et al*., 2018; Heathcote, 2021; Hunton *et al*., 2022). Although likes, comments and shares are all opportunities for a user to interact with a Facebook post (Wallace *et al*., 2014), they are unequal in how frequently they are used. Whilst an individual can like a Facebook post to indicate endorsement (Brison *et al*., 2015), commenting on a post is a lot more time-consuming and sharing a post can leave a user vulnerable to hostile reactions from within their friendship group (Wang *et al*., 2011). Consequently, it isn't unusual to expect greater numbers of likes than comments and greater numbers of comments than shares as the personal investment increases with each method of engagement (Pletikosa Cvijikj and Michahelles, 2013). However, Sabate *et al* (2014) notes that some posts can be exceptions to this rule, as Facebook posts which pose questions to their followers or posts which offer prizes in a competition both incentivise users to respond with a comment or perhaps a share. Many such Facebook posts were recorded within this study, possibly as a result of trying to increase audience interactivity during periods of societal lockdown restrictions. Consequently it was decided that online engagement would be calculated as the cumulative sum of likes, comments and shares so that the effect of zoological collections 'manifesting' engagement would be reduced.

It was not practical within the scope of this project to reliably assess the extent to which individuals within online communities engaged with online zoo content as that would have involved textual analysis of users' comments which would have been too

time-consuming given the quantity of posts analysed within this research. The number of Facebook users following each zoological collection was recorded between 13:00-13:15 on 19/07/21 so that all recordings of community size were taken at an equal time across the different collections, however; it should be noted that a large Facebook community size does not always correlate into higher levels of engagement (Bonsón *et al*., 2015). Nevertheless, zoological collection was identified as a random effect in every statistical model. This research was screened under Bangor University Research Ethics Framework, no issues were identified.

Statistical analysis

Statistical analysis of Facebook data as well as formatting of graphical outputs was conducted on RStudio (R core team, 2021) using the lme4 package to construct generalized linear mixed models (Bates *et al*., 2015). It was necessary to partition the main dataset into smaller datasets for each analysis in order to include the maximum number of posts without including data omissions. Numeric variables such as 'Facebook community size' and 'body mass of photographed animals' were log transformed in order to rescale the data to similar ranges. Additionally, engagement data (sum of likes, comments and shares) was z-scored to improve the discriminatory ability of datasets between different zoos (Cochran *et al*., 2021). Several generalized linear mixed models were used to identify possible linear relationships between predictor variables and public engagement with the Facebook post (see table 3 below). The models included zoological collection name as a random effect to account for the fact that Facebook postings from the same collection are likely to be less independent than Facebook postings from different collections, thus controlling for potential pseudoreplication of data. Model comparison ANOVA tests were used to compute p-values using restricted maximum likelihood comparison (Crawley, 2012). No model selection took place as full models were used based upon a-priori predictions.

Table 3: General linear mixed models for predictors of engagement metrics in Facebook posts posted by Zoos from 2019-2020. The data was split into different subsets because not all variables related to each post. Therefore, subsets were

partitioned from the main dataset in order to maximise the sample size for each predictor, whilst avoiding blank data entries. For example, a post with a photo of a hedgehog would have a blank data entry for 'Human facing forward' predictor variable, so it was included in models 1, 2 and 4 but not model 3.

Model	Response	N	Predictors
1	Engagement	7069	Zoo (random) Year Quarter Content Media Weekend Month
2	Engagement	4089	Zoo (random) Animal class Species identification Animal babies Animal facing forwards Animal active behaviour Number of individuals Enclosure visible Human Year Content Quarter Weekend Month
3	Engagement	1043	Zoo (random) Animal visible

			Human facing forwards Type of human Human-animal contact Enclosure visible Month Year Content Quarter Weekend
4	Engagement	5778	Zoo (random) Human Year Animal visible Infographic Enclosure visible Weekend Month

Results

Summary of datasets collected

Data for this study were collected from the Facebook pages of 30 different UK zoological collections over a period of 8 months across both 2020 and 2019. The complete dataset includes 7541 individual posts of which 3731 posts were published in 2019 and 3812 posts were published in 2020. The number of posts collected from each zoological collection varied; Twycross zoo contributed the greatest number of posts from a single collection (5.93% of the complete dataset) and Chester Zoo published the fewest posts within the study period (1.54% of the complete dataset) of all the collections included in the study. The median number of Facebook posts

published by each collection was 260 (IQR: 197.25 – 305.75), inclusive of all study months in 2019 and 2020.

Medium and message of post (Model 1)

Comparison of Facebook posts from zoological collections during 2019 and 2020 showed that online engagement was significantly higher for 2020 than in 2019 (β = 0.42, 95% CI: 0.39 to 0.46)(see table 4 and figure 1). The month was also found to have a significant effect upon public engagement with a Facebook post with May, August & October receiving higher levels of engagement than February (β = 0.19, 95% CI: 0.14 to 0.23)(see table 4 and figure 2). Time of post publication was found to have a significant effect upon online engagement as Facebook posts which were published in the morning received higher levels of engagement than posts published later in the day/evening. The day of post publication was then added to the model to evaluate whether it had an additional effect upon Facebook engagement, but it did not have a significant effect on engagement with the post (see table 4). There was significantly greater levels of public engagement with Facebook posts which featured either promotional marketing content (β = 0.26, 95% CI: 0.21 to 0.32) or content which showcased the zoo's actions towards conserving wildlife (β = 0.22, 95% CI: 0.13 to 0.31) in comparison to educational Facebook posts. Furthermore, there was also a significant increase in engagement associated with multimedia Facebook posts that included either a photo (β = 0.59, 95% CI: 0.46 to 0.71) or a video (β = 0.69, 95% CI: 0.56 to 0.82) when compared with Facebook posts that only featured text (see table 4 and figure 4).

Table 4: General linear mixed model analysing the effect of Facebook post design variables on public engagement for 7069 Facebook posts across 30 UK zoological collections for both 2019 and 2020. Engagement was measured as the total number of likes, comments and shares. Due to a strong skew in the data, engagement was log-transformed and then z-scored for analysis. P-values for each predictor in the model were computed using restricted maximum likelihood model comparison.

Predictor	Estimate	95% confidence interval	Df	Chi-squared	P-value
Intercept	-1.08	-1.38, -0.78			
Year			1	544.18	<0.001
2019	0	-			
2020	0.42	0.39, 0.46			
Month			3	66.71	<0.001
February	0	-			
May	0.18	0.13, 0.23			
August	0.19	0.14, 0.23			
October	0.13	0.08, 0.18			
Time of day			2	8.19	0.017
Morning	0	-			
Afternoon	-0.06	-0.09, -0.02			
Night	-0.04	-0.10, 0.03			
Weekend			1	5.12	0.024
No	0	-			
Yes	0.05	0.01, 0.08			
Content			2	98.05	<0.001
Education	0	-			
Marketing	0.26	0.21, 0.32			
Zoo action	0.22	0.13, 0.31			
Media			2	109.09	<0.001
Text	0	-			
Photo	0.59	0.46, 0.71			
Video	0.69	0.56, 0.82			

