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Zoological education: Can it change behaviour?

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ABSTRACT

The behaviour of zoo visitors towards captive animals is a largely under-studied area of research. Evidence is beginning to emerge that certain behaviours by visitors like shouting, banging and staring can negatively affect animals. Previous methods to minimise negative visitor behaviours have primarily focused on physical exhibit alterations, such as barriers. The current study used an educational intervention (EI) in an attempt to decrease negative visitor behaviour and promote positive animal welfare. The visitors were groups of children, while three species of captive animals were studied: ring-tailed lemurs (*Lemur catta*), Humboldt penguins (*Spheniscus humboldti*) and Gentoo penguins (*Pygoscelis papua*). The children were studied under two conditions: 1) control groups who did not receive an educational intervention and 2) treatment groups who received the educational intervention. Children's and animals' behaviour were simultaneously recorded using behaviour and scan sampling. The results showed a statistically significant reduction in negative behaviour by the children in the treatment groups at all three animal exhibits (ring-tailed lemurs: $p = 0.020$; Humboldt penguins: $p < 0.001$; Gentoo penguins: $p = 0.031$). Findings varied for the animals' behaviour. Generally, there was no corresponding change in the animals' behaviour associated with the presence of a treatment or control group. In conclusion, education programs in zoos could be enhanced by introducing programs aimed at reducing negative visitor behaviour.

1. Introduction

Literature from the last two decades has shown that despite many different variables of the zoo setting, visitors have the potential to affect the behaviour of a wide variety of species as they view them (Hosey, 2000, 2005, 2013; Sherwen and Hemsworth, 2019). Often, that effect has been reported as negative with increases in visitor number and proximity associated with some captive animals displaying more avoidance, stereotypic and aggressive behaviours (Sherwen and Hemsworth, 2019). Many factors may affect an animal's response to visitors (Stoinski et al., 2012), including the behaviour visitors exhibit as they view animals (Mitchell et al., 1992). For example, visitor noise has been found to be a contributory cause of agitation, aggression and possibly reduced welfare in captive animals (Birke, 2002; Morgan and Tromborg, 2007; Quadros et al., 2014). Other active visitor behaviours like banging, staring, shouting and offering food are less well studied, but also have the potential to negatively affect captive animals, especially if they provoke fear in the animals (Nimon and Dalziel, 1992; Birke, 2002; Choo et al., 2011; Sherwen et al., 2014; Chiew et al., 2019). If zoo visitor behaviour is 'loud, fast and unexpected' this may be perceived as a threat by some animals who will react with fear (Sherwen and Hemsworth, 2019; p. 366), which overtime could lead to reduced welfare. Additionally, zoo staff commonly complain that visitors harass animals by engaging in these types of behaviours (Ross and Lukas, 2005). Furthermore, these behaviours are against the regulations of most zoological institutions. However, more researched is needed to clarify the exact implications of negative visitor actions on captive animal behaviour.

Previous studies have sought to control negative visitor behaviour and improve animal welfare through physical means such as barriers and sound-proofing material (Blaney and Wells, 2004; Keane, 2005; Chiew et al., 2019), which produced mixed results. Additionally, researchers have tried to minimise negative visitor behaviour by appealing to visitors' emotions or intellect with the usage of signage or the presence of zoo staff (Kratochvil and Schwammer, 1997; Keane, 2005; Sherwen et al., 2014; Chiew et al., 2019). Kratochvil and Schwammer (1997) stated that aquarium fish are disturbed by visitors banging on glass, and in their seminal study the authors reduced this visitor behaviour by posting three different types of signs at the aquarium. The

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most effective sign read 'only loonies would knock' (Kratochvil and Schwammer, 1997). However, there was no subsequent research on whether fish welfare improved. More recently, Sherwen et al. (2014) considered the effect of visitor behaviour on meerkats (*Suricata suricatta*). The authors used signage and researchers dressed as zoo staff to communicate to visitors to be quiet and not to interact with the animals. While the authors do report a reduction in noise and negative visitor behaviour with the signs and staff present, they found no corresponding effect on meerkat behaviour (Sherwen et al., 2014). Recently, Chiew et al. (2019) reported that visitor behaviour generally did not affect penguin behaviour, but that close proximity to visitors can induce fear in little penguins (*Eudyptula minor*). Increasing viewing distance with a barrier reduced the fear response in the birds, but this may have been because certain behaviours such as banging on the glass viewing window were inherently limited by increasing the viewing distance (Chiew et al., 2019).

Another way to control negative visitor behaviour could be through purposefully educating zoo visitors about how their behaviour could affect captive animals (Fernandez et al., 2009; Quadros et al., 2014; Hosey, 2013). One pioneering study developed an educational intervention to control visitor behaviour during a wild dolphin feeding program (Orams and Hill, 1998). By quantifying inappropriate behaviour, the study revealed that eco-tourists who had participated in a structured education program about dolphins were significantly less likely to engage in negative behaviour during a dolphin feeding session than the control group that did not attend an education program (Orams and Hill, 1998). Negative behaviour towards animals and the environment was also monitored during a children's conservation education camp in China (Bexell et al., 2013). At the end of the camp, Bexell et al. (2013) detected a significant increase in knowledge, and, as the week progressed, the campers also exhibited fewer negative behaviours towards animals and the environment. Unfortunately, neither Orams and Hill (1998) nor Bexell et al. (2013) considered any associated reduction of negative visitor behaviour on animal behaviour.

