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Animal Welfare 2014, 23: 11-24
ISSN 0962-7286
doi: 10.7120/09627286.23.1.011

Identification of major welfare issues for captive elephant husbandry by stakeholders

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Abstract

Accurate identification of key welfare issues for captive elephants could improve standards and help in the development of a welfare index. In the absence of adequate scientific information on the relative importance of key issues, the views of a range of stakeholders were sought using adaptive conjoint analysis. Fifteen key welfare issues were identified by experts, and three to six Levels of each, representing common husbandry practices. In order of declining importance, 224 stakeholders rated the issues as enclosure substrate > group size > healthcare > enrichment > chaining > enclosure type > exercise provision > enclosure size > interaction with keeper > enclosure environment > keeper knowledge/experience > diet > contact method with keeper > display duration > enclosure security. Enclosure size was considered more important by scientists and keepers than zoo directors/managers and animal welfare organisation representatives. Animal welfare organisation representatives rated enclosure security higher than scientists. Keeper husbandry methods and ability of elephants to be active were two principal components in responses. Three principal groups of respondents were identified: scientists/veterinarians focusing more on conditions for the elephants and less on interaction with the public; keepers, focusing on keeper contact method, feeding and knowledge of elephants; and a group with mainly animal welfare organisation representatives/zoo directors focusing on enclosure security. It is concluded that there are some differences between stakeholders in their recognition of the most important welfare issues for elephants in zoos. However, recognising that a diversity of informed opinion is necessary to adequately devise welfare standards, an index of elephant welfare in zoos is proposed, based on the relative merits of different husbandry practices and the importance of the different issues.

Keywords: *animal welfare, attitude, elephant, sanctuary, welfare index, zoo*

Introduction

Elephants are one of the flagship species of zoos and being large, interesting animals are highly attractive to visitors and able to generate considerable revenue for the zoos that display them. Attending to their welfare represents perhaps the biggest challenge of any species, both from a husbandry and public perception perspective (Veasey 2006; p 63). Concerns regarding the declining population of captive elephants in American zoos have prompted the AZA's Species Survival Plan (SSP) to include a statement that Asian and African elephants in North American zoos will be ''demographically dead'', ie the captive population unsustainable, within the next few decades (Olson & Wiese 2000; Wiese 2000; Faust 2005; Faust *et al* 2006). Thus, zoos today face a challenging task in improving the captive husbandry and hence the welfare of their elephants from both an ethical and economic perspective (Clubb & Mason 2002).

Many people advocate that elephants do not belong in zoos, and zoos themselves acknowledge a need to improve elephant welfare and management in captivity (AZA 2001). Some of the greatest areas of concern include poor reproduction, inadequate facilities, lack of exercise and obesity, inappropriate animal numbers and social grouping, as well as health problems such as arthritis and disease (Taylor & Poole 1998; Clubb & Mason 2003). Improved husbandry, that implements high welfare breeding programmes and accreditation standards for captive elephants, with research directed towards solving specific husbandry challenges, is important for successful captive elephant management (Hutchins *et al* 2003; Hutchins 2006). Even though some captive elephant facilities have excellent programmes to achieve these goals most others are slow to implement these standards (Hutchins & Keele 2006).

There are many well developed welfare assessment systems that have been used for farm animals, of which the Animal Needs Index (ANI) developed by Bartussek (1999) is the most popular. Many of these indices are used in conjunction with the local animal welfare legislation to control welfare. The assessment systems are mainly based on environmental variables rather than animal-based measures (Bartussek 1999; Zaludik *et al* 2007), which has been criticised for lack of relevance to welfare (Sandøe *et al* 1997; Sundrum 1997;

Whay *et al* 2003; Mollenhorst *et al* 2005; Zaludik *et al* 2007). In the absence of a large body of scientific evidence on factors influencing captive elephant welfare, it is important to take into account both the scientific evidence and expert opinion when developing useful indices (Bracke *et al* 2002; Kohari *et al* 2006; Seo *et al* 2007).

As animal welfare science has evolved from mere concepts to the current state of regulated standards, more pressure is placed on the zoo community to evolve a uniform set of standards and guidelines for management of wild animals in captivity (Shimmura *et al* 2011). Several zoos and sanctuaries holding captive elephants are bound to the regulations and guidelines of minimum regional standards and specifications, which do not necessarily represent uniform and optimal welfare requirements for captive elephants. This study aimed to use expert opinion from a stakeholder survey to identify optimal welfare requirements for captive elephants. In addition, these welfare requirements were incorporated into an index of captive elephant welfare, based on ratings of the different husbandry methods and the perceived importance of the welfare issues.

Materials and methods

Stakeholder selection

Stakeholder groups for the survey were initially identified and selected from scientific publications about captive elephants, elephant management protocols and interviews with ten elephant experts around the world (Georgia Mason, University of Guelph, Canada; Terry Maple, Georgia Institute of Technology, United States; Jacob V Cheeran, Kerala, India; Lisa Faust, Department of Conservation and Science, Lincoln Park Zoo; Khyne U Mar, University of Sheffield/Myanmar; Chris Sherwin, Bristol University; Janine L Brown, Conservation and Research Centre, Smithsonian Institution; Elke Riesterer; Kathy Carlstead, Honolulu Zoo Society; and Vivek Menon, Wildlife Trust of India). Following the consultation with experts, five stakeholder groups were confirmed for the survey: relevant scientists; elephant keepers; veterinarians; zoo managers/directors; and animal welfare organisations' representatives (AWOR). The members of the stakeholder groups were selected from lists managed by elephant organisations, elephant research publications, and elephant information databases. In addition, information obtained from the Association of Zoos and Aquariums (AZA), European Association of Zoos and Aquaria (EAZA), British and Irish Association of Zoos and Aquariums (BIAZA), Australasian Regional Association of Zoological Parks and Aquaria (ARAZPA), South East Asian Zoos Association (SEAZA) and corresponding websites of the zoological parks and sanctuaries having captive elephants was considered. The scientist stakeholder group included those who were researching elephants at the time and were perceived to have extensive experience of working with captive elephants. The animal welfare organisations were identified using the Google website, with requests sent to the organisations to be forwarded to the member or members who had knowledge about elephants, regardless of their direct experience of working with captive elephants. The survey respondents also included elephant veterinarians, scientists and elephant keepers from the zoological parks and captive elephant sanctuaries in southern India. Respondents were able to identify with only one stakeholder group.

