**Using rangers to deliver a behavior change campaign on sustainable palm
oil in a UK zoo**

Running title: Zoo campaigns and rangers

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Abstract

A fundamental objective of modern zoos is promoting pro-environmental behaviors. This study experimentally assessed whether zoo rangers (staff employed to engage visitors) can promote sustainable palm oil use, with rangers either ‘present’ or ‘absent’ in the campaign space. Questionnaires assessing awareness, knowledge and purchasing intentions were completed by 1032 visitors. Two analyses were conducted: 1) comparing the impact of ranger presence versus absence (to assess the overall impact of the having rangers present regardless of whether they talked to visitors); and 2) comparing the impact of talking to a ranger against demographically-matched individuals visiting when rangers were absent (to assess the specific impact of talking to a ranger). Visitors who talked to rangers were more aware of palm oil, had more knowledge and greater intentions of purchasing sustainable palm oil. However, as only one-quarter of visitors talked to a ranger, fewer differences were found comparing ranger presence versus absence. These findings suggest that rangers can be instrumental in communicating complex conservation issues and delivering zoo-based behavior change campaigns, but their impact is limited by low engagement rates.

Keywords: pro-environmental behavior, visitor engagement, conservation campaigns, communication, sustainability.

1. Introduction

The role that zoos play in conserving biodiversity is changing. Over the past few decades zoos have predominantly focused their efforts on conserving species through captive breeding and reintroduction, preserving wild populations, and public education (Minteer et al., 2018). Yet many conservation issues faced today are the result of human behavior, particularly overexploiting natural resources and agricultural expansion (Grooten & Almond, 2018; Maxwell et al., 2016). Changing how people act is therefore critical. Consequently, zoos are increasingly acting as facilitators of behavior change by encouraging pro-environmental behaviors among visitors. The latest World Association of Zoos and Aquariums (WAZA) Conservation Strategy highlights behavior change as a critical component to the long-term success of zoo conservation efforts (Barongi et al., 2015), with a recent joint WAZA and International Zoo Educators Association strategy report reinforcing this focus (Thomas, 2020). With over 700 million visitors annually (Gusset & Dick, 2011), zoos have huge potential to promote pro-environmental behavior worldwide.

Conservation education is an important component of many zoo mission statements (Patrick et al., 2007), and zoos have well-established education programs that aim to raise awareness on wildlife and the threats they face (Ballantyne et al., 2007; Tribe & Booth, 2003). Previously it was assumed that educating people on biodiversity during their zoo visit would motivate them to take actions that benefit species they had encountered (Hungerford & Trudi, 1990), yet research suggests that this might not be the case (Schultz, 2011). For instance, a study of over 6,000 visitors across 30 zoos found that biodiversity knowledge only weakly predicted self-reported pro-conservation actions, with factors such as pro-environmental group membership and knowledge of conservation actions having larger effects (Moss et al., 2017).

To promote pro-environmental behaviors among the public, zoos are being encouraged to deliver behavior change campaigns (Clayton et al., 2013). By applying knowledge from the behavioral sciences (Litchfield & Foster, 2009; Lowry, 2009), zoos have launched various behavior change campaigns to encourage conservation action (Dunstan, 2014; Macdonald, 2015; Pearson et al., 2014). For example, a campaign at Zoos Victoria encouraged visitors to recycle used mobile phones to

reduce the impact of mining on gorilla habitats (e.g. for coltan; Litchfield, Lowry, & Dorrian, 2018). Although there has been a push towards promoting pro-environmental behaviors – rather than simply raising awareness – this is still new for many zoos.

While previous research has evaluated various conservation education interventions (Mellish et al., 2019), there is still a need to establish which techniques are most effective in promoting pro-environmental behavior. While lessons can be learned from other disciplines (*health*: Michie, 2008; *social marketing*: Lee, 2017; *policy*: Thaler & Sunstein, 2008), a potential advantage that zoos have in delivering behavior change campaigns is that many already employ staff who are responsible for engaging visitors with biodiversity and conservation while enhancing visitor experience. These staff members, sometimes known as ‘rangers’, ‘presenters’, ‘docents’ and ‘educators’ (hereafter ‘rangers’), engage with visitors through public animal talks and one-to-one conversations (Roe et al., 2015), and interactive activities, including games and props (Whitehouse et al., 2014). At the time this research was conducted (summer 2018), rangers at Bristol Zoo Gardens were responsible for providing exhibit tours, staffing walk-through enclosures and giving multiple public talks daily.