Kratochvil and Schwammer (1997) speculate that the majority of disturbance (e.g. banging on glass) is instigated by younger visitors. Although there is minimal research to support this suggestion, children and school groups do constitute a large number of zoo visitors each year, yet they are a generally neglected area of visitor research (Jensen, 2011). In fact, there is little research examining the efficacy of zoo education programs, especially concerning children's learning in the zoo setting. However, it has been found that scientific learning in school groups almost doubled when coupled with an educational presentation given by the zoo (Jensen, 2011, 2014). Interpretive presentations and work stations have also been found to enhance children's learning in the zoo setting (Randler et al., 2007; Visscher et al., 2009). However, zoological education programs should not only aim for their students to acquire knowledge, but also develop pro-conservation behaviours as a result of participating in their program (Hungerford and Volk, 1990; Ogden and Heimlich, 2009). Typically, pro-conservation behaviour change is aimed at adults, and includes actions like recycling, buying environmentally friendly products, donating money to conservation causes or signing a petition (Dierking et al., 2004; Smith et al., 2008; Godinez and Fernandez, 2019). However, these actions can be challenging to measure and difficult to attribute to an education program (Smith et al., 2008). Kuhar et al. (2010) state that ultimately environmental education should progress one step beyond pro-conservation behaviour change to show a significant biological impact.

The current study considers if zoological education may lead to a reduction in negative behaviour in children as they view animals. Here, negative visitor behaviour is defined as behaviour that is not compliant with the rules of the institutions included in this study. Additionally, this study considers if a reduction in negative visitor behaviour could lead to improved animal welfare, if the animals experience less intense visitor behaviour, which could potentially cause stress (Sherwen et al., 2014). Fota Wildlife Park attracts many children and school groups each year, and most species are in close proximity to visitors. Therefore, visitors touching, chasing, feeding and throwing objects at both the lemurs and the penguins included in this study is a possibility. Indeed, the lemurs at Fota are free-ranging, which means that they could be subjected to more intense interactions from visitors, but paradoxically they also have the ability to retreat (Mun et al., 2013), which can reduce visitor induced stress (Morgan and Tromborg, 2007). At Dingle Aquarium, visitors have more limited access to the animals, but both camera flashes and banging on the glass at the penguin exhibit are a concern to aquarium staff as these behaviours may disturb the birds or induce fear (Chiew et al., 2019). The current research both empirically tests the effectiveness of educating visitors with a structured educational intervention (EI), with an objective of reducing negative visitor behaviour, and simultaneously observes the captive animals' behaviour for any indication of a behavioural response to different visitor conditions. The aims of this research were to 1) investigate the usefulness of an educational intervention at reducing negative children's behaviour towards captive animals, and 2) to identify if there is any corresponding change in the behaviour of three species of captive animal as a result of being viewed by groups of children that have participated in the educational intervention or groups that engaged in a lower rate of negative behaviour.

2. Methodology

2.1. Study sites and animals

The research was carried out at Fota Wildlife Park (Fota), Carrigtwohill, County Cork, Ireland and Dingle Oceanworld Aquarium (Dingle), County Kerry, Ireland. Animal species included in the study were ring-tailed lemurs (*Lemur catta*), Humboldt penguins (*Spheniscus humboldti*) and Gentoo penguins (*Pygoscelis papua*) (Table 1).

The ring-tailed lemurs at Fota Wildlife Park were kept in a free-range setting, which consisted of a woodland environment with 26 different species of predominantly native trees, a lake, a stream and grassland areas. The animals were able to roam the entire park; their movements were completely unrestricted even at night and staff have occasionally observed them leaving the park. However, they were most often located in the lower half of the park (approximately 25 acres), where all of the data for this study were recorded. Visitors could directly approach the animals, but were discouraged from touching and feeding the lemurs by signs and staff. In fact, 'lemur patrol' staff are always present throughout the day to protect the free-ranging lemur group, though visitor-animal interactions still occurred (Collins et al., 2017). The lemurs had access to a sheltered hut and were given a scatter feed of monkey pellets plus fruit and vegetables each morning and evening, though natural foraging also contributed to their diet.

The Humboldt penguins at Fota Wildlife Park were housed in an outdoor enclosure with a large pond. The pond is fed by a local tidal inlet, which allows the penguins natural foraging opportunities. However, they were also fed a diet of whole fish, twice a day at approximately 10am and 4 pm. A low stone wall (0.50 m high) with a wooden railing separated the penguins from the viewing public. At the time of the study, there were no signs indicating that the public should not touch or feed the penguins. However, depending on the penguins' location they are easily accessible and interactions have been observed by staff. At Fota, the weather during the study was generally good or observations of lemurs and penguins did not occur, because children viewing the animals were not able to tour the park in inclement conditions. The temperature varied from 12 to 20 °C throughout the study.