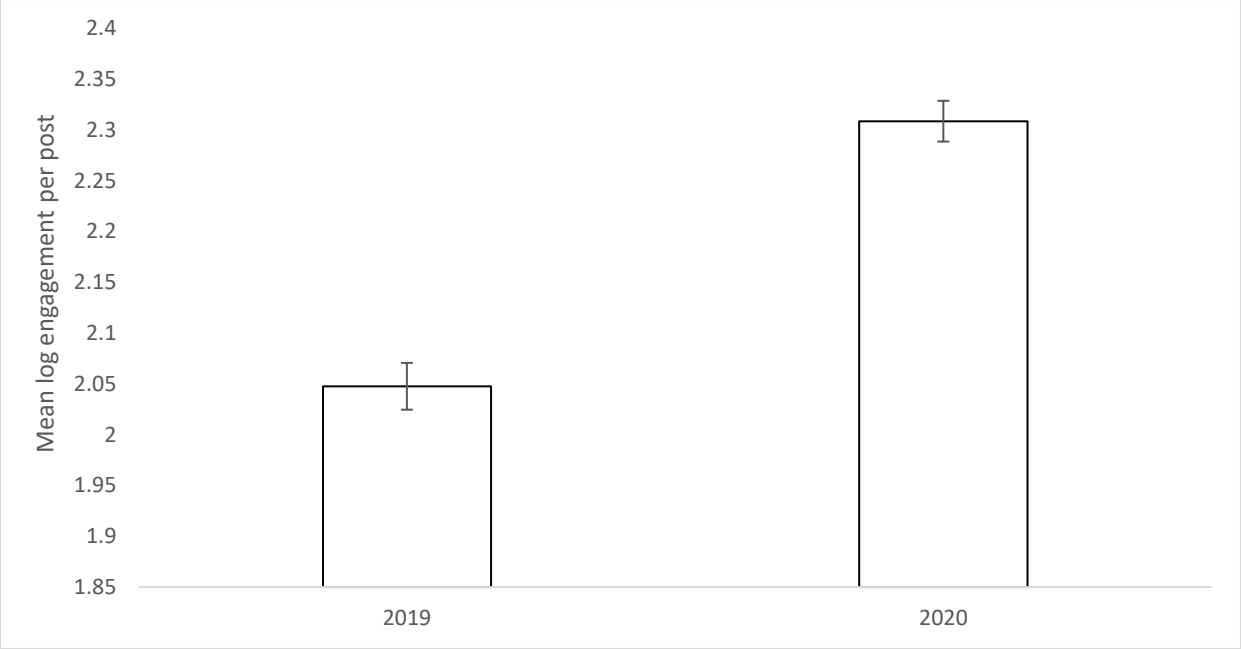

Figure 1: Log-transformed mean social media engagement for Facebook posts during 2019 and 2020. Data includes 95% confidence intervals illustrated by the error bars. The data for 2020 has a significantly higher mean engagement score than Facebook posts during 2019.

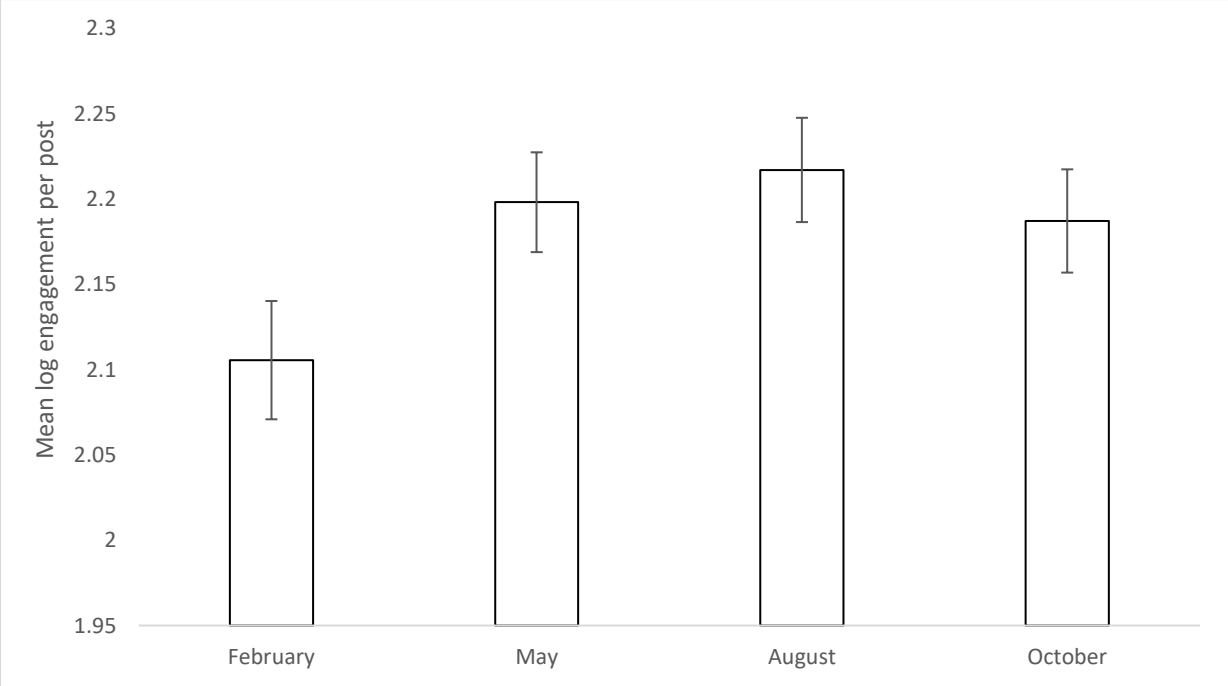

Figure 2: Log-transformed mean social media engagement for Facebook posts during the four surveyed months, inclusive of posts published during both 2019 and 2020. Data includes 95% confidence intervals illustrated by the error bars. The data for May, August and October all have significantly higher mean engagement scores than Facebook posts during February.

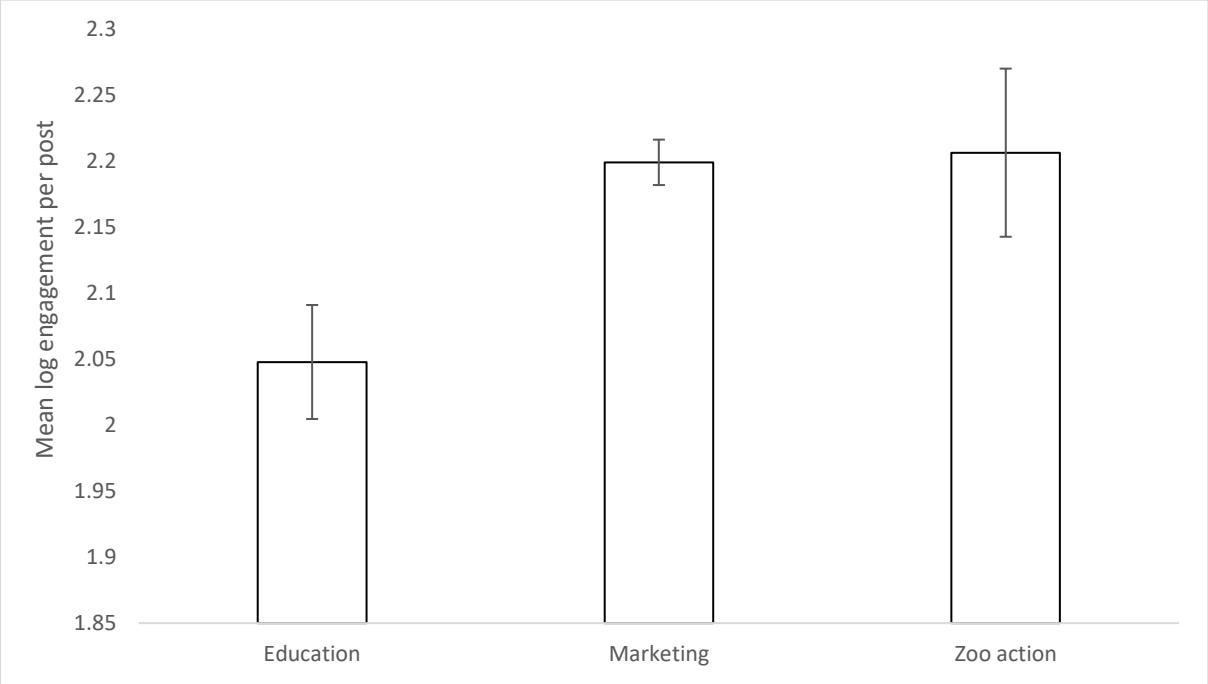

Figure 3: Log-transformed mean social media engagement for Facebook posts according to the subject content of the post. Data includes 95% confidence intervals illustrated by the error bars. The data for Facebook posts focusing upon marketing or zoo action content both have significantly higher mean engagement scores than Facebook posts focused upon educational content.