A total of 1,626 survey invitations were sent out, with individual stakeholder group numbers as follows: 448 elephant keepers/mahouts, 381 animal welfare organisation representatives, 307 scientists, 255 zoo or sanctuary directors or managers and 235 veterinarians.

Creation of Attributes and Levels

Key husbandry Attributes were identified as candidates for a welfare index, and Levels for these were selected based on an extensive review of previous scientific studies and in consultation with the elephant experts. Each Attribute represented an important welfare issue, which could be described by various Levels representing the range of husbandry and welfare practices worldwide, as described in various regional standards and guidelines. The conjoint analytical process adopted assumed that the respondents view husbandry requirements as composed of various Attributes and Levels. Respondents placed a certain utility value on each of those Levels, when presented with paired vignettes that describe them. The calculation of a Utility value is detailed in the *Statistical analysis*. Our method adapted the vignettes that were presented to the research participants based on previous responses. This adaption focused on the respondent's most preferred Attributes and Levels and sought to maximise the information gathered from each respondent by formulating the concepts so that they were approximately equal in preference (Orme 2002a). The fifteen Attributes selected for the survey were: group size; substrate in enclosure; healthcare; enrichment; restraining the animal; enclosure type; exercise provision; enclosure size; interaction with handler/keeper; enclosure environment; keeper knowledge and experience; diet; keeper contact method; display duration; and enclosure security. For each Attribute, three to six Levels were assigned, depending on the range of husbandry practices (Table 1). These described the common husbandry situations for captive elephants, based on the opinion of the experts and standards for captive elephant management adopted from various protocols, manuals and elephant database websites (eg AZA standards and BIAZA Guidelines).

Online survey

The survey was constructed in Sawtooth Software® (Sawtooth Software®. Sequim, WA, USA) using the Adaptive Conjoint Analysis module. Conjoint analysis is a statistical technique used for analysing stakeholder preference, which attempts to assess the impact of specific features on overall preference and determines which combination of a limited number of Levels of Attributes presented concurrently is most preferred.

The aim of the survey was to determine the relative importance of each of the 15 Attributes and the Utility values for

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Table 1 Attributes, Levels and their Utility values included in the captive elephant husbandry survey.

Attribute	Levels	Utility value
Keeper contact method	1) Free Keeper contact method (animal can be approached by keeper at any time; both keeper and elephant share unrestricted space)	25.39
	2) Protected Keeper contact method (animal handled by keeper with some protective measure like a barrier/elephant hook etc, while elephant has unrestricted space and is free to move away at will)	12.38
	3) Limited/Confined Keeper contact method (animal only handled through protective barrier or restraining chute)	9.28
	4) No Keeper contact method (elephant handled only when sedated)	–47.05
Group size	1) Four or more animals together	47.49
	2) Three animals together	25.74
	3) Two animals together	–13.07
	4) Solitary animal	–60.17
Display duration	1) 1–2 h on display each day	6.07
	2) 3–4 h on display each day	19.71
	3) 5–6 h on display each day	18.79
	4) 7–8 h on display each day	–5.89
	5) More than 8 h on display each day	–38.69
Exercise provision	1) Exercised for 3–4 h and taken for rides/safari walks daily	25.78
	2) Exercised for 1–2 h and taken for rides/safari walks daily	24.42
	3) Exercised for 3–4 h but not taken for rides/safari walks daily	10.50
	4) Exercised for 1–2 h but not taken for rides/safari walks daily	–2.74
	5) No exercise but taken for rides/safari walks	7.02
	6) Not exercised and not taken for rides/safari walks	–64.98
Interaction with handler/keeper and training	1) 3–4 h interaction with handler/keeper, with positive reinforcement training	33.99
	2) 1–2 h interaction with handler/keeper, with positive reinforcement training	34.30
	3) 3–4 h interaction with handler/keeper, with both positive and negative reinforcement training and occasional punishment	12.65
	4) 1–2 h interaction with handler/keeper, with both positive and negative reinforcement training and occasional punishment	16.15
	5) 3–4 h interaction with handler/keeper, with negative reinforcement training	–51.53
	6) 1–2 h interaction with handler/keeper, with negative reinforcement training	–45.57
Healthcare	1) Foot care and health monitoring performed daily	30.21
	2) Foot care and health monitoring performed once weekly	29.17
	3) Foot care and health monitoring performed once every fortnight	16.75
	4) Foot care and health monitoring performed once a month	–10.44
	5) No foot care or health checks done	–65.69
Chaining	1) Animal not chained at any time	44.93
	2) Animal chained only for examination	36.02
	3) Animal chained in the indoor enclosure but not in the outdoor enclosure	–10.46
	4) Animal chained when not on display	–15.86
	5) Animal always chained	–54.63
Enclosure type	1) Both indoor and outdoor enclosures	47.49
	2) Outdoor enclosure only with shelter	15.72
	3) Outdoor enclosure only with no shelter	–7.28
	4) Indoor enclosure only	–55.94

Table 1 (cont)