At Dingle Aquarium, the Gentoo penguin enclosure is a purpose-built indoor facility. It consists of a 120,000 l pool and a land surface area where a snow machine produces half a ton of snow and ice throughout the day. The temperature of the enclosure is kept between 6–11 °C. A glass wall, interspersed with artificial rock structures, separates the penguins from the viewing public. The penguins have no access to an outside area, and there is no 'off exhibit' area. The penguins are hand-fed at

Table 1
Details of study sites, exhibits, animals and observation dates.

Study site	Animals observed	Observation dates and times	No. of animals	Enclosure dimensions (m^2)
Fota Wildlife Park	Ring-tailed lemurs (*Lemur catta*)	October 2013, April – October, 2014 – 2015, April – August 2016 11:00 – 12:30	8–10 5 – 6 ♀ 3 – 4 ♂	Free- ranging
Fota Wildlife Park	Humboldt penguins (*Spheniscus humboldti*)	April – August 2014 – 2015 April – August 2016 11:00 – 12:30	24 – 31 sex unidentified	61
Dingle Aquarium	Gentoo penguins (*Pygoscelis papua*)	May 2014 – 2016 11:00 – 15:00	12 8 ♀ 4 ♂	35

10:00 h and 14:00 h daily. Signs are posted throughout the penguin enclosure at Dingle asking visitors not to climb the artificial rock structures, use flash photography, shout or bang on the glass, yet these behaviours have previously been observed at this enclosure (Collins et al., 2016).

2.2. Child participants and the educational intervention

The children that participated in this study were on a scheduled visit of Fota Wildlife Park or Dingle Aquarium, including school tours at both facilities and five-day camps at Fota Wildlife Park. Before their scheduled visit, but after agreeing to participate in the research, each group was randomly assigned by the primary researcher as a control or treatment group. The primary researcher had previously travelled to the schools to administer a survey (see Collins, 2018, for results), and if the school was categorised as a treatment group, the researcher conducted the educational intervention (EI) at that time. In the case of a camp, treatment groups completed the EI during the week at Fota. Children (boys and girls) participating in the research were aged between 6 and 12 years. Group size varied, but averaged 23 children (23.10 ± 1.00), which represents a standard class size in Ireland. The variation in age, gender and group size was out of the control of the researcher; groups participated voluntarily and institution policy and scheduling had to be followed. However, preliminary research conducted during a pilot study indicated these variations did not affect behaviour. In total, 49 groups (25 control; 24 treatment) of children participated in the study.

The educational intervention was designed by the authors to enhance children's learning in the zoo. It consisted of a one-hour class conducted by the primary researcher (see Collins, 2018, for complete details of the EI). The EI focused on children's knowledge, attitude and behaviour towards zoo-housed animals. Specifically, it included a PowerPoint presentation which described the biology of penguins and lemurs, threats to their existence in the wild, what life might be like for animals in the zoo versus the wild. For environmental education to successfully impact a specific behaviour, messages about that behaviour should be clearly communicated to visitors (Smith et al., 2008; Mann et al., 2018). Therefore, visitor behaviours that were intended to change were described and discussed (e.g. 'you should not feed the lemurs because it could make them sick' or 'you should not bang on the penguins' glass wall because you could disturb or frighten them'). Furthermore, emotionally engaging visitors with environmental issues has a positive impact on learning and behaviour (Ballantyne et al., 2001; Myers et al., 2004; Ballantyne et al., 2007, Ballantyne et al., 2011; Mann et al., 2018). Therefore, the PowerPoint presentation included emotionally appealing pictures and stories of the species studied.

However, children learn by doing (Dewey, 1998). Therefore, part of the intervention was dedicated to a hands-on activity during which children made enrichment devices for the animals included in the study. The purpose of the enrichment was multifunctional. First, it was intended to improve animal welfare by encouraging the penguins to swim and the lemurs to be more active by providing a non-scheduled feeding/foraging opportunity. Second, the animals' interest in the enrichment device and potential increased activity, was intended to stimulate children's learning. Although McPhee et al. (1998) reported that an enrichment device itself had little effect on visitors, others suggest it is the animal behaviour that the device elicits that is interesting to visitors (Wood, 1998; Davey et al., 2005). In the present study, the children had the opportunity to prepare a scatter feed of fruit for the ring-tailed lemurs, which they later saw them eating (Dr Maggie Esson, pers. comm., 2013). For the penguins, the children made an enrichment device, which consisted of plastic bottles that the children filled with shiny bits of paper (Clarke, 2003). Additionally, at Fota the students made bubble mix which was then blown by machine when they viewed the penguins.

2.3. Procedure and data collection

All practices adhered to the strict ethical guidelines for working with children outlined by Cohen et al. (2007). Furthermore, the

Table 2
Ethograms for the animal and children's behaviour observed at the three study sites (A, B & C).