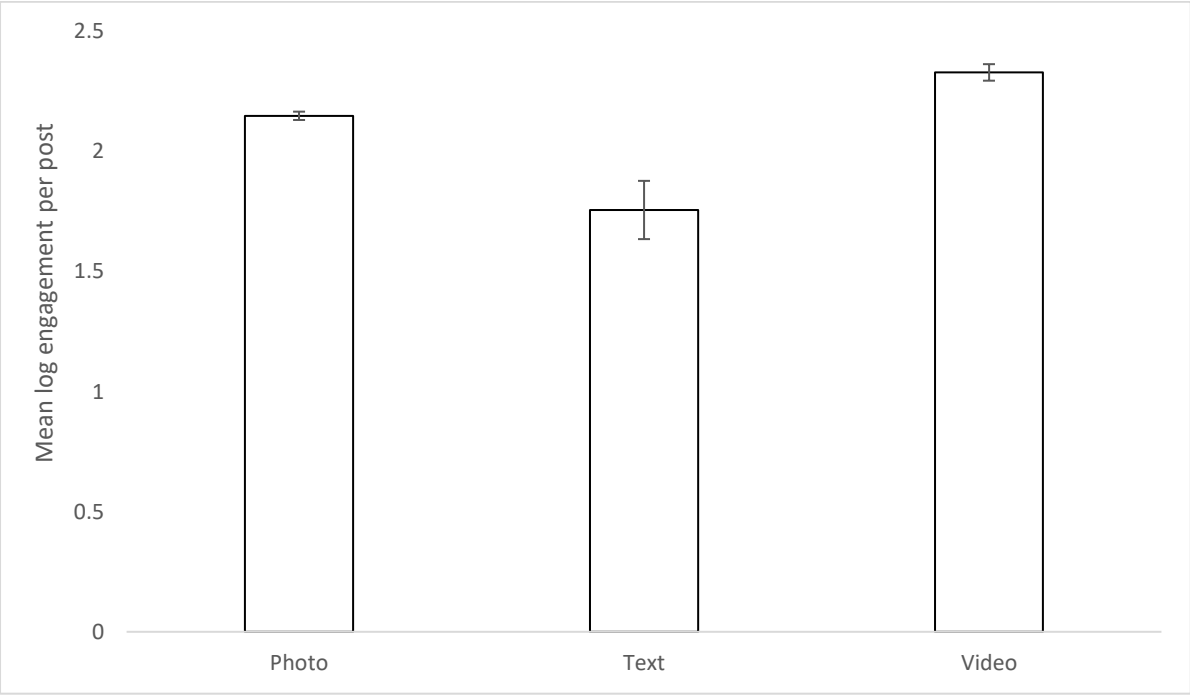

Figure 4: Log-transformed mean social media engagement for Facebook posts according to the media type of the post. Data includes 95% confidence intervals illustrated by the error bars. The data for Facebook posts with either videos or photos both have significantly higher mean engagement scores than Facebook posts which only feature text.

Zoological biases (Model 2)

The results show that taxonomic bias had a significant effect upon how much engagement a post featuring photographed animal/s received. Photographs of mammals received more engagement than photographs of birds (β = 0.12, 95% CI: 0.04 to 0.19), but photographs of birds received significantly more engagement than photographs of all other species (β = -0.17, 95% CI: -0.27 to -0.06)(see table 5 and figure 5). Online engagement was greater if the author of the post identified the photographed species instead of not referring to the species in the text of the post (β = 0.25, 95% CI: 0.20 to 0.29)(see table 5 and figure 6). Furthermore, engagement was higher when juvenile animals were photographed than when photographs only included adult individuals (β = 0.35, 95% CI: 0.29 to 0.41)(see table 5 and figure 7). Although engagement was unaffected by whether the photographed species was engaged in active behaviour or not, engagement was significantly higher when the photographed species was facing the camera as opposed to when it's face was not fully visible (β = 0.09, 95% CI: 0.05 to 0.14)(see table 5 and figure 8). Online engagement was lower for naturalistic photographs of animals compared to photographs where enclosure materials or artificial enrichment items were visible (β = 0.15, 95% CI: 0.10 to 0.19)(see table 5 and figure 9). The number of photographed individuals had no significant effect upon the levels of engagement that the post received (see table 5). Facebook posts with photographs which only featured animals received higher levels of engagement than those which included photographs of animals and humans together (β = -0.11, 95% CI: -0.18 to -0.03)(see table 5). As in the aforementioned general linear mixed model (see table 4), the month and year of post publication as well as the content of the post were all statistically significant indicators of engagement with similar variable estimates as reported above.

Table 5: General linear mixed model analysing the effect of animal photographic variables on public engagement for 4089 Facebook posts across 30 UK zoological collections for both 2019 and 2020. Engagement was measured as the total number of likes, comments and shares. Due to a strong skew in the data, engagement was log-transformed and then z-scored for analysis. P-values for each predictor in the model were computed using restricted maximum likelihood model comparison.

Predictor	Estimate	95% confidence interval	Df	Chi-squared	P-value
Intercept	-0.92	-1.23, -0.62			
Class			2	41.80	<0.001
Bird	0	-			
Mammal	0.12	0.04, 0.19			
Other	-0.17	-0.27, -0.06			
Identified			1	118.58	<0.001
No	0	-			
Yes	0.25	0.20, 0.29			
Babies			1	137.17	<0.001
No	0	-			
Yes	0.35	0.29, 0.41			
Animals facing the camera			1	16.88	<0.001
No	0	-			
Yes	0.09	0.05, 0.14			
Active behaviour			1	0.12	0.726
No	0	-			
Yes	0.01	-0.04, 0.05			
Individual count	0	-0.01, 0.01	1	0.01	0.918
Enclosure visible			1	39.86	<0.001
No	0	-			
Yes	0.15	0.10, 0.19			
Human			1	8.38	0.004
No					

Yes	0 -0.11	- -0.18, -0.03			
Month			3	62.13	<0.001
February	0	-			
May	0.14	0.08, 0.20			
August	0.22	0.16, 0.28			
October	0.17	0.12, 0.23			
Year			1	335.35	<0.001
2019	0	-			
2020	0.39	0.35, 0.43			
Content			2	120.17	<0.001
Education	0	-			
Marketing	0.36	0.29, 0.43			
Zoo action	0.15	0.05, 0.26			
Time of day			2	6.90	0.032
Morning	0	-			
Afternoon	-0.06	-0.10, -0.01			
Night	-0.07	-0.15., -0.01			
Weekend			1	4.24	0.039
No	0	-			
Yes	0.05	0.01, 0.09			