Attribute	Levels	Utility value
Enclosure size	1) 180 m^2 for one female elephant (with calf) and 370 m^2 for one male elephant	46.09
	2) 140 m^2 for one female elephant (with calf) and 280 m^2 for one male elephant	23.31
	3) 100 m^2 for one female elephant (with calf) and 190 m^2 for one male elephant	–15.56
	4) 60 m^2 for one female elephant (with calf) and 100 m^2 for one male elephant	–53.85
Enclosure environment	1) Shade in outdoor enclosure and heating/cooling in indoor enclosure as required	41.41
	2) Shade in outdoor enclosure and no heating/cooling in indoor enclosure	6.56
	3) No shade in outdoor enclosure but heating/cooling in indoor enclosure as required	8.60
	4) No shade in outdoor enclosure and no heating/cooling in indoor enclosure	–56.57
Enclosure security	1) Sufficient distance between animal enclosure and public viewing area	16.46
	2) Barrier between the animal enclosure and public viewing area	15.21
	3) Moat between the animal enclosure and public viewing area	12.71
	4) Presence of keeper in animal enclosure during the public viewing time	–44.38
Substrate in the enclosure	1) Sand/soil/sawdust on the floor in both indoor and outdoor enclosure	70.10
	2) Sand/soil/sawdust on the floor in outdoor enclosure and concrete floor in indoor enclosure	–19.36
	3) Concrete floor in both the indoor and outdoor enclosure, with no sand/soil/sawdust covering	–50.74
Enrichment provision	1) Enrichment in the enclosure with free access to wallows	43.42
	2) Enrichment in the enclosure without wallows	24.06
	3) No enrichment but wallows available	–8.34
	4) No enrichment and no wallows	–59.14
Diet type	1) Diverse food (forages and concentrate) two or more times per day	46.61
	2) Diverse food (forages and concentrate) with one feed per day	18.75
	3) Either concentrated food or forages, with two or more feeding times per day	–18.00
	4) Either concentrated food or forages with one feed per day	–47.36
Keeper knowledge and experience	1) Extensive experience and good knowledge of elephants	39.03
	2) Little experience but good theoretical knowledge of elephants	–10.54
	3) Extensive experience and little theoretical knowledge of elephants	27.13
	4) Little experience or theoretical knowledge of elephants	–55.61

each Level of Attribute. The initial page of the survey included instructions on how to complete the survey, the survey consent form and a brief explanation of the research project. A comment form was provided at the completion of the survey to record respondents' views and comments.

A pilot survey was conducted with 15 people who had had experience of the management and welfare of captive elephants. Following this, the survey was modified slightly. Potential respondents were sent emails containing information about the online survey, and an invitation was provided to complete the survey with a unique username. A reminder was sent two months after the initial email to all invitees to participate in the survey if they had not responded. We used the Windows-based software Sawtooth Software Market Research Tools® (SMRT 2011) on a laptop to offer the survey to respondents who did not have internet access, in particular mahouts/elephant keepers and veterinarians in India. The survey was approved by the University of Queensland Human Ethics Committee (Approval number 2007001739).

The first page of the survey introduced the questionnaire as 'Welfare assessment in captive Asian elephants through an on-line survey'. It described the organising centre, the respondents' rights and who to contact in the case of a complaint. The questionnaire had four sections.

Preference for Levels

The respondent rated each Level of the Attributes in terms of its desirability for elephant welfare using a seven-point scale.

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Importance of Levels within Attributes

The relative importance of each Attribute was determined from paired comparisons based on the learned preferences for the Levels within each Attribute from the previous section. Respondents were asked how important differences between paired Levels within Attributes were for them, using a seven-point scale. Some levels within specific Attributes were considered to be incompatible with other levels of different Attributes, and as a result nine Levels of selected Attributes were prohibited from appearing with certain other Levels of the Attributes in the survey to avoid conflicts of opinion in the discriminant process. As an example: the level 'No keeper contact method' in the attribute 'Keeper contact method' was prohibited from appearing with the level 'Exercised for 3–4 h and taken for rides/safari walks daily' of the attribute 'Exercise provision' as the two are incompatible.

Paired-comparison questions

This section used conjoint analysis to present the respondent with a series of paired-comparisons. In each question the respondent was shown two vignettes, each with two different Levels of the same two Attributes, and the respondents were asked for the strength of their preference for one or other vignette.

Expanded vignettes

The software composed a series of expanded vignettes, using those Attributes determined to be most important. These were chosen to occupy the entire range of Levels for the respondent from least important to very important. The respondent indicated their rating of each vignette using a numeric score from one to ten.

Statistical analysis

Only completed surveys were included in the analysis and a total of 37 partially completed or incomplete surveys were discarded. The SMRT Market Simulator estimated Utility and Importance Values, using the Attributes and Levels included in the conjoint analysis study. Utility Values were determined for each Level of each Attribute using the Simulator, which imported respondents' Level preferences into a hierarchical Bayes model using a Monte Carlo Markov chain algorithm. This used data from the population (means and covariances) to describe the preferences of individuals that had made a limited number of choices. The data were used to estimate the probability distribution of the parameters using conditional probability techniques at different levels (Gelman *et al* 1995). The data were normalised across respondents by zero-centring the Utility values within each Attribute so that the sum was equal to zero. Levels of an Attribute which a respondent rated highly were indicated by a positive Utility value, and those with a low rating, a negative value.

Importance Values were a measure of how much difference each Attribute made in the total score for each respondent. These were ratio data, so an Attribute with an Importance Value of 10% was twice as important as an Attribute with a value of 5%. They were based on the Utility value ranges obtained for each Attribute, and Importance Values for all respondents' Attributes added up to 100%. For example, if there were only three Attributes with ranges 40, 90 and 20 (total 150), the respective Attribute Importance Values would be 40/150 = 26.7%, 90/150 = 60.0% and 20/150 = 13.3%. Attribute Importance Values were relative to the other Attributes in the study, and can therefore be compared to one another (Orme 2002b).