A. Ring- tailed lemurs at Fota Wildlife Park

Behaviour	**Definition**
Inactive	Lying down, sitting, no movement, sleeping, no contact or interaction with conspecifics
Groom	Autogroom; biting, licking, scratching
Feed/Forage	Ingesting food; eating, drinking, looking for food; head in contact with the ground, uncovering or searching for a food item.
Locomotion	Any movement from one location to another; walking, running, climbing
Affiliative	A positive social behaviour; allo-grooming; huddled or basking together; play
Agonistic	A negative social behaviour; biting, scratching, chasing a conspecific
Not visible	Out of sight (including hut)

Children's groups

Behaviour	**Definition**
Feed	Any attempt to feed an item of food
Touch	Any attempt to make physical contact in a non-aggressive way such as touching, petting or lifting
Chase/kick/throw	Any attempt to make contact in a more aggressive way; including chasing, kicking or throwing any object at a lemur.
Shout	A raised voice loud vocalisation directed at the lemurs

Enrichment
Scatter-feed present for both control and treatment groups to encourage the lemurs to come into view. However, it was prepared by the treatment groups.

B. Humboldt penguins at Fota Wildlife Park.

Behaviour	**Definition**
Pool - use	Any activity that took place in the penguins' pool; swimming, preening, standing at edge of water.
Vocalisation	Any vocalisation

Children's groups

Behaviour	**Definition**
Feed	Any attempt to feed and item of food
Touch	Any attempt to make physical contact in a non-aggressive way such as touching, petting or lifting
Chase/kick/throw	Any attempt to make contact in a more aggressive way; including chasing, kicking or throwing any object at a penguin.
Climb	Climbing the enclosure wall/fence and standing over the penguins
Shout	A raised voice; a loud vocalisation directed at the penguins

Enrichment
Bubble machine and plastic bottles were present for the treatment groups.

C. Gentoo penguins at Dingle Aquarium

Behaviour	**Definition**
Surface swimming	Swimming on the surface of the water
Under water swimming	Swimming under water
Preening in Pool	Preening (see definition below) in the water
Porpoising	Jumping in an out of the water in typical penguin style
Inactive	Individual is not in the pool and is; sitting, sleeping, standing, the absence of any other behaviour
Preening	Feather maintenance, scratching, shaking
Locomotion	Movement on land; walking, hopping, running
Affiliative	Positive social behaviour with another penguin; allo-preening, bowing
Agonistic	Negative social behaviour with another penguin; staring, beaking, attacking
Attention to enrichment	Playing with, chasing or manipulating an enrichment device
Attention to visitors	Attempting to engage in some type of interaction with a visitor such as, tapping glass with beak, following in water, actively staring at a visitor through the glass wall
Nest behaviour	Engaged in any type of behaviour involving the nest such as, moving stones or sitting on the nest
Other	An unusual occurrence, any behaviour not listed above

Children's groups

Behaviour	**Definition**
Bang	Banging on the glass with a hand or other object
Flash	Using flash photography

(*continued on next page*)

Table 2 (*continued*)

C. Gentoo penguins at Dingle Aquarium	
Climb	Climbing the artificial rock structures and standing over the penguins
Shout[†]	A raised voice; a loud vocalisation directed at the penguins
Enrichment	
Plastic bottles were present for the treatment groups.	

[†] Although the glass is sound-proofed, this behaviour was included as it is not compliant with aquarium rules.

procedures used in this study were ethically reviewed and had approval from the University College Cork Ethics Committee for working with children and animals. During the visit to Fota or Dingle, children's behaviour and animals' behaviour were observed and recorded simultaneously. The primary researcher recorded the children's behaviour, while a research assistant recorded the animals' behaviour. Inter-observer reliability (IOR) testing was carried out between the primary researcher and all research assistants involved in recording animal behaviour (Martin and Bateson, 2007). The primary researcher recorded all of the children's behaviour. However, for quality control purposes a simple test of observer reliability was conducted by employing a methodology similar to that of Jensen (2011). This included the primary researcher and a member of staff at Fota or Dingle rating students' overall behaviour on a three-point Likert as: 1 (repeated bad behaviour from many children), 2 (generally good behaviour with a few incidences of negative behaviour) and 3 (the entire group was well behaved). Children's negative behaviours included in the study were determined and categorised based on preliminary observation of behaviours that children engaged in, institution rules and previous research (e.g. Sherwen et al., 2014; Orams and Hill, 1998) (see Table 2A–C).

Animals' and children's behaviour were recorded during two conditions:

1) Control groups, children who had not participated in the EI;
2) Treatment groups, children who had participated in the EI.

Ethograms were used to record the animals' behaviour and the children's behaviour during each observation (Table 2A–C). Animals' behaviour was recorded using instantaneous scan sampling and all occurrence sampling (Altmann, 1974; Martin and Bateson, 2007). Children's behaviour was recorded using event sampling, when each instance of a specific behaviour which occurred during the observation period was recorded (Sattler, 1988; Bexell et al., 2013). Data collection did not occur for thirty minutes before or after feeding times at penguin enclosures, and took place on days that a group of children was available to participate in the study. Observations began once the entire group was present. This led to a total of 74 children's observation sessions, including 22 observations at the ring-tailed lemurs, 39 at the Humboldt penguins and 13 at the Gentoo penguin enclosure. The length of each observation varied from 3 to 12 min (5.82 ± 0.29) and was guided by staff and school teachers.