Research on the impact that rangers have in facilitating behavior change is limited, but they have been found to enhance learning among visitors attending exhibits with interactive displays (Marshall, 2016) and encourage specific conservation actions, such as recycling mobile phones (Litchfield et al., 2018). They also evoke conversations among visitors on conservation issues (Idema & Patrick, 2016), and enhance visitors’ overall zoo experience (Doodson et al., 2019). This impact is greater with in-person ranger interactions, with Miller et al. (2020) finding that visitor knowledge, experience and behavioral intentions increased after engaging with an in-person animal experience session compared to viewing a video recording. Unfortunately, the education and conservation content of these ranger conversations can be limited, often being brief, narrow in focus and frequently not conveying key conservation messages (Mony & Heimlich, 2008; Roe et al., 2015). Furthermore, important conservation issues, such as climate change, are often avoided for fear of visitor disengagement (Swim & Fraser, 2014). Although there is great potential to involve visitors in behavior change campaigns through ranger engagement, more research is needed to explore the extent of this impact and to further examine the role that rangers can have in encouraging pro-environmental behaviors.

This paper explores the impact that rangers have in communicating and delivering a zoo-based behavior change campaign, by examining the impact of rangers on visitors' awareness and knowledge of the campaign topic (sustainable palm oil), their intended future purchasing behaviors regarding palm oil, and their campaign enjoyment. This paper also intends to provide insight into how zoos (and similar organizations) can develop public engagement strategies that ensure they are delivering conservation messages that encourage pro-environmental behaviors effectively.

2. Materials and Methods

2.1. Behavior change campaign

In 2018, Bristol Zoological Society launched the behavior change campaign 'Supporting Sustainable Palm Oil'. Palm oil is the most widely-produced vegetable oil worldwide, yet this high demand has resulted in unsustainable production methods, causing negative environmental and social consequences, including deforestation, biodiversity loss and human rights issues (Meijaard et al., 2018). As palm oil is an efficient crop with a high yield, replacing this demand with another vegetable oil could have worse environmental impacts (Meijaard et al., 2018), whereas certified sustainable palm oil helps minimize these issues (Carlson et al., 2018). Currently only 19% of palm oil is sustainably produced (RSPO, 2019).

The 'Supporting Sustainable Palm Oil' campaign aimed to engage and inform visitors on the topic of palm oil and encouraged them to purchase food products containing sustainable palm oil. The campaign was delivered in the 'Tree Kangaroos of Papua New Guinea' walk-through exhibit, with a space near the exhibit's exit devoted to the campaign. The space conveyed information on palm oil, and the benefits of using sustainable palm oil, through signs, self-led games and interactive activities. Activities included a board game showing the differences between sustainable and non-sustainable oil palm plantations, and an interactive activity comparing the high yield of palm oil to other vegetable crops. Signs also discussed sustainable palm oil production in Papua New Guinea. The campaign was designed by the lead author and zoo staff members responsible for public engagement. Development

of the signs, games and activities were based on previous successful engagement programs at the zoo (e.g., Doodson et al., 2019). All signs, games and activities were available throughout the duration of the study regardless of whether a ranger was present.

The campaign space was managed by a team of nineteen rangers who were trained to deliver the campaign. Rangers facilitated the activities, encouraged visitor participation and engaged in conversations, either one-on-one or with groups (Figure 1). Although children would take part in the activities, the rangers predominately engaged in conversations with adults due to the complexity of the topic and the nature of the action being encouraged (as adults make the purchasing decisions for the household). Rangers were also told to inform visitors about four main palm oil facts which would form the knowledge questions in the subsequent questionnaire (see Table 1 for these facts and the estimated percentage of visitor conversations which included them). The campaign space was managed by two rangers at a time.

[Figure 1 near here]

[Table 1 near here]

2.2. Study design and data collection

An experimental study was conducted comparing the difference in responses from visitors who attended the campaign space when rangers were present compared to visitors who attended when rangers were absent. The study was undertaken on weekday afternoons between 1pm and 4pm from 30th July to 24th August 2018. Weekday mornings were not included as the zoo was concerned about the potential detrimental impact that the exhibit would have on visitor satisfaction if unstaffed for long periods of time, and weekends were excluded due to the researcher's capacity. Rangers managed the campaign space for 10 afternoons, while the campaign space was not staffed for another 10 afternoons. Although the study was intended to be a randomized-control trial, this was not possible due to the ranger's limiting rotas, meaning the schedule was based on the rangers' availability to staff the area. Note that for practical purposes the intended randomization element was based on days the

rangers were present versus absent, rather than random allocation of individual zoo visitors to the conditions within days. This type of experimental design can be challenging and is under-used in visitor studies, but can help identify causal relationships between interventions and outcomes (Pattison et al., 2019).

A questionnaire assessing visitors' awareness and knowledge of palm oil, intended future purchasing behavior of products containing palm oil, and campaign enjoyment was developed (see supplementary information). With regards to visitor knowledge, perceptions of how much visitors knew about palm oil was measured (perceived knowledge), while four multiple-choice questions assessed actual palm oil knowledge. These questions reflected the information that visitors could have learnt in the campaign space (Table 1), either by engaging with a ranger or by reading the signs and engaging with the activities on their own. The questionnaire also asked if visitors had talked to a ranger about palm oil and contained two demographic questions (gender and age).