The Importance Values and Utility values for each respondent were exported from the Sawtooth Software® programme into Minitab®. A General Linear Model was constructed which included stakeholder group, qualifications, educational level, sex, experience and age. It was used to calculate least square means and standard errors of Importance Values. Residuals were determined to be normally distributed by the Anderson-Darling test. Pairwise differences were determined by Student's *t*-test. Because of the risk of Type 1 errors, some correction for multiple comparisons was considered important. However, Bonferroni and other corrections are considered by many to be too stringent, increasing the risk of Type 2 errors (Perneger 1998). Therefore, the critical *P*-value was reduced from the usual 0.05 to 0.01 and a degree of flexibility of interpretation allowed.

A Principal Component Analysis without rotation was performed to aggregate respondents into groups by Importance Values using Eigen-values. A graphical description of relationships between Attributes (Armitage & Colton 1998) was depicted by a perceptual map of the stakeholders' Importance Values for Principal Components 1 and 2. This was followed by a linear discriminant analysis to identify the correlation between the original and correct classification of respondents within stakeholder groups by variation in Importance Values. A hierarchical cluster analysis was performed using Ward's weighted method to identify key groups within the 242 stakeholders who participated in the survey. This minimised the within-group sums of squares and was found to produce compact clusters.

Results

A total of 242 completed surveys were returned, representing an overall response rate of 14.9%. The proportional representation of the different stakeholder groups in the responses was as follows: elephant keepers/mahouts 27.6%, animal welfare organisation representatives 23.4%, scientists 18.9%, zoo/sanctuary directors or managers 15.7% and veterinarians 14.5%.

The majority of respondents were male (80%), and most respondents (68%) were aged between 20 and 40 years and had gained experience for between 5 and 30 years (Table 2). Most of the 8% of respondents who did not have any experience with captive elephants were in the animal welfare organisation representatives group. Nearly all respondents (84%) considered that they had moderate to extensive knowledge of elephants and their welfare, with the remainder being in the zoo/sanctuary director and managers category or animal welfare representatives. A total of 44% of respondents had formal qualifications and these were

Table 2 Respondent demographic characteristics (n = 242).

Demographic	Number of respondents (%)
Age (years)	
20–35	85 (35.0)
36–40	79 (32.6)
41–55	63 (26.0)
56–70	14 (5.8)
> 70	1 (0.4)
Gender	
Female	48 (19.8)
Male	194 (80.2)
Experience (years)	
1–5	58 (24.0)
6–10	86 (35.5)
11–15	42 (17.4)
16–20	17 (7.0)
21–30	13 (5.4)
> 30	6 (2.5)
No experience	20 (8.3)
Knowledge	
Extensive	104 (43)
Moderate	100 (41)
Little	38 (16)
Qualifications	
Bachelors	15 (6.2)
Diploma	13 (5.4)
Honours	21 (8.7)
Masters	56 (23.0)
PhD	50 (20.7)
No education/other education	87 (36)
Species experience	
Asian	163 (67.5)
African	2 (1)
Both species	52 (21.5)
Neither species	25 (10.0)

predominantly in the scientists, veterinarians and zoo/sanctuary directors and managers stakeholder groups. The remaining 36% of respondents without formal qualifications were mainly mahouts/keepers and animal welfare organisation. The 21% of respondents who had a PhD were mostly in the scientist group. Most respondents (68%) had experience with just Asian elephants, but 22% had experience with both Asian and African elephants.

Importance Value ranks

The mean Importance Value for each of the 15 Attributes ranged from 5.2 to 8.1, out of a maximum possible score of 10 (Table 3). Attributes were ranked in the following order: substrate in enclosure > group size > healthcare > enrichment > restraining the animal > enclosure type > exercise provision > enclosure size > interaction with handler/keeper > enclosure environment > keeper knowledge and experience > diet > keeper contact method > display duration > enclosure security. A MANOVA analysis of stakeholder effects on Attribute rankings showed overall significant differences between stakeholders (Wilks Lamda, $F = 3.96$, $P < 0.001$). 'Enclosure size' was considered more important by scientists and keepers than zoo director/managers and AWORs ($P < 0.001$). The importance of 'enclosure security' was rated very high by AWORs and low by scientists, with the other groups in between. 'Keeper contact method' tended to be ranked more highly by keepers than the other stakeholder groups, with the Utility values for the various Levels within the Keeper Contact Method attribute being 32.5, 31.0, 2.3 and –65.8 for free keeper contact, protected keeper contact, limited keeper contact and no keeper contact, respectively. 'Chaining' was ranked higher by scientists than zoo director/managers and keepers (both $P = 0.02$).

Respondent demographic characteristics and Importance Values

A higher level of education led to more importance being placed on group size, substrate in the enclosure and restraining the animal, and less on keeper contact method and keeper knowledge/experience (Table 4). Respondents with more captive elephant experience placed more importance on keeper contact method than respondents with less experience (Table 5). Those with extreme low or high levels of experience placed more importance on substrate in the enclosure. Female respondents rated substrate, group size, enrichment and exercise as more important compared with males, and they gave keeper knowledge, keeper contact method and enclosure security a lower rating relative to male respondents (Table 6). With regards to respondents' self-declared knowledge about elephants, respondents that said that they had little knowledge placed more importance on substrate and enrichment and less on exercise and keeper contact method (Table 7). There were no significant effects of respondent age on Importance Values.

Identification of different groups of respondents

Identification of the principal components of respondents' Importance Values produced seven components with Eigen-values in excess of 1, explaining 62% of the variation (Table 8). The first two principal components are illustrated in Figure 1. The y-axis represents all of the time-based Attributes, thereby relating to the elephants' time budget. The x-axis represents a variety of Attributes that include keeper-related ones on the negative end of the scale and foot health-related ones at the positive end of the scale. In combination they may represent management

https://doi.org/10.7120/09627286.23.1.011 Published online by Cambridge University Press

Table 3 Mean Importance Values of each Attribute for each stakeholder group.