At Fota, in order to facilitate the children's groups meeting the free-ranging primates, the lemurs were called by Fota staff and received a small scatter feed of fruit next to the lemurs' hut. In the case of treatment groups, this was introduced as the fruit they had prepared during the educational intervention. Some observations were discounted, if they did not follow the set parameters of the study, such as if none of the lemurs were visible or staff did not arrive to administer the scatter feed. This reduced the number of useable lemur-child observation sessions from 30 to 22. At each one-minute interval, the research assistant recorded the behaviour of each individual in the group (Table 2A). These values were summed and then divided by the length of the session in minutes to give the mean number of individuals engaged in each behaviour per minute of each observation session. At the same time, the primary researcher counted the total number of negative children's behaviours per observation period, which was then divided by the length of the observation period in minutes to give the rate of negative behaviour per minute for each observation period. This recording procedure was also followed for the groups of children and Gentoo penguins at Dingle Aquarium (Table 2C).

For the Humboldt penguin group at Fota Wildlife Park, the recording procedure differed slightly. It was not possible to observe a range of behaviours with this group of penguins because there were too many penguins to accurately count which birds were engaged in which behaviours. Since pool use has previously been used as an indicator of

penguin welfare (Larsson, 2012; Collins et al., 2016), it was chosen as the behavioural measure for the current study (Table 2B). At each one-minute interval, the number of penguins in the pool was counted. This was then summed for the entire observation session and divided by the length of the session and the total number of penguins in the group because both the session length and the number of penguins in the group varied throughout the project. Additionally, the total number of penguin vocalisations per viewing session was recorded using behaviour sampling (Martin and Bateson, 2007) because preliminary research indicated that the penguins vocalised more when excited (e.g. at feeding time). The total number of penguin vocalisations was counted for each observation period and then divided by the length of the observation time in minutes to give the rate of penguin vocalisations per minute for each observation session. Children's behaviour was simultaneously recorded as previously described (Table 2B). For both penguin species, if they were viewed by a treatment group, the enrichment made by the children during the educational intervention was introduced at the beginning of the observation period (Table 2B and C).

2.4. Data analysis

All data were tested for normality using the Kolmogorov-Smirnov test, and visually inspected with histograms and quantile-quantile plots. The Spearman rank-order correlation test was used to measure inter-observer reliability between all research assistants recording animal behaviour and the primary researcher; a correlation of 0.7 or greater was considered acceptable before each research assistant began working on the project. However, a mean correlation of 0.9 ± 0.02 was achieved between the assistants and the primary researcher throughout the project (Martin and Bateson, 2007; Meagher, 2009). Independent variables were tested for multicollinearity and were found to be below the variance inflation factor (VIF) tolerance level of 1.5 in all cases.

First, for the groups of children the effect of participation in a control or treatment group (condition) on children's behaviour was assessed. Ideally, the effect of other variables, such as gender, would have been analysed; however, while group composition did differ slightly, the variance of each independent variable was small. For example, control groups (n = 25) consisted of three girls' schools and 22 mixed gender schools, whereas treatment groups (n = 24) included four girls' schools and 20 mixed gender schools. In control groups age ranged from 6 to 12 years (mean 9.54) and in treatment groups age ranged from 5 to 12 years (mean 10.31). Therefore, because of small sample sizes, non-normality of data and little variation within each independent variable, the Mann-Whitney *U test* was used to analyse the effect of the main independent variable (condition) on the rate of children's negative behaviour.

Next, it was considered essential to evaluate the lemur and penguin behaviour data in such a way as to use both condition (categorical: control or treatment group present) and the rate of negative behaviour (continuous) as independent variables. When possible, length of session was also included as an independent variable to account for possible variation in behaviour which may occur with a shorter or longer viewing session. When a general linear model (GLM) was used to test the significance the independent variables, a backwards stepwise procedure was used to remove the non-significant factors from the model. Validation for the model was conducted for each model by plotting a histogram of residuals, plotting residuals against predicted values and checking the linearity of the models. Behavioural diversity (BD) was considered an appropriate indicator of welfare for the ring-tailed lemurs and the Gentoo penguins (see Collins et al., 2016, 2017) and was used as the dependent variable. The mean BD level for each observation period was calculated using the Shannon-Weaver diversity index H (Shannon and Weaver, 1949) and used for the analysis. See Collins et al. (2016) for a description of the methodology involving BD. Pool use and vocalisation were used as dependent variables for the Humboldt penguin group.

Finally, the Mann-Whitney *U test* was used to examine differences in individual lemur and Gentoo penguin behaviours when either a negative behaviour occurred or did not occur or during the two test conditions (control or treatment group present). The Bonferroni correction was applied if multiple comparisons occurred and the alpha level was adjusted accordingly. All data were organised and analysed using IBM SPSS Statistics Version 22 and Microsoft Excel 2007. The accepted alpha level for these analyses was 0.05 unless otherwise stated, and all tests are two-tailed.