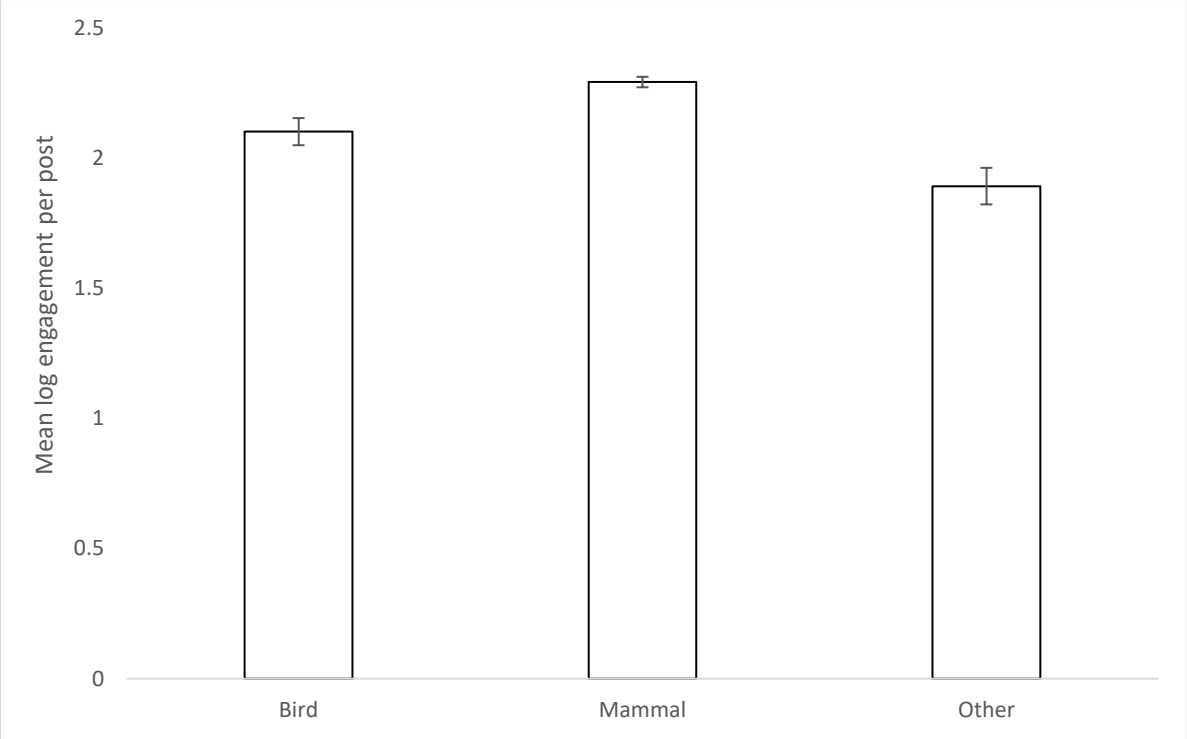

Figure 5: Log-transformed mean social media engagement for Facebook posts according to the class of the photographed species. Data includes 95% confidence intervals illustrated by the error bars. The data for Facebook posts with photographs of mammals has a significantly higher mean engagement score than the mean engagement score of Facebook posts with photos of birds. The data for Facebook posts with photographs of either mammals or birds both have higher mean engagement scores than the mean engagement score for Facebook posts with photos of any other species.

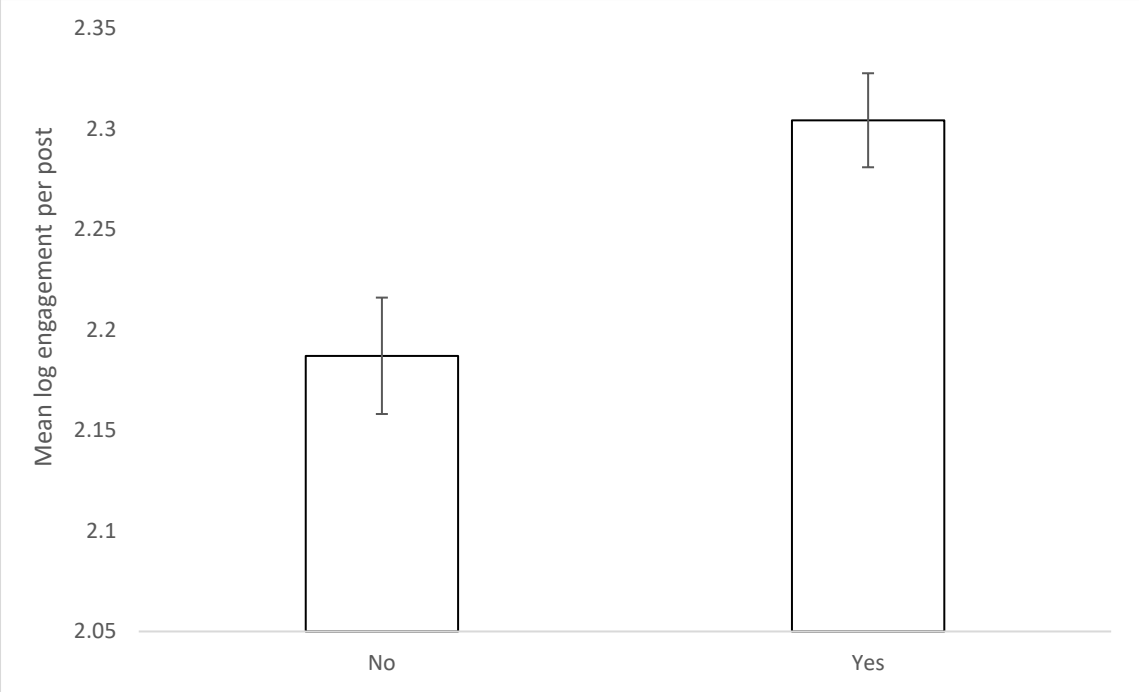

Figure 6: Log-transformed mean social media engagement for Facebook posts according to whether or not the photographed species was identified within the post. Data includes 95% confidence intervals illustrated by the error bars. The data for Facebook posts which do identify the photographed species has a significantly higher mean engagement score than that for Facebook posts which do not identify the photographed species.

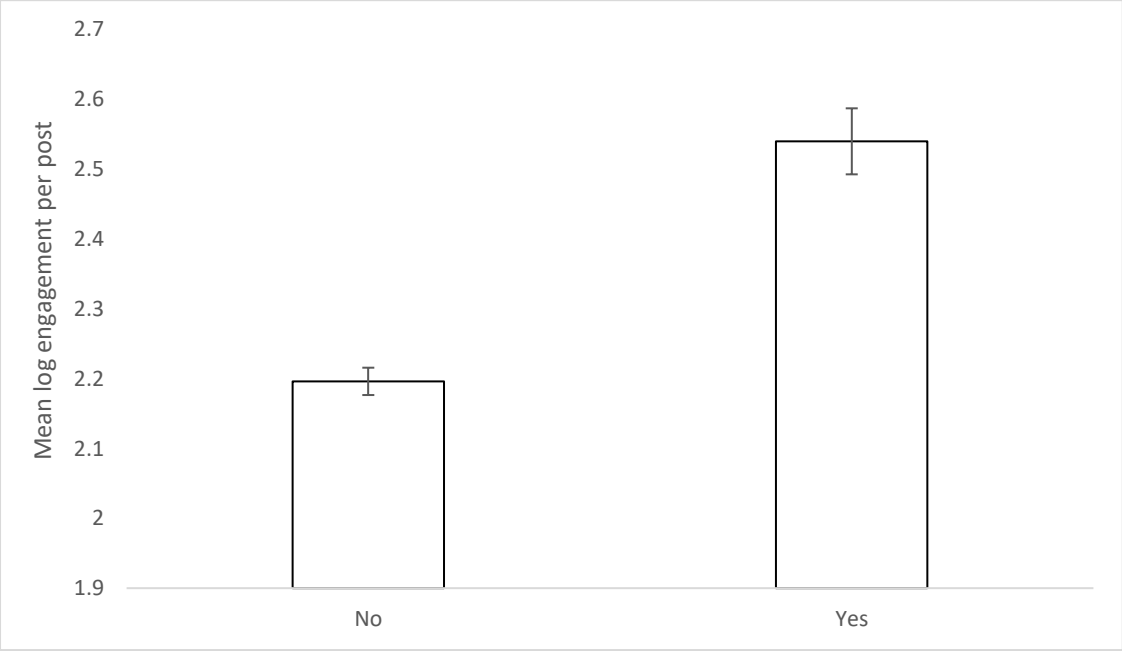

Figure 7: Log-transformed mean social media engagement for Facebook posts according to whether or not any juvenile animals were photographed. Data includes 95% confidence

intervals illustrated by the error bars. The data for Facebook posts which include at least one juvenile animal within the photograph has a significantly higher mean engagement score than that for Facebook posts which have not photographed juvenile animals.