Attributes	Veterinarian	Scientist	Elephant keeper	AWORs	Zoo director/manager	Weighted mean	SED	*P*-value
Substrate in enclosure	8.1	8.5	8.1	8.0	7.9	8.1	0.18	0.13
Group size	7.7	8.0	7.0	7.2	7.1	7.3	0.11	0.06
Healthcare	7.2	7.2	7.1	7.1	7.3	7.1	0.14	0.87
Enrichment	7.3	7.3	6.8	6.8	7.1	7.0	0.08	0.51
Restraining the animal	7.2	7.5	6.7	7.0	6.7	7.0	0.09	0.02
Enclosure type	7.4	6.8	6.9	6.1	7.2	7.0	0.09	0.07
Exercise provision	6.9	6.8	6.8	6.6	6.8	6.8	0.09	0.30
Enclosure size	6.7^{ab}	7.0^{a}	6.9^{a}	6.4^{b}	6.5^{b}	6.8	0.10	< 0.001
Interaction with handler/keeper	6.6	6.9	6.5	7.1	6.9	6.7	0.12	0.60
Enclosure environment	6.4	6.7	6.6	6.4	6.7	6.7	0.11	0.40
Keeper knowledge and experience	6.3	6.4	6.7	6.4	6.6	6.6	0.21	0.63
Diet	6.23	6.3	6.5	5.8	6.6	6.4	0.08	0.14
Keeper contact method	5.5^{b}	4.9^{c}	7.2^{a}	5.5^{b}	5.2^{bc}	6.1	0.10	0.02
Display duration	5.6	5.5	5.1	6.0	5.6	5.4	0.11	0.11
Enclosure security	5.0^{c}	4.3^{d}	5.3^{bc}	6.7^{a}	5.9^{b}	5.2	0.12	< 0.001

SED: Standard error of the difference between two means.
Mean Importance Values followed by the same superscript are not significantly different ($P > 0.01$) across rows.
AWOR: animal welfare organisation representative.

Table 4 The effects of stakeholder qualifications on mean Importance Values for each Attribute.

Attributes	PhD	Masters	Honours	Bachelors	Diploma	No education	SED	*P*-value
Substrate in enclosure	8.3^{a}	8.1^{b}	8.4^{a}	7.8^{c}	7.8^{c}	8.1^{b}	0.08	< 0.001
Group size	7.8^{a}	7.7^{a}	7.4^{b}	6.6^{d}	7.1^{c}	7.0^{c}	0.11	< 0.001
Healthcare	7.4	7.0	7.4	7.2	7.1	7.0	0.09	0.07
Enrichment	7.5	7.1	6.7	7.1	6.9	6.7	0.09	0.39
Enclosure type	7.1	7.0	6.9	7.0	6.7	7.0	0.10	0.04
Restraining the animal	7.2^{a}	7.1^{ab}	7.2^{ab}	7.0^{bc}	6.5^{d}	6.8^{c}	0.10	< 0.01
Exercise provision	7.0	6.8	6.7	6.6	7.1	6.7	0.08	0.04
Enclosure size	6.8	6.7	6.9	6.8	6.8	6.7	0.12	0.93
Interaction with handler/keeper	6.8	6.9	6.9	6.8	7.1	6.4	0.09	0.98
Enclosure environment	6.5	6.7	6.5	6.3	6.8	6.6	0.11	0.70
Keeper knowledge and experience	6.2^{c}	6.5^{bc}	6.3^{bc}	6.6^{ab}	6.4^{bc}	6.9^{a}	0.11	0.01
Diet	6.4	6.1	6.4	6.3	6.1	6.5	0.11	0.24
Keeper contact method	4.7^{d}	5.6^{c}	5.1^{d}	6.3^{b}	6.7^{b}	7.3^{a}	0.17	< 0.01
Display duration	5.7	5.5	5.7	5.5	5.5	5.1	0.15	0.67
Enclosure security	4.6	5.2	5.5	6.3	5.5	5.3	0.23	0.05

SED: Standard error of the difference between two means;
Mean Importance Values followed by the same superscript are not significantly different ($P > 0.01$) across rows.

Table 5 The effects of duration (years) of stakeholder experience on mean Importance Values for each Attribute.

Attributes	No experience	1–5	6–10	11–15	16–20	21–30	> 30	SED	*P*-value
Substrate in enclosure	8.3^{bc}	8.4^{ab}	8.1^{c}	7.9^{d}	7.8^{d}	8.0^{cd}	8.5^{a}	0.08	0.001
Group size	7.5	7.6	7.4	6.9	7.2	7.0	7.2	0.12	0.03
Healthcare	7.0	7.3	7.1	7.0	7.3	7.1	7.2	0.09	0.09
Enrichment	7.2	7.2	6.9	7.1	6.4	6.9	6.8	0.10	0.38
Restraining the animal	7.3	7.2	7.0	6.6	7.1	6.24	7.2	0.12	0.56
Enclosure type	6.9	7.1	7.0	7.0	6.9	6.6	6.9	0.10	0.62
Exercise provision	6.7	6.7	7.0	6.7	6.6	6.9	6.9	0.08	0.08
Enclosure size	6.8	6.8	6.7	6.8	6.8	6.7	6.3	0.12	0.82
Interaction with handler/keeper	6.7	6.9	6.7	6.6	6.5	6.7	6.4	0.09	0.95
Enclosure environment	6.7	6.3	6.7	6.8	6.9	6.4	6.6	0.11	0.43
Keeper knowledge and experience	6.3	6.4	6.7	6.5	6.8	7.0	6.7	0.12	0.02
Diet	6.1	6.2	6.4	6.7	6.0	6.1	6.4	0.11	0.08
Keeper contact method	5.1^{d}	5.6^{cd}	5.9^{c}	6.7^{b}	6.8^{b}	6.9^{b}	8.0^{a}	0.24	0.01
Display duration	5.6	5.45	5.4	5.3	5.4	5.4	3.8	0.15	0.16
Enclosure security	5.9	4.7	5.1	5.4	5.6	6.1	5.4	0.23	0.30

SED: Standard error of the difference between two means.
Mean Importance Values followed by the same superscript are not significantly different ($P > 0.01$) across rows.