3. Results

3.1. Children's behaviour

A strong positive association (mean 0.92 ± 0.05, for observations at all species) was maintained for observer reliability testing between the researcher and staff for children's behaviour. Statistically significant differences were found for the rate of children's negative behaviour between control and treatment groups at all three study species' enclosures (Table 3). Control groups, who did not participate in the EI, were significantly more likely to engage in negative behaviour at each exhibit (Table 3 and Fig. 1).

3.2. Fota Wildlife Park – ring-tailed lemur results

Testing for normality indicated that behavioural diversity data are approximately normally distributed (p = 0.101). A GLM showed that the rate of children's negative behaviour was the only remaining explanatory variable in the model. However, this was not statistically significant (F = 3.241; p = 0.087).

Next, the Mann-Whitney *U test* was used to explore the effect of negative children's behaviour on specific lemur behaviours, the rate of negative behaviour was changed to a categorical variable: a negative behaviour occurred (n = 12) or did not occur (n = 10). The only lemur behaviour that was found to be significantly affected by children's behaviour was locomotion (U = 25.50; p = 0.023), however, this did not remain significant after the Bonferroni correction was applied (Fig. 2).

3.3. Fota Wildlife Park – humboldt penguin results

Data did not follow a normal distribution (p < 0.001, for both vocalisation and pool use); however, visual inspections of the histograms were near normal and the sample size was considered large enough to test using a GLM. However, because an assumption of the statistical test was violated, the accepted alpha level for this section was reduced to 0.01, in order to avoid making a Type I error (Plowman, 2008).

For pool use, neither the length of the session (F = 0.109; p = 0.743), experimental condition (F = 2.002; p = 0.166) nor the rate of negative behaviour (F = 2.791; p = 0.103) was statistically

Table 3
Results of the Mann-Whitney *U test* for the rate of children's negative behaviour between control and treatment at each enclosure site. SEM = Standard error of the mean.

Study site	Species	Condition Mean ± SEM	Test results		
Fota Wildlife Park	Ring-tailed lemurs	Control 0.24 ± 0.06 Treatment 0.03 + 0.03	n = 16,6	U = 18.00	p = 0.020
Fota Wildlife Park	Humboldt penguins	Control 0.61 ± 0.10 Treatment 0.14 + 0.05	n = 24,15	U = 36.50	p < 0.001
Dingle Aquarium	Gentoo penguins	Control 1.13 ± 0.18 Treatment 0.53 + 0.09	n = 7,6	U = 6.00	p = 0.031

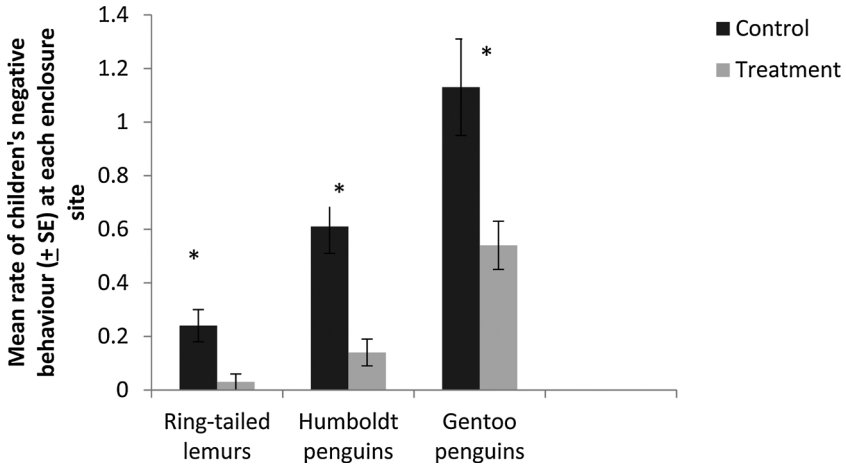

Fig. 1. The mean rate of children's negative behaviour per observation session at each enclosure site during control and treatment conditions. *denotes statistically significant difference.

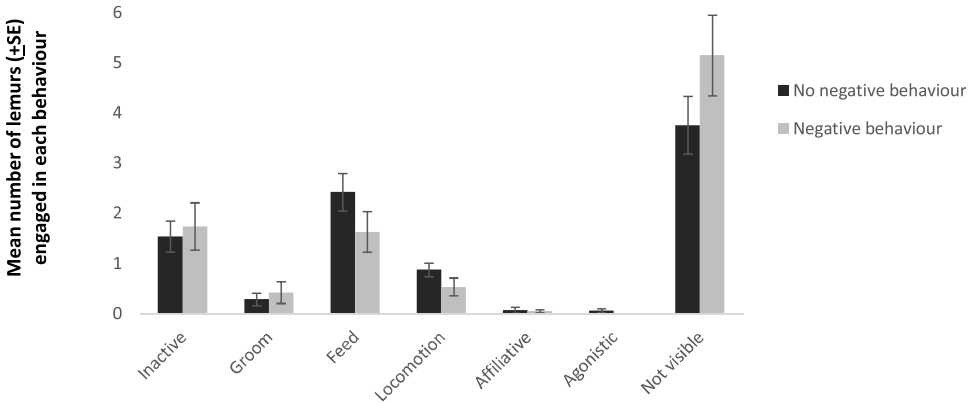

Fig. 2. The mean number of lemurs engaged in specific behaviours per observation session during periods with and without negative behaviours from children at Fota Wildlife Park.

significant, meaning that none of the explanatory variables affected penguins' pool use. Vocalisation resulted in a final model with condition and length of session as the remaining explanatory variables. In this case, they were both statistically significant (condition: $F = 121.297$; $p < 0.001$; length of session: $F = 12.941$, $p < 0.01$). More vocalisations occurred when treatment groups were present and as the length of the session increased.