Visitors were invited to complete the questionnaire when exiting the exhibit. As the exhibit had a specified entrance and a separate exit, it was assumed that visitors walking through the exit door had walked through the exhibit and passed the campaign space. If visitors declined to participate, the next visitor leaving the exhibit was approached. If visitors were in a group, the first person to step through the exit door was asked, and if that visitor declined then the second visitor to exit was asked unless another group member volunteered to participate. If multiple members of the group offered to complete a questionnaire, then they were all permitted to do so. Unfortunately response rate was not recorded, but it is estimated that approximately 75-80% of visitors invited to participate completed a questionnaire.

Individuals aged 18 years and above were invited to participate. Participants were requested to complete the questionnaire on their own and not to confer with others. To ensure this happened, the researcher remained within earshot of the participant. If the visitor was heard conferring, the answers to the questions which the participant had help with were removed from the dataset, or the whole questionnaire was discarded if the researcher was unsure which question(s) the participant had conferred on. As the area was open and contained no covered space, questionnaires were not handed out during periods of heavy rain. Only one researcher (KM) administered questionnaires during the

study. Ethical approval was granted from the Bristol Zoological Society Conservation, Ethics, and Sustainability Committee for Research Involving Human Participants. All participants gave written informed consent.

2.3. Participants

1056 visitors completed the questionnaire, of which 1032 (97.7%) were used for the analysis. Twenty-four questionnaires were discarded because participants had either conferred with others when completing the questionnaire or had informed the researcher that they had based their answers on a previous visit to the zoo (e.g., individuals attended on a non-ranger day but told the researcher that they had responded ‘yes’ to talking to a ranger because they talked to a ranger on a previous visit). Of these 1032 valid questionnaires, 540 participants visited when rangers were present (52.3%; males=168; females=367; not answered/preferred not to say=5) and 492 participants visited when rangers were absent (47.7%; males=144; females=344; not answered/preferred not to say=4). The distribution of age by condition is displayed in Figure 2A. Age data was missing for one individual.

Of the 540 participants who visited when a ranger was present, 152 (28.1%) reported talking to a ranger about palm oil (males=50; females=101; not answered/preferred not to say=1), 380 (70.4%) said they did not (males=118; females=260; not answered/preferred not to say=2) and data were missing for eight individuals (1.5%). For individuals in the ranger condition, the percentage of visitors in each age category is displayed in Figure 2B, split by whether they talked to a ranger.

[Figure 2 near here]

2.4. Data analysis

t-tests were used to assess for differences in visitor attendance between the non-ranger and ranger conditions. This was to examine whether there were any systematic differences in how busy the zoo was (which may impact visitor engagement with the campaign; Moss et al., 2010) between the two

conditions. Chi-squared tests were used to assess for demographic differences (in age or gender) between conditions.

To examine visitor awareness, knowledge and intended future purchasing behaviors of palm oil, two sets of analyses were conducted (figure 3). The first compared the two conditions (ranger versus non-ranger), regardless of whether individuals in the ranger condition talked to a ranger. As ~70% of individuals in this condition did not actually talk to a ranger (and thus did not receive the intervention), this is likely to underestimate the true impact of talking to a ranger. Nonetheless, this comparison is useful, particularly for designers of zoo public engagement programs, as this is the effect size of the intervention on zoo visitors, should the intervention be implemented (this is known as an ‘intention-to-treat’ analysis; Gupta, 2011). One benefit of this analysis is that allocation to conditions is random (or quasi-random, in this case), meaning that any differences are likely to be due to the intervention, rather than confounding factors or selection bias (Rare and The Behavioural Insights Team, 2019). We refer to this analysis as the ‘ranger-present analysis’.

The second analysis compared those who received the intervention (talking to a ranger) against a demographically-matched set of individuals in the control condition who engaged with the campaign (defined as entering the exhibit’s campaign space and/or engaging with interactive palm oil activities). This analysis estimates the actual effect of talking to a ranger, relative to those who engaged with the campaign but did not talk to a ranger. While this analysis (also known as a ‘per-protocol’ analysis) allows a calculation of the effect of talking to a ranger, it can lead to biased results. For instance, individuals who talked to a ranger may differ from those who did not (e.g., age, values, existing knowledge of palm oil, etc.). To help mitigate this bias, in this analysis individuals in the control condition who engaged with the campaign were matched based on age and gender to those who talked to a ranger (Rare and The Behavioural Insights Team, 2019). We refer to this analysis as the ‘talked-to-ranger analysis’.