Table 6 The effects of gender on mean Importance Values for each Attribute.

Attributes	Male	Female	SED	*P*-value
Substrate in enclosure	8.0	8.6	0.08	0.01
Group size	7.3	7.7	0.12	0.01
Healthcare	7.1	7.2	0.09	0.30
Enrichment	6.9	7.3	0.10	0.001
Restraining the animal	6.9	7.3	0.10	0.19
Enclosure type	7.0	6.8	0.10	0.52
Exercise provision	6.7	7.2	0.08	< 0.01
Enclosure size	6.7	6.8	0.12	0.18
Interaction with handler/keeper	6.7	6.9	0.09	0.62
Enclosure environment	6.5	6.8	0.11	0.13
Keeper knowledge and experience	6.7	6.1	0.11	0.01
Diet	6.3	6.3	0.11	0.22
Keeper contact method	6.5	4.7	0.22	0.01
Display duration	5.3	5.6	0.15	0.87
Enclosure security	5.4	4.7	0.24	0.001

SED: Standard error of the difference between two means.

of elephants' activity. The third component focuses on feeding and enrichment, and the fourth component on characteristics of the enclosure: type, size and thermal environment. The fifth and sixth component are difficult to discern and the seventh component concentrates on keeper: elephant interactions, with keeper knowledge, enrichment, enclosure type (providing opportunities for keepers to interact), and keeper contact method.

Overall, 142 out of 241 (59%) respondents could be placed in their correct stakeholder groups by linear discriminant analysis (Table 9). This proportion was highest for the keeper/mahout group (75%) and lowest for the veterinarian group (31%). Thus, most respondents were appropriately classified by our original stakeholder groups.

A cluster analysis using Euclidean distance and Ward linkage identified that there were three principal clusters of respondents, containing 57, 110 and 74 respondents. The first cluster placed relatively more importance on group size, substrate, enrichment, chaining, foot care and health and less importance on keeper contact method and protection from the public (Table 10). They comprised mainly the scientists and veterinarians (Table 11). The second cluster placed relatively more importance on keeper contact method, feeding and knowledge and less importance on display to the public (Table 10). This group comprised relatively more elephant keepers/mahouts (Table 11). The third cluster placed relatively more importance on protection from the public (Table 10) and comprised relatively more AWORs and zoo directors/managers (Table 11).

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Table 7 The effects of stakeholders' self-declared knowledge about elephants on mean Importance Values for each Attribute.

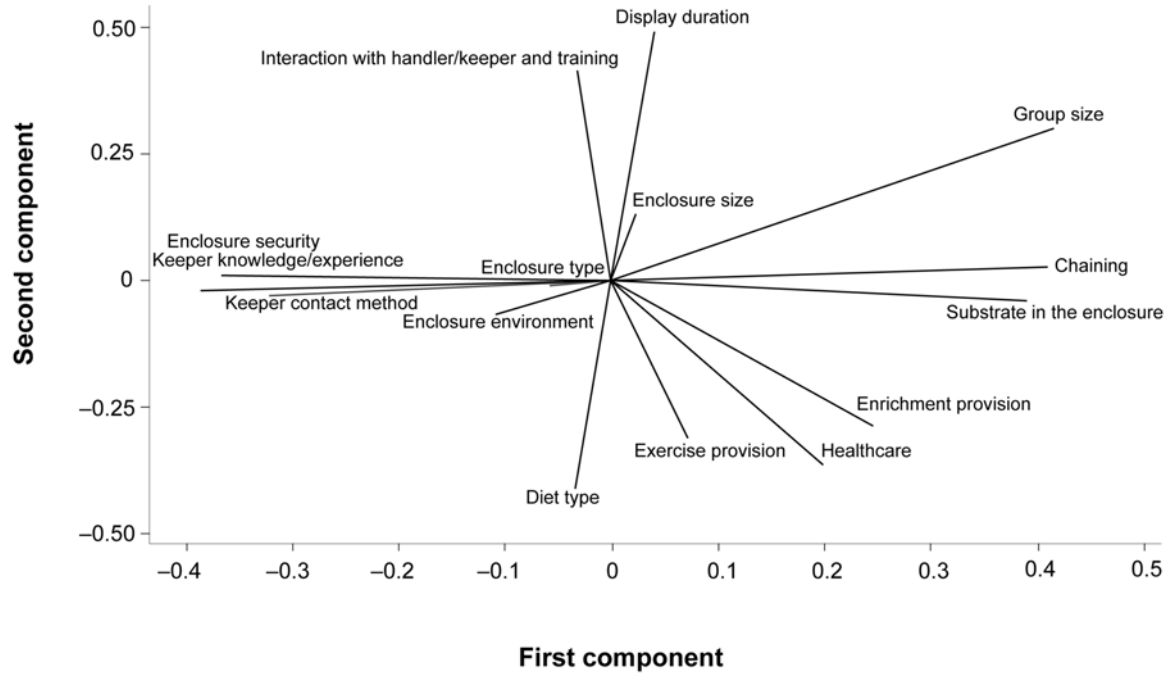
Attributes	Extensive	Moderate	Little	SED	*P*-value
Substrate in enclosure	8.1[b]	8.1[b]	8.5[a]	0.08	< 0.001
Group size	7.1	7.4	7.8	0.12	0.02
Healthcare	7.1	7.2	7.2	0.09	0.76
Enrichment	6.8[b]	7.1[a]	7.2[a]	0.10	0.01
Restraining the animal	6.8	7.0	7.5	0.10	0.06
Enclosure type	6.9	7.1	6.9	0.10	0.86
Exercise provision	6.7[b]	7.0[a]	6.5[c]	0.08	0.002
Enclosure size	6.8	6.7	6.9	0.12	0.66
Interaction with handler/keeper	6.6	6.8	7.1	0.09	0.89
Enclosure environment	6.6	6.5	6.7	0.11	0.27
Keeper knowledge and experience	6.5	6.7	6.4	0.12	0.02
Diet	6.5	6.2	6.2	0.11	0.35
Keeper contact method	7.0[a]	5.7[b]	4.7[c]	0.21	0.01
Display duration	5.2	5.5	5.7	0.15	0.13
Enclosure security	5.4	5.2	4.8	0.24	0.30