3.4. Dingle Aquarium – Gentoo penguin results

The data did not follow a normal distribution ($p = 0.034$), and the sample size was considered too small to apply a GLM, therefore the Mann-Whitney *U test* was used to detect differences in behaviour between treatment or control groups. The length of the session and the rate of children's negative behaviour, as an independent variables, were excluded to avoid multiple comparisons. There was no difference in the penguins' behavioural diversity level found between treatment or control groups ($U = 16.00$; $p = 0.475$). Individual penguin behaviours were also examined using the Mann Whitney *U test* Attention to visitors was the only penguin behaviour found to be significant ($U = 5.00$; $p = 0.020$); however, this did not remain significant after the Bonferroni correction was applied (Fig. 3).

4. Discussion

Behaviours such as banging on glass or feeding attempts may be the visitors' way of establishing a connection or provoking a response from animals, and they are not necessarily intended to be insensitive (Luebke et al., 2016). However, it is the zoo's responsibility to ensure that visitors have the experiences they seek, while maintaining a high standard of animal welfare. The current study proposed that education could be the link between reducing negative visitor behaviour and thus improving animal welfare. The results found here showed that the presence of the treatment group was associated with a reduction in negative visitor behaviour at every animal species observed in both institutions. This supports previous research (Orams and Hill, 1998; Bexell et al., 2013; Sherwen et al., 2014), which found that educational material successfully reduced negative visitor behaviour. In contrast, a recent study which attempted to reduce negative visitor behaviour at a penguin enclosure with the use of regulatory signage and the presence of staff found no reduction in negative visitor behaviour (Chiew et al., 2019). This result indicates that perhaps a more intense educational experience is necessary to reduce negative behaviour. Chiew et al. (2019) stated that barriers were an effective way to mitigate unwanted behaviours from visitors. Yet, physical barriers may not be optimal, if restricting visitor viewing reduces visitor enjoyment or a species is free-ranging.

The current study, which offered a structured hour-long educational intervention developed specifically for children, was successful at reducing negative visitor behaviour. This finding represents one of the first instances that a causal link has been found between education and the reduction of a negative behaviour in children visiting the zoo or aquarium. Bexell et al. (2013) stated that a decrease in negative visitor behaviour towards animals is suggestive of an increase in cognitive empathy, which may lead to pro-conservation behaviour or environmental stewardship (Bexell et al., 2013). Future studies should continue to explore these links to assess if zoo education may be successful at

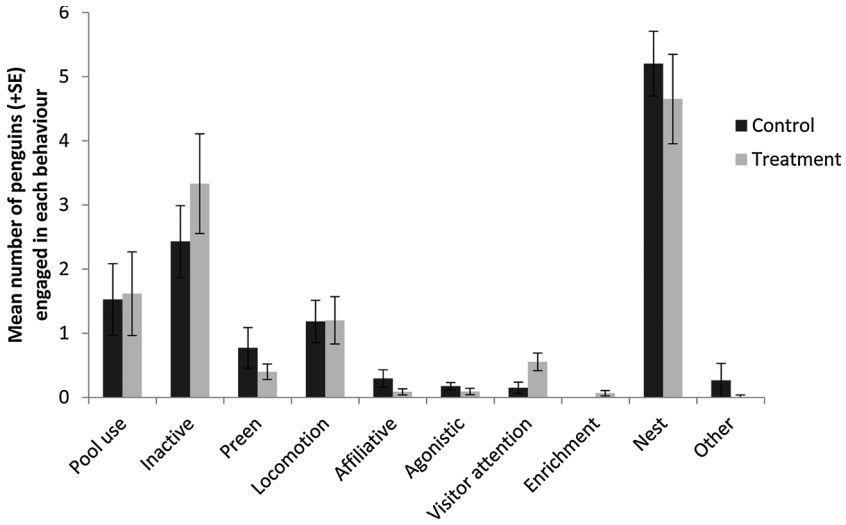

Fig. 3. Mean number of penguins engaged in each specific behaviour per observation session with control and treatment groups present at Dingle Aquarium.

promoting pro-conservation behaviour in children. The present research is likely to be beneficial to zoos that have a need to control negative visitor behaviour. Additionally, the efficacy of zoos' education programmes may be improved by implementing curriculum similar to what this research describes. For example, educational material developed for a particular age group, which specifically describes the unwanted behaviours, promotes empathy towards animals and includes a hands-on activity may be useful for decreasing negative visitor behaviour.