For all analyses, logistic or multinomial regressions were employed to examine the direction and magnitude of any differences between conditions. In these analyses, the non-ranger condition was always the baseline condition. All multiple-choice questions from the questionnaire were analyzed. Analyses were performed using IBM SPSS version 24.

[Figure 3 near here]

3. Results

To assess for potential differences between the non-ranger and ranger conditions, visitor attendance during the study period and the demographic information of participants in both conditions were examined. There were no differences in the number of visitors per day between the conditions (non-ranger condition: mean=2,230, SD=282; ranger condition: mean=2,128, SD=266; $t(18)=0.84$, $p=0.414$, 95% CI: [-155.19; 360.39]), suggesting no systematic differences in zoo busyness between conditions. No differences were found in participants' age or gender between the two conditions (age: $\chi^2(5, n=1031)=2.82$, $p=0.728$; gender: $\chi^2(1, n=1023)=0.43$, $p=0.511$), indicating random allocation to conditions. However, when looking within the ranger condition at individuals who talked to a ranger versus those who did not, visitors aged 35-64 were more likely to talk to a ranger while younger visitors were less likely to ($\chi^2(5, n=532)=14.65$, $p=0.012$; Figure 2B). No differences in gender were found ($\chi^2(1, n=529)=0.18$, $p=0.672$).

3.1. Awareness of palm oil

In the ranger-present analysis, most visitors had heard of palm oil (Table 2) and no differences were found between conditions ($b=1.12$, $p=0.507$, 95% CI: [0.80; 1.55]). When focusing on those who talked to a ranger (the talked-to-ranger analysis), these individuals had four times greater odds of having heard of palm oil, relative to matched individuals in the non-ranger condition ($b=3.89$, $p=0.001$, 95% CI: [1.71, 8.88]).

The number of participants who had heard of sustainable palm oil was lower compared to having heard of palm oil (Table 2). In the ranger-present analysis there was a slight increase in awareness of sustainable palm oil, although the evidence for this effect was relatively weak ($b=1.25$, $p=0.074$, 95% CI: [0.98; 1.60]). In the talked-to-ranger analysis, those who talked to a ranger had approximately twice the odds of having heard of sustainable palm oil ($b=2.13$, $p=0.001$, 95% CI: [1.34; 3.38]).

[Table 2 near here]

3.2. Knowledge of palm oil

In terms of perceived knowledge of palm oil (Table 3), in the ranger-present analysis there were no differences between the ranger and non-ranger conditions (not know very much: $b=1.07$, $p=0.715$, 95% CI:[0.75; 1.53]; have some knowledge: $b=1.15$, $p=0.454$, 95% CI:[0.8; 1.66]; have a lot of knowledge: $b=1.05$, $p=0.894$, 95% CI:[0.49; 2.27], with ‘none’ as the baseline category). However, in the talked-to-ranger analysis, perceived knowledge was higher among those who talked to a ranger. Compared to the baseline category of ‘none’, these individuals had nearly four times greater odds of having not very much knowledge ($b=3.81$, $p=0.006$, 95% CI:[1.46; 9.97]), five times greater odds of having some knowledge ($b=5.07$, $p=0.001$, 95% CI:[1.95; 13.19]) and nine times greater odds of having a lot of knowledge ($b=9.00$, $p=0.004$, 95% CI:[2.05; 39.50]), although the confidence intervals around these estimates are wide.

To analyze actual knowledge of palm oil, each participant was given a knowledge score out of 4 (based on the number of knowledge-based questions answered correctly). Due to small sample sizes, scores of 3 and 4 were combined (only 14 individuals possessed a knowledge score of 4). In the ranger-present analysis, visitors in the ranger condition had nearly three times greater odds of scoring a 3/4 ($b=2.68$, $p<0.001$, 95% CI:[1.54; 4.68]), compared to a knowledge score of 0 (Figure 4). No differences were found for scoring a 1 ($b=0.95$, $p=0.746$, 95% CI:[0.72; 1.27]) or 2 ($b=1.36$, $p=0.107$, 95% CI:[0.94; 1.98]). In the talked-to-ranger analysis, visitors who talked to a ranger had twice the odds of scoring a 1 ($b=1.88$, $p=0.047$, 95% CI:[1.01; 3.49]), triple the odds of scoring a 2 ($b=3.31$, $p<0.001$, 95% CI:[1.71; 6.4]), and eight times the odds of scoring a 3/4 ($b=7.72$, $p<0.001$, 95% CI:[3.51; 16.95]), compared to a knowledge score of 0.