SED: Standard error of the difference between two means.
Mean Importance Values followed by the same superscript are not significantly different ($P > 0.01$) across rows.

Table 8 Principal components (PC, Eigen-value > 1) identified in respondents' Importance Values for individual Attributes.

Attributes	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Keeper contact method	–0.39	0.36	0.006	–0.20	0.13	0.13	0.32
Group size	0.46	0.12	0.21	0.10	–0.08	0.22	–0.02
Display duration	0.04	–0.56	0.20	0.13	–0.01	–0.36	0.02
Exercise provision	0.07	0.28	–0.22	0.24	–0.42	0.21	0.03
Interaction with handler/keeper	–0.03	–0.40	–0.06	0.11	–0.57	0.05	0.16
Healthcare	0.20	0.21	–0.09	–0.10	–0.08	–0.63	–0.22
Restraining the animal	0.40	0.16	0.22	–0.09	–0.02	0.17	–0.04
Enclosure type	–0.06	–0.15	–0.17	0.46	0.24	0.24	–0.47
Enclosure size	0.02	–0.41	0.06	–0.30	0.27	0.39	0.21
Enclosure environment	–0.11	0.00	0.17	–0.54	–0.36	–0.03	–0.18
Enclosure security	–0.36	0.13	0.27	0.36	0.16	–0.28	0.28
Substrate in enclosure	0.38	0.08	0.17	–0.07	0.38	–0.09	–0.04
Enrichment	0.23	0.06	–0.49	0.14	0.01	–0.02	0.37
Diet	–0.05	–0.11	–0.63	–0.31	0.19	–0.10	–0.18
Keeper knowledge and experience	–0.31	0.10	0.12	0.02	–0.06	0.16	–0.54
Eigen-value	2.1	1.4	1.3	1.2	1.1	1.1	1.1
Cumulative proportion of variance	0.14	0.23	0.32	0.40	0.47	0.55	0.62

Figure 1



Perceptual map of means for Attribute loadings. The x- and y-axes represent the two underlying dimensions that best characterise how respondents' differentiate between Attributes in Importance Values.

Table 9 Summary of stakeholder classification by original group and new grouping based on respondents' Importance Values.

	Original group				
	AWOR	**Director/Zoo manager**	**Elephant keeper/mahout**	**Scientist/Scientist**	**Veterinarian**
New group					
Animal welfare activist	15	7	12	4	9
Director/zoo manager	3	10	4	5	5
Elephant keeper/mahout	1	3	82	7	5
Scientist	2	2	4	23	8
Veterinarian	1	1	7	9	12
Total N	22	23	109	48	39
N correct	15	10	82	23	12
Proportion	0.68	0.44	0.75	0.48	0.31

AWOR: animal welfare organisation representative.

Discussion

As there have been no previous studies that included the ranking of important Attributes for the welfare of captive elephants, this study was conducted to establish a uniform ranking system of important Attributes which are perceived to be essential for better husbandry conditions and improvement in elephant welfare. The objectives of the Harris *et al* (2008) survey previously referred to were similar to ours: harnessing expert opinion to develop methods of welfare assessment and select variables for data collection during zoo visits. However, their survey used purely UK experts commenting on elephants in UK zoos, whereas our survey had a wider geographical base. Harris *et al* (2008) included an overall welfare score for each elephant which was constructed from different components of a questionnaire. In contrast to our inclusion of an Importance value for Attributes, they gave each component equal weighting in the final score and attempted to relate the scores to animal and

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environmental measures. Correlations with the final score were detected for space availability and group size. Group size was of high ranking importance in our survey, but space availability only of middle ranking. Many of the Attributes included in our survey were not included in the Harris *et al* (2008) survey, therefore direct comparison is not possible.

Approaching a wide variety of stakeholders was considered a necessity because of their diverse views on which issues are important for captive elephants. The high response rate from the elephant keepers and mahouts is likely to have been because requests sent to zoos were forwarded to keepers, as it pertained more directly to them, and personal approaches to the mahouts and keepers in sanctuaries and zoos in India would also elicit a positive response. Scientists produced the next highest return, probably because they were easily approached by email. Although the statistical analysis identified differences between groups of stakeholders, both the groups that we originally identified and the new groupings identified by similarity in responses, the uniformity of responses from respondents in different stakeholder groups was high. A simple comparison of the number of Attributes significantly affected demonstrates that both the respondents' qualifications and their gender had a greater effect on responses than stakeholder group. Respondents' knowledge and experience had rather less effect than stakeholder group, and age had no significant effect. Enrichment and substrate were more commonly advocated by those that thought that they had little knowledge about elephants, but we believe that a diversity of views is important and all stakeholders should be included in the outcome of the survey because a breadth of opinion is important. It is possible that they indicated that they had little knowledge because they had not worked with elephants, but this could also have brought an impartial viewpoint that should be respected.