It has proved more difficult to show a connection between reduced negative visitor behaviour and improved animal welfare (Sherwen et al., 2014; Chiew et al., 2019). There were no statistically significant effects of the presence of either the control or treatment group on the lemurs' behavioural diversity level nor were individual behaviours affected by negative visitor behaviour. This supports a previous study with this group of lemurs that found that the free-ranging ring-tailed lemurs at Fota rarely react to visitors (Collins et al., 2017).

At Fota, the penguins' pool use was not affected by any condition that was tested. This confirms results of previous studies that captive penguins are unlikely to give a behavioural response to visitors or enrichment (Ozella et al., 2015; Collins et al., 2016). Saiyed et al. (2019) reported a neutral to positive effect on penguin welfare when visitors are allowed in close proximity to penguins during an animal ambassador programme. In contrast, Sherwen et al. (2015) reported that little penguins (*Eudyptula minor*) showed increased aggression and avoidance behaviour when exposed to visitors, though they did not report the visitors' behaviour. At Fota, logistical constraints made it impossible to observe a range of penguin behaviours; however, given the findings of Sherwen et al. (2015), it would be optimal to include individual behaviours in future research. However, it was discovered that the Humboldt penguins at Fota were more likely to vocalise when the treatment group was present. The increase in vocalisation, probably due to the presence of the enrichment, could be an indication of increased socialisation (Thumser et al., 1996; Reiss-Woolever, 2017). The penguins vocalised more the longer the group remained, indicating that the novelty of the enrichment did not diminish during the observation session. However, generally, the penguins showed little interest in the enrichment, which is similar to the findings of previous research involving enrichment on this penguin group (Dunne, 2015). Yet, individual animals may give a different behavioural response to enrichment devices (Makecha and Highfill, 2018), and here the group rather than individuals were observed.

The Gentoo penguins at Dingle Aquarium received the most negative behaviour from visitors of any species in the study. Collins (2018) suggested that differences in visitor learning may be due to different enclosure types, with visitor at naturalistic outdoor enclosures exhibiting higher knowledge scores on a survey than those at indoor enclosures. Indeed, previous research has shown that visitors like to see animals in naturalistic settings (Rhoads and Goldworthy, 1979; Coe, 1985; Finlay et al., 1988). Sommer (1972) stated that cage-like exhibits could lead to disrespect towards captive animals. Although the penguin exhibit at Dingle Aquarium is reflective of a natural Gentoo penguin environment, it is completely indoor with no outside access for the birds. The different environments between the enclosures at Fota and Dingle could lead to different types of visitor behaviour. The influence of enclosure design on visitor behaviour is certainly area that would benefit from further research. However, despite receiving the most negative behaviour from visitors, neither the Gentoo penguins' behavioural diversity level nor any individual behaviours were affected by the presence of control or treatment groups (Collins et al., 2016).

Previous research conducted on the Gentoo penguins (Collins et al., 2016) and the ring-tailed lemurs (Collins et al., 2017) included in this study suggested that the animals were not negatively affected by visitor behaviour, and may in fact be suitable for supervised educational experiences with visitors, which the current research supports. However, it is important to consider individual animal characteristics and personality before participation in any programme, and allow animals choice of participation and control over their environment during any animal-visitor interaction experience (Saiyed et al., 2019). Additionally, animal-visitor interactive experiences should follow a protocol to assess animal welfare and visitor experience (Mori et al., 2019). Given the previous lack of response to visitors by the species included in this study, it is not surprising that differences between the control and treatment conditions did not lead to a noticeable behavioural response. Or, perhaps repeated exposure to visitors has led to habituation (Hosey, 2013). However, it is also possible that there is a cumulative effect of negative visitor behaviour and that a behavioural response is only detectable after multiple encounters with badly behaved groups. Equally, the animals may give a physiological response, such as increased heart rate (Carney and Sydeman, 1999), that is not detectable through observation. Future research in this area should perhaps focus on animals definitively known to suffer from reduced welfare, as a consequence of visitor behaviour, so that any effects of an applied treatment are easier to detect (Sherwen et al., 2014). However, there could be ethical implications of purposely bringing groups of visitors to view animals that are known to suffer from visitor induced stress and this must be carefully assessed.

Like previous studies in this complex area (Bexell et al., 2013; Sherwen et al., 2014), the current study was not able to examine how visitor age, gender or group size might have affected behaviour, but the study brings new information to the area by focusing on children, an under-studied group. Future research should examine specific visitor variables so that

zoo staff would be aware that certain groups may be more inclined to direct negative behaviours at the animals. Also, it was not possible to separate observations with enrichment from groups that had received the educational intervention. It would have been optimal to observe this separately so any affect could be directly related to one condition; however, due to scheduling and time constraints this was not possible.

In conclusion, the findings of this study show that it is possible to reduce negative visitor behaviour in the zoo setting with a simple, cost-effective educational intervention, which may be more optimal than restrictive barriers, which could reduce visitor enjoyment. The EI used here is broadly generalisable to many zoo settings, and although the results presented here are limited to penguins and ring-tailed lemurs, it is reasonable to assume it could be adapted to included other species, especially those known to suffer from visitor stress.

Author declaration

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

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