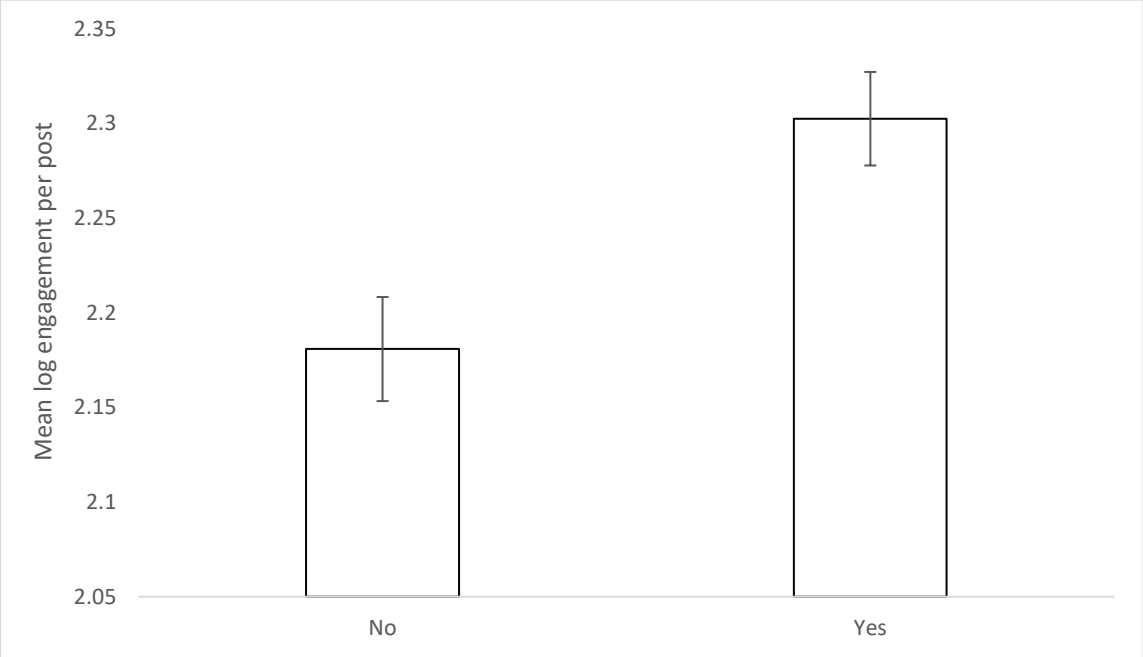

Figure 8: Log-transformed mean social media engagement for Facebook posts according to whether or not the photographed species was facing the camera. Data includes 95% confidence intervals illustrated by the error bars. The data for Facebook posts in which the photographed species is facing the camera has a significantly higher mean engagement score than that for Facebook posts in which the photographed species face is not clearly visible.

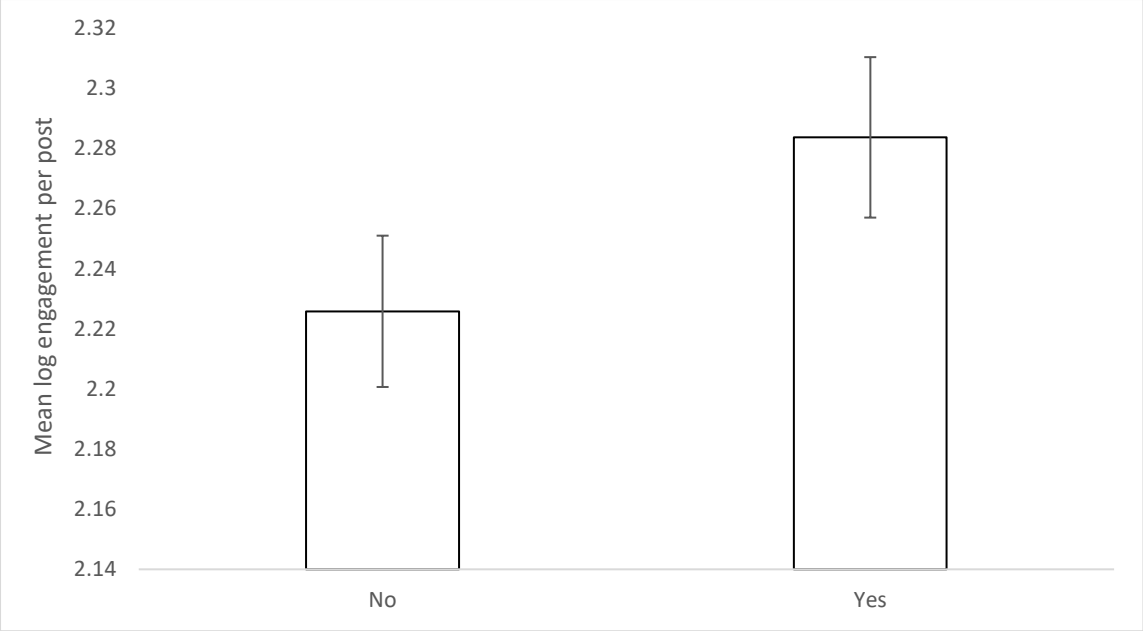

Figure 9: Log-transformed mean social media engagement for Facebook posts according to whether or not artificial enclosure materials are visible in the photograph. Data includes 95% confidence intervals illustrated by the error bars. The data for Facebook posts in which artificial enclosure materials are visible in the photograph has a significantly higher mean engagement score than that for Facebook posts which feature more naturalistic photos of animals without artificial enclosure materials.

Human-animal relationships (Model 3)

When analysing all of the Facebook posts within the dataset which featured photographs of humans, the results show that online engagement was higher for posts which had both animals and humans visible in the photograph than for those posts with photographs solely of people (β = 0.32, 95% CI: 0.20 to 0.45)(see table 6 and figure 10). There was significant differences in the levels of engagement received by Facebook posts, depending upon the 'type' of human photographed. Both zookeepers (β = 0.50, 95% CI: 0.34 to 0.66) and celebrities (β = 0.23, 95% CI: 0.05 to 0.41) were more popular online than photographs of regular visitors to the attraction (see table 6 and figure 11). Although they were included in the table below, the analyses for zoological collection 'staff' (non-zookeeper) and 'someone not visiting the attraction' have too much variability to be considered as accurate due to their small sample size within the dataset. Online engagement was lower for naturalistic photographs of humans than

for photographs where enclosure materials or artificial enrichment items were visible (β = 0.20, 95% CI: 0.09 to 0.31)(see table 6). Engagement was not found to be significantly affected by whether human-animal contact was visible in the photograph (see table 6). Similarly, human facial visibility was found to have an insignificant impact upon engagement (see table 6). As in the aforementioned general linear mixed model (see table 4), the year of post publication and the content of the post were both statistically significant indicators of engagement with similar variable estimates as reported above. The β-estimates for the month of post publication remain similar to those reported above, however the impact upon engagement was found to be not statistically significant within this general linear mixed model.

Table 6: General linear mixed model analysing the effect of Human photographic variables on public engagement for 1043 Facebook posts across 30 UK zoological collections for both 2019 and 2020. Engagement was measured as the total number of likes, comments and shares. Due to a strong skew in the data, engagement was log-transformed and then z-scored for analysis. P-values for each predictor in the model were computed using restricted maximum likelihood model comparison.