[Table 3 near here]

[Figure 4 near here]

3.3. *Intended future behavior*

The number of visitors who stated that they would check products to see if they contain palm oil, avoid products containing palm oil, and purchase products containing sustainable palm oil during the month after their visit are displayed in Table 4. First, regarding checking for palm oil, in the ranger-present analysis with not checking for palm oil as the baseline category, there were no differences in terms of checking for palm oil between the conditions (yes: $b=0.93$, $p=0.653$, 95% CI:[0.67; 1.29]; unsure: $b=1.04$, $p=0.809$, 95% CI:[0.74; 1.48]). Similar null results were found in the talked-to-ranger analysis (yes: $b=1.57$, $p=0.218$, 95% CI:[0.77; 3.19]; unsure: $b=1.01$, $p=0.989$, 95% CI:[0.46; 2.20]).

Next, in the ranger-present analysis there was weak evidence that visitors in the ranger condition were less likely to say they would avoid buying products containing palm oil ($b=0.72$, $p=0.058$, 95% CI:[0.51; 1.01]); with not avoiding palm oil as the baseline category). There were no differences between the conditions regarding being unsure about avoiding buying products containing palm oil ($b=0.96$, $p=0.786$, 95% CI:[0.70; 1.31]). In the talked-to-ranger analysis, visitors who talked to a ranger were four times less likely to report they would avoid products containing palm oil ($b=0.28$, $p<0.001$, 95% CI:[0.15; 0.53]), and approximately half as likely to be unsure about avoiding these products ($b=0.42$, $p=0.003$, 95% CI:[0.23; 0.75]), relative to a baseline category of not avoiding products containing palm oil.

Lastly, regarding intentions to purchase products containing sustainable palm oil, in the ranger-present analysis with not intending to buy sustainable palm oil as the baseline category, there were no differences in terms of buying sustainable palm oil between the conditions (yes: $b=1.19$, $p=0.425$, 95% CI:[0.77; 1.85]; unsure: $b=0.98$, $p=0.927$, 95% CI:[0.63; 1.52]). In the talked-to-ranger analysis, visitors who talked to a ranger had three times greater odds of reporting that they would buy products containing sustainable palm oil compared to those who said they would not ($b=3.16$, $p=0.04$, 95% CI:[1.06; 9.45]). No differences were found regarding visitors being unsure of whether they would purchase products containing sustainable palm oil ($b=1.21$, $p=0.746$, 95% CI:[0.39; 3.76]).

[Table 4 near here]

3.4. Campaign enjoyment

To analyze visitors' enjoyment of the campaign, the responses 'neutral', 'slightly unhappy' and 'unhappy' were collapsed into a single 'neutral/unhappy' category due to low sample size (78 visitors responded neutral, 10 responded slightly unhappy and 9 responded unhappy). Also note that the sample size here is lower as only visitors who said they directly engaged in the campaign (i.e., interacted with the signs and activities) responded to this question ($n=527$; 51.1% of the 1032 visitors).

Descriptive statistics for campaign enjoyment are presented in Table 5. In the ranger-present analysis, with 'neutral/unhappy' as the reference category, visitors in the ranger condition had two and a half times the odds of rating their enjoyment of the campaign as 'slightly happy' ($b=2.61$, $p<0.001$, 95% CI:[1.59; 4.28]), and over three times the odds of rating their enjoyment as 'happy' ($b=3.43$, $p<0.001$, 95% CI:[2.03; 5.81]). Similar results were found in the talked-to-ranger analysis, with individuals who talked to a ranger possessing four times greater odds of rating their enjoyment as 'slightly happy' ($b=3.94$, $p=0.001$, 95% CI:[1.77; 8.79]), and nine times greater odds of rating their enjoyment as 'happy' ($b=9.38$, $p<0.001$, 95% CI:[4.16; 21.12]), compared to a baseline of 'neutral/unhappy'.

[Table 5 near here]

4. Discussion

Encouraging visitors to perform pro-environmental behaviors is becoming a core component of the role that zoos play in conserving biodiversity (Barongi et al., 2015; Thomas, 2020). The current research suggests that rangers may be an effective method of delivering behavior change campaigns that inspire such actions. Our findings show that visitors who talked to rangers had increased awareness and knowledge of palm oil, were more likely to have heard of sustainable palm oil and

perceived that they knew more about palm oil than visitors who did not talk to a ranger. Furthermore, their actual knowledge of palm oil was much higher (figure 4B). Rangers were also associated with visitors' intended future behavior; individuals who engaged with a ranger were more likely to report that they would purchase products containing sustainable palm oil, and not avoid products containing palm oil, after their zoo visit (although no differences in checking products for palm oil was reported).

However, given that most visitors do not talk to a ranger (only ~30% in this study), the absolute impact that rangers may have on visitor knowledge and intentions may be somewhat limited. This is demonstrated by the ranger-present analyses finding few differences between ranger and non-ranger conditions (Table 6), although in most cases the results were in the expected direction. Nonetheless, when rangers do engage with visitors, they seem to have a noticeable impact on knowledge and intended future behavior, suggesting that rangers may be an important conservation tool. However, they need to reach enough visitors to have large population-level impacts.

[Table 6 near here]

Implementing behavior change campaigns is relatively new in zoos, yet our study suggests that zoos have a unique advantage in this area because many already employ rangers who can deliver such campaigns. Although previous research on the effectiveness of rangers delivering conservation messages has been mixed (Litchfield et al., 2018; Marshall, 2016; Mony & Heimlich, 2008; Roe et al., 2015), our findings suggest that rangers may be an effective mechanism for delivering such messages, including those on complex, and often emotive, conservation topics such as palm oil. Many behavior change campaigns are based on conservation issues which the public may not be aware of, such as the bushmeat trade (Stoinski et al., 2002), or may have previously been misinformed about, such as the causes of climate change (Reynolds et al., 2010). Using rangers as part of zoos' public engagement strategy can help overcome these issues by enhancing visitor understanding of conservation problems and motivating pro-environmental behaviors that aid biodiversity conservation while talking through how to overcome potential barriers to performing such actions. Previous research has found that multiple interventions in zoos are associated with increased conservation

knowledge (Weiler & Smith, 2009); rangers can be an important additional part of this toolkit. However, this is only possible if key conservation messages are conveyed during the majority of visitor conversations rather than sporadically (Mony & Heimlich, 2008), and confidence issues among rangers are overcome, such as concerns about disinterested visitors (Roe et al., 2015). Although our results are not especially surprising, research in this area is limited and further studies that use experimental methods are needed to establish which techniques effectively promote pro-environmental behaviors. This research contributes to the growing body of literature in this area (also see Dunstan, 2014; Litchfield et al., 2018; Macdonald, 2015; Pearson et al., 2014) and will aid in establishing best practices for delivering behavior change campaigns both in zoos and visitor attractions more widely.

One of the strongest effects in the ranger-present analysis was campaign enjoyment, with visitors in the ranger condition reporting greater enjoyment. In a post-hoc exploratory analysis we compared visitors' campaign enjoyment of those in the non-ranger condition, those in the ranger condition who did not talk to a ranger and those in the ranger condition who did talk to a ranger. Interestingly, enjoyment was higher in the ranger condition even among those who had not talked to a ranger, relative to the non-ranger condition (see supplementary information). Although the impact of ranger engagement on visitor experience is consistent with previous research (Doodson et al., 2019), the current research indicates that the mere presence of rangers may be enough to trigger this effect. Although requiring further research and replication, this effect may be due to visitors listening to rangers while exploring the campaign space or the rangers' presence influencing visitors' perceptions of the zoo's credibility by having experts available to talk to, even if they did not personally engage with them. Alongside conservation and learning, entertainment is a core goal for zoos (Patrick et al., 2007) and is commonly used to engage visitors in educational exhibits while enhancing visitor experience. Visitor satisfaction is an important component to learning as it can influence individuals' intentions to revisit the zoo (Tomas et al., 2002), and repeat visitors have been found to engage in conservation efforts more than individuals visiting for the first time (Godinez & Fernandez, 2019). Therefore, via their effect on enjoyment, rangers could have a wider impact on visitors' learning beyond directly imparting knowledge and promoting behavior change.

The current research encounters two main limitations. Firstly, the research relies on visitors' reported future behavior and not their actual behavior. Due to the complexities of measuring visitors' purchasing behavior, this was not possible. However, although it is uncertain whether individuals actually perform their intended behavior (Hughes, 2013; Smith et al., 2008), it provides insight into the actions that visitors were considering taking when completing the questionnaire. Of course, research on the impact that rangers have on visitors' actual behavior and the long-term impact of these behaviors is needed. Additionally, as the study used a self-completed questionnaire, response biases are possible and there may be difficulties in interpreting responses. For instance, of those who talked to a ranger, 66% said they would check products for palm oil, yet 74% said they would purchase sustainable palm oil. This appears inconsistent, as buying sustainable palm oil requires checking for it first. This may reflect social desirability bias, given that the campaign was about sustainable palm oil. Alternatively, this could be due the rangers advising visitors that most own-brand supermarket products contain sustainable palm oil, meaning that checking these products for palm oil would be unnecessary.

The study's second major limitation is that no data were collected on visitors' knowledge or behavior towards palm oil before their zoo visit. It is possible that, within the ranger condition, there were existing differences between the visitors who talked to a ranger and those who did not. Although participants were matched based on age and gender in the talked-to-ranger analysis, it is possible that, beyond these demographic variables, visitors who engaged with rangers were more aware of palm oil and were already purchasing products containing sustainable palm oil before their zoo visit, which may bias the results and exaggerate the effect of the intervention. The ranger-present analysis is likely to be less biased (as allocation to each condition was essentially random), but as relatively few visitors interacted with rangers the reported estimates from comparing these conditions is almost certainly much smaller than the true effect of interacting with a ranger. Further research is needed on changes in visitors' knowledge levels and actions before and after their zoo visit to assess the impact that rangers have in greater detail.