Predictor	Estimate	95% Confidence interval	Df	Chi-squared	P-value
Intercept	-0.76	-1.08, -0.44			
Animal			1	25.50	<0.001
No	0	-			
Yes	0.32	0.20, 0.45			
Human facing the camera			1	0.96	0.328
No	0	-			
Yes	-0.05	-0.16, 0.05			
Type of human			4	39.35	<0.001
Visitor	0	-			
Celebrity	0.23	0.05, 0.41			
Keeper	0.50	0.34, 0.66			

Staff	0.04	-0.12, 0.21			
Someone not visiting the zoo	0.15	-0.05, 0.36			
Animal contact			1	1.81	0.178
No	0	-			
Yes	-0.11	-0.28, 0.05			
Enclosure visible			1	12.21	<0.001
No	0	-			
Yes	0.20	0.09, 0.31			
Month			3	13.25	0.004
February	0	-			
May	0.14	-0.01, 0.28			
August	0.25	0.11, 0.39			
October	0.17	0.03, 0.31			
Year			1	29.09	<0.001
2019	0	-			
2020	0.29	0.18, 0.39			
Content			2	18.14	<0.001
Education	0	-			
Marketing	0.33	0.18, 0.49			
Zoo action	0.21	-0.04, 0.47			
Time of day			2	0.12	0.944
Morning	0	-			
Afternoon	-0.02	-0.13, 0.09			
Night	0	-0.16, 0.16			
Weekend			1	1.42	0.233
No	0	-			
Yes	-0.07	-0.18, 0.04			

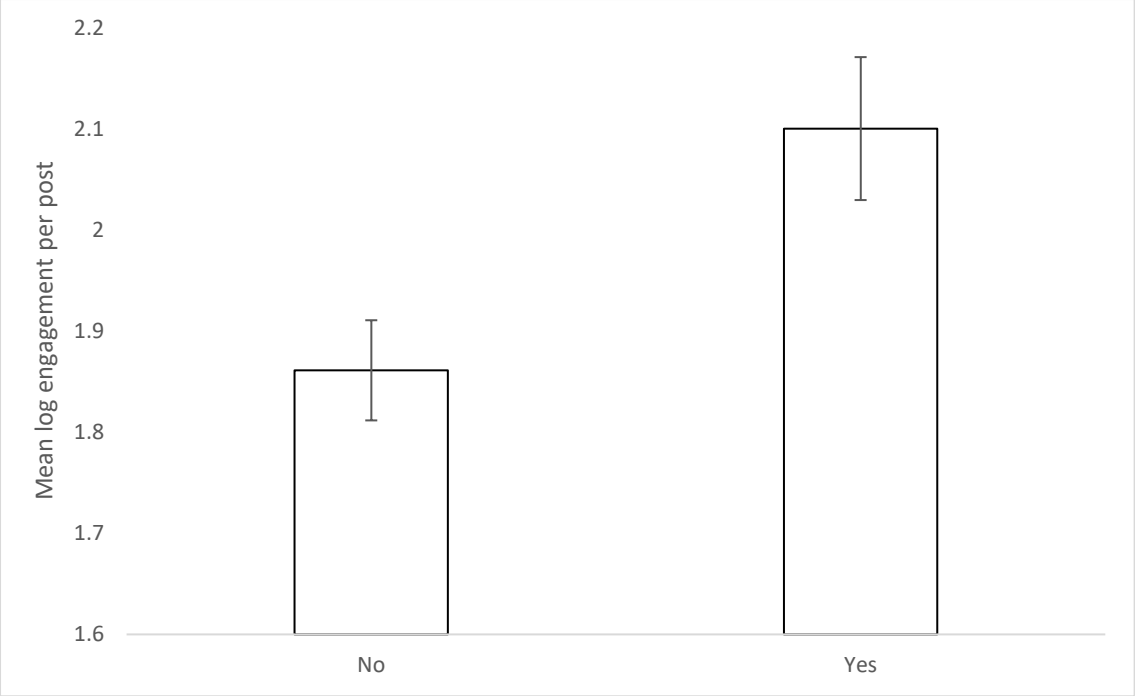

Figure 10: Log-transformed mean social media engagement for Facebook posts according to whether or not an animal featured in the photograph. Data includes 95% confidence intervals illustrated by the error bars. The data for Facebook posts which did photograph animals has a significantly higher mean engagement score than that for Facebook posts which did not feature photographed animals.

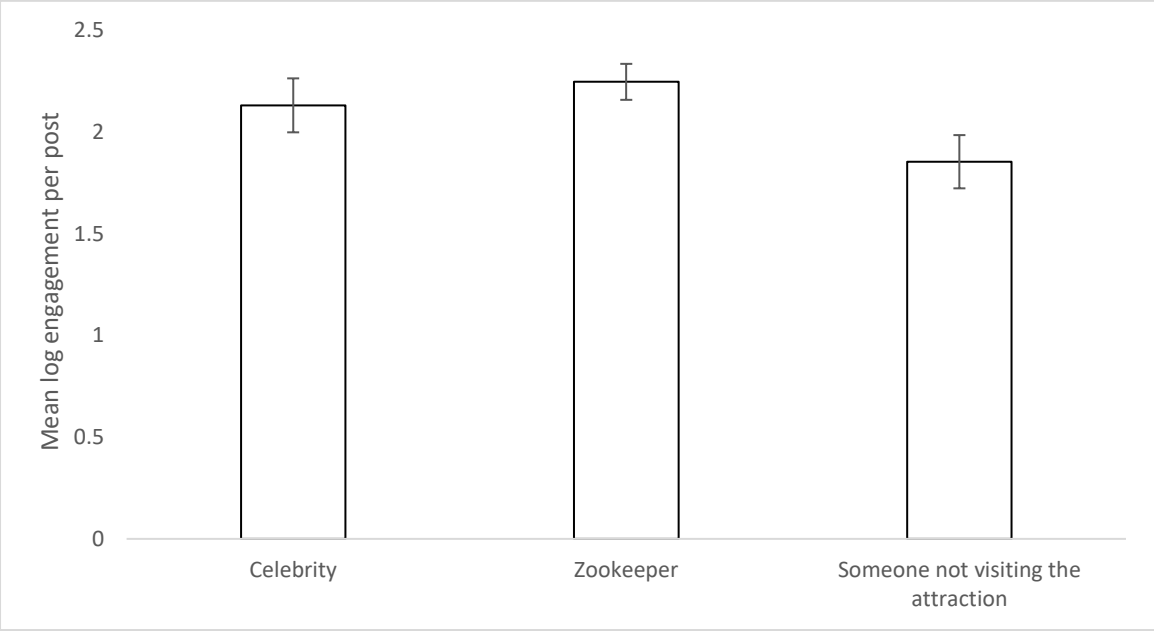

Figure 11: Log-transformed mean social media engagement for Facebook posts according to the type of human visible in the photograph. Data includes 95% confidence intervals illustrated by the error bars. The data for Facebook posts which have a photograph of either

a zookeeper or a celebrity have significantly higher mean engagement scores than that for Facebook posts which have a photograph of a regular visitor to the zoological collection. The data for 'other zoo staff' and 'someone not visiting the attraction' have been excluded from this graph due to their large confidence intervals as a result of small sample sizes, thus making their estimates too inaccurate.

Marketing promotional material (Model 4)

Infographics, photos that had been digitally composed to communicate informative content (a poster, animation or a logo), were found to have significantly lower levels of online engagement than photos without written text or an animation on them (β = -0.37, 95% CI: -0.42 to -0.32)(see table 7 and figure 12). Photographs featuring animals were still found to be significant predictors for increased levels of engagement in comparison to photographs without animals (β = 0.35, 95% CI: 0.30 to 0.40)(see table 7). Conversely, photographs featuring humans were again found to receive lower levels of engagement than photographs without humans (β = -0.18, 95% CI: -0.23 to -0.13)(see table 7). Online engagement was significantly higher for photographs where enclosure materials or artificial enrichment items were visible as opposed to naturalistic images without artificial materials (β = 0.13, 95% CI: 0.09 to 0.17)(see table 7). Furthermore, similar to the first general linear mixed model (see table 4), the year and month of post publication were both statistically significant indicators of engagement with similar variable estimates as reported earlier.

Table 7: General linear mixed model analysing the effect of Infographics on public engagement for 5778 Facebook posts across 30 UK zoological collections for both 2019 and 2020. Engagement was measured as the total number of likes, comments and shares. Due to a strong skew in the data, engagement was log-transformed and then z-scored for analysis. P-values for each predictor in the model were computed using restricted maximum likelihood model comparison.