On a final note, we must acknowledge the current COVID-19 pandemic situation and the financial stresses this places on zoos and other visitor attractions. While it may not presently be possible to

implement recommendations on employing rangers to promote pro-environmental behavior among visitors due to current budgetary concerns and government restrictions, we hope that this research will provide useful insights in the development of future behavior change campaigns.

4.1. Conclusion

This research demonstrates the positive impact that rangers can have in delivering behavior change campaigns that promote pro-environmental behaviors in zoos. By delivering these campaigns, rangers may enhance visitors' awareness and knowledge of conservation issues, positively influence their intention to take conservation action, and increase their enjoyment of the campaign. These findings highlight that rangers may enhance the success of behavior change campaigns on complex conservation issues in zoos. By using rangers to deliver these campaigns and including them as part of their wider public engagement strategy, zoos may be able to more effectively promote pro-environmental behaviors to their visitors that benefit biodiversity conservation.

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461 Data statement

462 Data and analysis code are available on the OSF: <https://osf.io/7bwxp/>.

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Table 1. Details of the conversations rangers had with visitors, based on data from 17 rangers who delivered the ‘Supporting Sustainable Palm Oil’ campaign (19 rangers delivered the campaign but two did not respond). Each ranger was asked to estimate the percentage of visitors they talked to about each fact (see supplementary information for the data collection survey). Data from rangers were collected retrospectively after the questionnaire data collection had finished.

Fact	Average % of visitor conversations (SD)	Minimum % of conversations	Maximum % of conversations
Palm oil provides the most vegetable oil per area of land	89.0% (11.9)	50%	100%
19% of palm oil produced is sustainable	56.6% (26.3)	22%	100%
50% of packaged supermarket products contain palm oil	93.0% (7.6)	75%	100%
Buying products containing sustainable palm oil is difficult as they are rarely labelled	84.1% (14.2)	50%	100%

Table 2. Numbers and percentages of visitors who had heard of palm oil and sustainable palm oil in the non-ranger condition versus the ranger condition, in both the ranger-present analysis (using all visitors in the ranger condition, even if they did not talk to a ranger) and in the talked-to-ranger analysis (comparing those who talked to a ranger against age- and gender-matched individuals from the non-ranger condition who engaged with the campaign).

	Ranger-present analysis		Talked-to-ranger analysis	
	No ranger	Ranger	No ranger	Ranger
Heard of palm oil	407/492 (82.7%)	455/540 (84.3%)	124/151 (82.1%)	143/151 (94.7%)
Heard of sustainable palm oil	201/490 (41.0%)	250/537 (46.6%)	63/150 (42.0%)	91/150 (60.7%)

Table 3. Numbers and percentages of visitors who perceived that they knew nothing, not very much, some or a lot about palm oil in the non-ranger condition versus the ranger condition, in both the ranger-present analysis (using all visitors in the ranger condition, even if they did not talk to a ranger) and in the talked-to-ranger analysis (comparing those who talked to a ranger against age- and gender-matched individuals from the non-ranger condition who engaged with the campaign).

	Ranger-present analysis		Talked-to-ranger analysis	
Perceived knowledge of palm oil	No ranger	Ranger	No ranger	Ranger
None	81/491 (16.5%)	82/540 (15.2%)	24/151 (15.9%)	6/151 (4.0%)
Not very much	219/491 (44.6%)	237/540 (43.9%)	63/151 (41.7%)	60/151 (39.7%)
Some	176/491 (35.8%)	205/540 (38.0%)	60/151 (39.7%)	76/151 (50.3%)
A lot	15/491 (1.3%)	16/540 (3.0%)	4/151 (2.6%)	9/151 (6.0%)

Table 4. Numbers and percentages of visitors who said they would check if products contain palm oil, purchase products that contain sustainable palm oil and avoid buying products that contain palm oil after their zoo visit in the non-ranger condition versus the ranger condition. Results are presented for both the ranger-present analysis (using all visitors in the ranger condition, even if they did not talk to a ranger) and in the talked-to-ranger analysis (comparing those who talked to a ranger against age- and gender-matched individuals from the non-ranger condition who engaged with the campaign).