Predictor	Estimate	95% Confidence interval	Df	Chi-squared	P-value
Intercept	-0.45	-0.72, -0.18			

Human			1	46.71	<0.001
No	0	-			
Yes	-0.18	-0.23, -0.13			
Year			1	357.85	<0.001
2019	0	-			
2020	0.37	0.33, 0.40			
Animal			1	186.84	<0.001
No	0	-			
Yes	0.35	0.30, 0.40			
Infographic			1	188.12	<0.001
No	0	-			
Yes	-0.37	-0.42, -0.32			
Enclosure visible			1	38.05	<0.001
No	0	-			
Yes	0.13	0.09, 0.17			
Weekend			1	1.51	0.220
No	0	-			
Yes	0.03	-0.02, 0.07			
Month			3	91.71	<0.001
February	0	-			
May	0.18	0.13, 0.24			
August	0.24	0.19, 0.29			
October	0.19	0.14, 0.25			

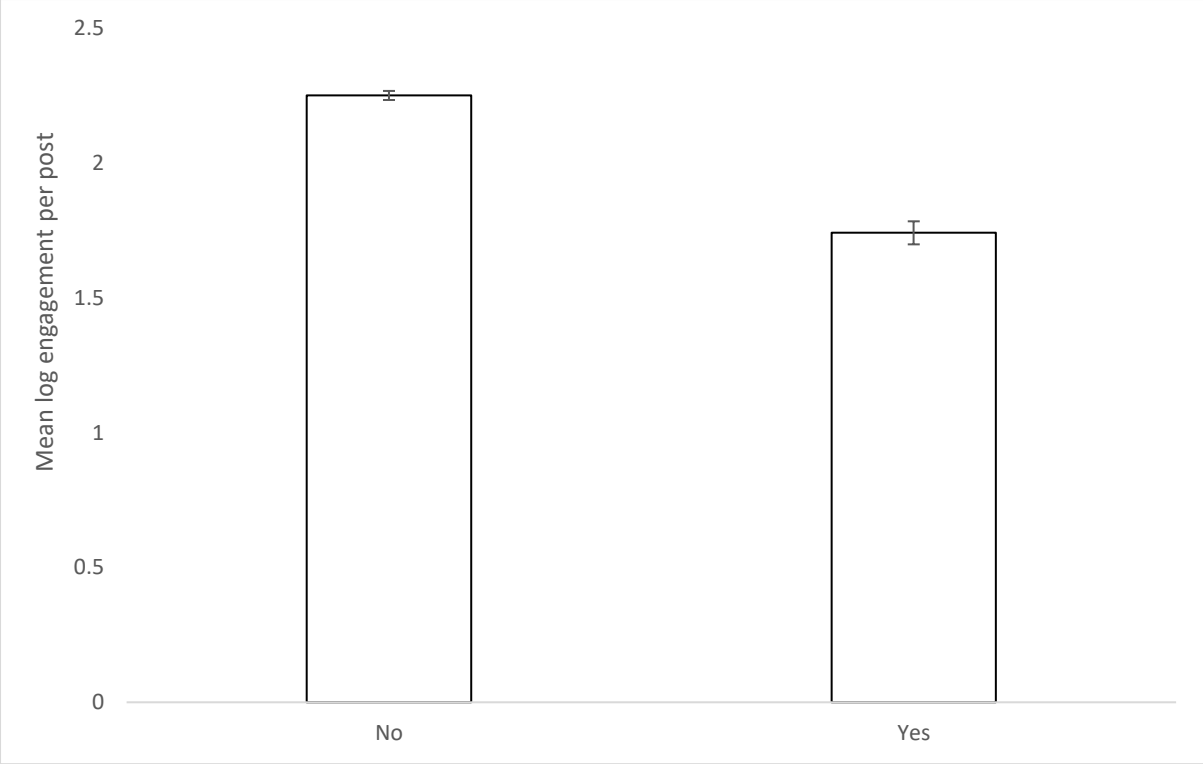

Figure 12: Log-transformed mean social media engagement for Facebook posts with an infographic. Data includes 95% confidence intervals illustrated by the error bars. The data for Facebook posts with an infographic has a significantly lower mean engagement score than that for Facebook posts without infographics.

Discussion

The data collected within this study aimed to assess several possible variables of a social media post and identify which predictors had a significant effect on public engagement online. The results highlight the frequency with which zoological collections use digital communications to generate online community – over 7500 Facebook posts were sampled across 30 different zoological collections within a total study period of 240 months. The findings of this research shows that, although some variables appear to have minimal effect upon engagement: human-wildlife contact, whether the human's face is visible, how many animals are in the photo; there are several key aspects of a Facebook post which have a strong, positive linear relationship with the number of likes, comments and shares which that post will receive: posting photos/videos, focusing on mammals and featuring photos of baby animals. Some post variables were found to be new predictors of engagement:

identification of species, whether the animal's face is visible in the photo, avoiding posting infographics and the type of photographed human. Therefore, given the frequency with which zoos use social media, it is hoped that the research-driven approach of this study will help inform digital communications so as to maximise public engagement in zoo content.

A significant seasonal effect was observed in public engagement with a preference for warmer months over February in the winter. This seasonal variation is reflective of monthly zoo visitation numbers (Aylen *et al*., 2014) and may suggest that zoos are already seeing some success in equipping their digital communications to increase custom as seen in other industries (McCarthy *et al*., 2014; Dolega *et al*., 2021; Gaffar *et al*., 2021; Yee *et al*., 2021). Further research would need to be conducted to consolidate whether social media marketing is driving visitation or whether the correlation is coincidental. It is also worth considering that Christmas holidays may have a positive impact upon engagement levels for December, which was not included within the scope of this study, and as such, further research would be required before fully accepting the effect of seasonal variation upon engagement. The findings of this study also contribute to the wider body of digital communications literature surrounding optimizing public engagement through: posting on weekends and during daytime hours, though the results of this study do not highlight these variables as significant predictors for online engagement (Rutz and Bucklin, 2011; Pletikosa Cvijikj and Michahelles, 2013; Sabate *et al*., 2014; Kanuri *et al*., 2018; Wahid and Wadud, 2020).

It is perhaps not surprising that educational content elicits lower levels of Facebook engagement in comparison to posts relating to marketing or the conservation work of the zoo as this supports existing literature (Rose *et al*., 2018). Of particular interest is the difference between the popularity of the zoo action category (the work of the zoological collection with an expressed wildlife conservation purpose) against the lack of engagement with education content (facts, Summer school programmes, provision of learning resources, keeper Q & A's…). It's possible that the more academic language of the educational material is not appropriate for Facebook

scrolling (Wu *et al*., 2018; Köse, 2020), or that the zoo action content is more positive and gives readers a sense of elation which encourages them to engage with that good-news story (McAfee *et al*., 2019; Buchanan *et al*., 2021). Either way, this lack of public interest in educational social media content poses a challenge for zoo communications, given that many zoological collections identify themselves as educational charities and all have a legal responsibility to teach their visitors about the natural world. Further research is needed to explore and evaluate the factors which disincentivise the public from engaging with zoo education content online.

There is also a strong public preference for visual multimedia content in zoo social media posts over posts which only feature text, with videos proving slightly more engaging than posts with photos. This may relate to increased feelings of telepresence for the social media user (Coyle and Thorson, 2001) which can enhance feelings of enjoyment and connection with the focal species' (Moriuchi and Murdy, 2022). It is evident that there is a public desire to see animals on zoo social media pages which is why much of the scope of this study focused upon the photographic variables which promote engagement with animal photos. Indeed this may explain why infographics receive poor levels of engagement, as the digital alterations may inhibit the public's enjoyment of viewing animals. Similar to Rose's study (2018), public engagement increased with photos of baby animals with many users then commenting to suggest a zoo visit to a friend or relative. This research also supports the existing literature surrounding societal taxonomic bias towards mammals (Rose *et al*., 2018; Hunton *et al*., 2022), although the effect of animal class was one of the weaker predictors for engagement amongst those that were significant.