	Ranger-present analysis		Talked-to-ranger analysis	
	No ranger	Ranger	No ranger	Ranger
Check products for palm oil				
Yes	233/492 (47.4%)	241/538 (44.8%)	83/151 (55.0%)	99/151 (65.6%)
No	95/492 (19.3%)	106/538 (19.7%)	21/151 (13.9%)	16/151 (10.6%)
Unsure	164/492 (33.3%)	191/538 (35.5%)	47/151 (31.1%)	36/151 (23.8%)
Avoid palm oil				
Yes	165/491 (33.6%)	147/539 (27.3%)	59/151 (39.1%)	36/150 (24.0%)
No	105/491 (21.4%)	130/539 (24.1%)	25/151 (16.6%)	54/150 (36.0%)
Unsure	221/491 (45.0%)	262/539 (48.6%)	67/151 (44.4%)	60/150 (40.0%)
Buy sustainable palm oil				
Yes	224/489 (45.8%)	273/539 (50.6%)	78/151 (51.7%)	112/151 (74.2%)
No	48/489 (9.8%)	49/539 (9.1%)	11/151 (7.3%)	5/151 (3.3%)
Unsure	217/489 (44.4%)	217/539 (40.3%)	62/151 (41.1%)	34/151 (22.5%)

Table 5. Numbers and percentages of visitors who were happy, slightly happy or neutral/unhappy with the campaign in the non-ranger condition versus the ranger condition, in both the ranger-present analysis (using all visitors in the ranger condition, even if they did not talk to a ranger) and in the talked-to-ranger analysis (comparing those who talked to a ranger against age- and gender-matched individuals from the non-ranger condition who engaged with the campaign). Note that neutral, slightly unhappy and unhappy were combined due to the small number of people who gave these responses. Note also that only individuals who engaged in the campaign answered this question ($n=527$), hence why the sample size is lower than the total number of questionnaires used in the analysis ($n=1032$).

Campaign enjoyment	Ranger-present analysis		Talked-to-ranger analysis	
	No ranger	Ranger	No ranger	Ranger
Happy	69/255 (27.1%)	106/275 (38.5%)	40/151 (26.5%)	75/136 (55.1%)
Slightly happy	119/255 (46.7%)	139/275 (50.5%)	66/151 (43.7%)	52/136 (38.2%)
Neutral/unhappy	67/255 (26.3%)	30/275 (10.9%)	45/151 (29.8%)	9/136 (6.6%)

Table 6: Summary of main results, comparing the ‘ranger-present’ analyses (using all visitors in the ranger condition, even if they did not talk to a ranger) and the ‘talked-to-ranger’ analyses (comparing those who talked to a ranger against age- and gender-matched individuals from the non-ranger condition who engaged with the campaign).

Topic/Question	Ranger-present analysis	Talked-to-ranger analysis
Heard of palm oil	No difference between conditions	Visitors who talked to rangers more likely to have heard of palm oil
Heard of sustainable palm oil	Visitors in ranger condition slightly more likely to have heard of sustainable palm oil	Visitors who talked to rangers more likely to have heard of sustainable palm oil
Perceived knowledge	No differences between conditions	Visitors who talked to rangers had greater perceived knowledge of palm oil
Actual knowledge	Visitors in ranger condition more likely to obtain a 3/4 score	Visitors who talked to rangers had greater actual knowledge (for all scores)
Intend to check products for palm oil in next month	No differences between conditions	No differences between conditions
Intend to avoid buying products containing palm oil in next month	Visitors in ranger condition slightly less likely to avoid products containing palm oil	Visitors who talked to rangers less likely to avoid products containing palm oil (and less likely to respond ‘unsure’)
Intend to buy products containing sustainable palm oil in next month	No differences between conditions	Visitors who talked to rangers more likely to buy products containing sustainable palm oil
Campaign enjoyment	Visitors in ranger condition enjoyed the campaign more	Visitors who talked to rangers enjoyed the campaign more

Figure 1. Rangers engaging with visitors in the campaign space.

Figure 2. Percentage of visitors in each age category. A) Grouped by ranger ($n=539$) and non-ranger condition ($n=492$). B) Grouped by whether they talked to a ranger ($n=152$) or not ($n=380$) within the ranger condition.

Ranger-present analysis = Comparing all visitors in the ranger condition, regardless of whether they talked to a ranger, against all visitors in the non-ranger condition (comparing the white circles)
Talked-to-ranger analysis = Comparing all visitors who talked to a ranger in the ranger condition against age- and gender-matched individuals from the non-ranger condition who engaged with the campaign (comparing the grey circles)

Figure 3. Visual representation of the samples used for the two analyses.

Figure 4. Percentage of visitors who scored a knowledge score of 0, 1, 2 or 3/4 (0=no questions were answered correctly; 3/4=three or four questions were answered correctly), in both the: A) ranger-present analysis (using all visitors in the ranger condition, even if they did not talk to a ranger; non-ranger condition $n=482$; ranger condition $n=529$), and B) in the talked-to-ranger analysis (comparing those who talked to a ranger against age- and gender--matched individuals from the non-ranger condition who engaged with the campaign; non-ranger condition $n=148$; ranger condition $n=148$). Note that scores of 3 and 4 were combined due to the small number of the visitors scoring 4.