Recent studies have explored the potential of zoological collections to contrast taxonomic bias (Roberge, 2014; Rose *et al*., 2018) by endearing the public towards less charismatic species through increased visual representation in their social media output (Shaw *et al*., 2022). As aforementioned, this study has found that the inclusion of baby animals within a photograph is a predictor for increased levels of engagement, but The novel findings of this study also offer new insight into other photographic

variables which can be altered in order to enhance the 'likeability' of non-mammalian species. People engaged significantly more when the photographed species was identified by the author of the post within the text, illustrating an unconscious public desire to know about the animal they're looking at. This may be achieved through including the common name of a species or even a personal name, for example: 'Panja and Jessie', the snow leopards at Paradise wildlife park (Facebook.com, 2020); any form of identification has been shown to act as a medium to allow the public to foster connection with the photographed species. Furthermore, this research highlights that visibility of an animal's face is a predictor for increasing the public engagement that a Facebook post will receive. Although existing literature has established that seeing an animal face elicits a visual recognition response in the ventral temporal cortex (Proklova and Goodale, 2022), there has been no conclusive evidence that people have an emotional connection with seeing animal faces outside of a human-pet relationship (Nagasawa *et al*., 2015). Therefore, the results of this study reveal that humans have an affinity with seeing any animal's face and may thus be extrapolated to inform a photographic approach to increasing the popularity of a non-charismatic species through social media posting.

It is interesting to note the zoological variables which had no significant effect upon engagement such as whether the animal is engaged in active behaviour or the number of animals within the photo. This contrasts with research that has shown animal activity (Ridgway *et al*., 2005; Moss and Esson, 2010) and animal density to be significant factors in determining visitor holding time at a zoo enclosure; however, these factors do not have the same influence in the digital sphere. Similarly, some research has indicated a public preference for predator species (Marcellini and Jenssen, 1988; Howell *et al*., 2019), however this was found to be an insignificant factor on social media and as such it wasn't included in the final mixed models of this study.

Furthermore, this study evaluated the human aspects of a photograph, having found that the inclusion of humans within an animal photograph decreased engagement with the Facebook post, although this effect was not considered to be significant.

Moreover, human-animal contact had no significant effect on public engagement. This is surprising given the animal selfie trend that populates social media channels in recent years (Lenzi *et al*., 2019; Rizzolo, 2020). This finding may encourage zoological collections to re-evaluate how animal experiences are marketed, in the knowledge that not portraying human-animal contact will not have an adverse effect on public engagement, but will avoid miscommunicating an educational message (Nekaris *et al*., 2013; Feddema and Nekaris, 2020). Although generally photos of humans have a positive impact upon engagement, it is surprising to see how some 'types' of human attract more social media attention than others. The social media hype around celebrities is fairly well-established in research literature (Erdogan, 1999; Jin *et al*., 2019), yet the popularity of zookeepers has not been so well-documented. This could potentially pave a way for zookeepers to have greater online presence within zoo digital communications as they may be publicly perceived as figures of admiration, either for the work that they do or that they may share 'celebrity status' as a result of appearing in zoo documentaries on TV – further research could explore this.

Although the vast quantity of Facebook posts analysed within this research provides good reliability for the conclusions found, there are restrictions in the study which warrant some caution. Firstly, this analysis did not record the frequency with which a collection posted about a certain topic, such as the promotion of a Summer event. This was something that has previously been highlighted as a significant consideration for social media research (Rose *et al*., 2018) as repeated postings may congregate engagement or they may dilute the engagement that each posting attracts over time as the Facebook community become apathetic to the message of the post. There was concern over the way in which Facebook posts would be discerned as being repeats – did they have to be word-for-word identical or only focusing on the same topic? Another challenge with the dataset was the large variability in the engagement that Facebook posts received. Whilst many posts received a similar number of likes, comments and shares, occasionally some posts would go viral and attract an enormously-inflated amount of engagement. These posts are important to include within the scope of the study, but may have had a disproportionate effect within data

analysis. It was also not known which, if any, posts received paid-for promotion online which would have given them greater exposure and thus increased probability to attract likes, comments or shares.

The results of this research are wide-ranging and offer specific guidance to zoological collections on the management of their social media channels. Many of the findings support the existing literature surrounding topics such as taxonomic bias, baby schema, post media type and multimedia richness. However, several new variables are proposed as having a significant effect upon social media engagement: content of post, species identification, whether the animal is facing the camera, type of photographed human and the visibility of animal enclosures. These results challenge some of the pre-existing assumptions about what is 'likeable' on social media and offer some alternative suggestions for how to generate online attention. Comprehensively, these findings can be used by zoological collections to continue to communicate their missional work without losing public support, whilst remaining commercially-competitive by increasing zoo visitation. Furthermore, it may be possible for wildlife organisations to apply some of the photographic variables which increase online engagement in order to promote public affection for less charismatic, non-mammalian species. There is scope for further research to analyse video content as it is clear from this study's findings that there is high variability in engagement with video posts which is important to quantify, given that videos are fairly time-consuming for a zoo to edit. It would also be good for future studies to evaluate how frequency of posting about a specific topic may impact public engagement, or the psychology behind why zookeepers increase the popularity of social media content.

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Appendix:

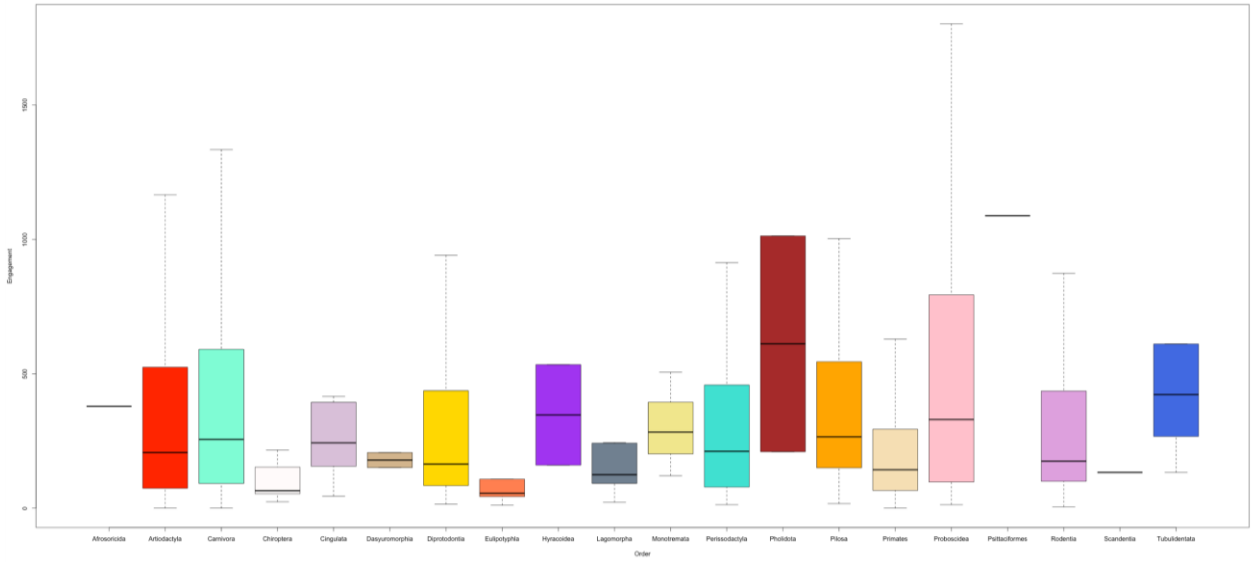

Figure 13: Proportion of social media engagement associated with different animal orders. Outliers have been removed from the graph, though not from statistical analysis, in order to best visualise the boxplot. There is great variability between the different orders, however the sample size is too narrow to conduct meaningful analysis.