Despite this, our analysis revealed that most respondents were correctly classified by stakeholder group, according to the variation in their responses. Most difficulty was experienced in classifying the veterinarian group, because of their diversity, whereas the keeper/mahout group was easier to identify and classify. Veterinarians are prominently involved in establishing national and international standards for the husbandry of captive animals, and the diversity of their views is likely to both add to the depth of debate on the most important Attributes but also gives some cause for concern due to low inter-rater consistency. The representativeness of the contributors to standards must be considered, and it should be noted that our population was male dominated and highly qualified academically, both of which were shown to influence Importance Values considerably. Women placed more importance on animal-related Attributes and less on keeper-animal interaction. Fortunately, neither experience with elephants nor knowledge about them had major influences on Importance Values but, where they did, the more experienced or knowledgeable view should prevail. This is relatively easy in a case, such as keeper contact method, in which the importance of the Attribute was directly related to the length of respondents' experience. However, in the case of substrate this was rated more highly by relatively inexperienced and the most experienced respondents. Such anomalies may only be explained by a larger survey that can identify interactions between variables, for example experience and stakeholder group. As knowledge increased, respondents rated the method of contact between elephant and keeper more highly, and the benefits of enrichment and a good substrate as less important. This recognises that the contact method, rather than the duration, is extremely important, and also demonstrated a depth of understanding of husbandry methods.

A simplified division into three, not five, groups emerged from our statistical analysis. This grouped scientists and

Table 10 Importance Values of the Attributes in the three clusters identified by Ward's cluster technique.

Attributes	Cluster 1	Cluster 2	Cluster 3
Handling	4.2	7.1	6.1
Group size	8.2	7.1	7.0
Display public	5.6	5.1	5.7
Exercise	7.1	6.7	6.6
Interaction handler	7.0	6.6	6.7
Foot care and health	7.5	7.1	6.9
Chaining	7.6	6.8	6.8
Enclosure type	7.0	7.1	6.8
Enclosure size	7.0	6.6	6.9
Thermal	6.7	6.6	6.5
Protect from public	3.9	4.8	6.9
Substrate	8.7	8.1	7.8
Enrichment	7.3	6.9	6.9
Feeding	6.1	6.7	5.9
Knowledge	6.1	6.8	6.5

Table 11 Allocation of respondents (and percentage of total respondents) in stakeholder groups to the three clusters identified by Ward's cluster technique.

Attributes	Clusters			
	1	2	3	All
AWOR	3 (1.2)	4 (1.7)	15 (6.2)	22 (9.1)
Director/zoo manager	5 (2.1)	7 (2.9)	11 (4.6)	23 (9.5)
Elephant keeper/mahout	5 (2.1)	76 (31.5)	28 (11.6)	109 (45.2)
Scientist	29 (12)	10 (4.1)	9 (3.7)	48 (19.9)
Veterinarian	15 (6.2)	13 (5.4)	11 (4.6)	39 (16.2)
All	57 (6.2)	110 (45.6)	74 (30.7)	241 (100)

AWOR: animal welfare organisation representative.

veterinarians together, focusing on the physical environment for the elephants and less on contact with keepers and the public. This combined group represents respondents with greater belief in welfare being regarded as how well an animal copes with its environment. The second group represented mainly keepers and mahouts, who focused on the keeper-animal interaction as key to the animals' welfare. The third group represented zoo directors/managers and AWORs, focusing more on interaction with the public. The alignment of AWORs with zoo directors/managers may stem from relatively little direct contact with elephants, but a shared common interest in their welfare and the views of the public about the welfare of the elephants. This interpretation of public attitudes is important to be included in the survey. Involvement of the public is not advocated because of their limited knowledge of welfare science issues concerning elephants. In compiling an elephant welfare index, the stakeholder groups that we originally identified could be given equal representation, but it has already been observed that the groups are not representative overall in terms of gender and academic qualifications.

We have observed previously that those involved in a particular aspect of a production process are more likely to rate it as more important (eg Pines *et al* 2007; Phillips *et al* 2009). For example, animal transporters rate the transport part of the overall livestock production process as more important for their welfare than those involved in other sectors. In relying on the opinions of those involved in the industry to identify the importance of each aspect, it is important to consider primarily the interests of the animals. A high level of concern among AWORs for the welfare of captive elephants in all current systems may have limited the scope of responses in the current survey. For example, some may have felt that enclosure size should be larger than the highest Level offered, 180–370 m^2 per animal, but as our survey was based on existing practices this option was not made available. The limited distance between Levels may have led them to downrate some important variables. However, our survey supports the incremental change that is likely to be the method of improving the welfare of captive elephants in zoos and sanctuaries.

The identification of substrate, chaining and healthcare as key Attributes alludes to respondents' recognition that bad foot condition is a major problem, affecting up to 50% of the captive elephant population (Mikota 1994). Foot problems in captive elephants are one of the most important health problems and the second highest cause of morbidity, with almost half of all the captive elephants experiencing foot problems at any point in their life (Schmidt 1986; Mikota *et al* 1994; Fowler 2001). The work of Harris *et al* (2008) also supports this, with 80% of 66 elephants surveyed in UK zoos having either one major foot problem or two minor foot problems during their study period. The predisposing factors for this condition are claimed to be enclosure substrate and the provision of exercise (Fowler 2001). Soft substrate floor, which would replicate the natural substrates like grass, soil and sand (AZA 2001), is recommended for the foot health of captive elephants (Fowler & Mikota 2006).

Stakeholder differences were confined mainly to enclosure size and security. The former was rated more important by scientists and keepers, who conceivably have the best understanding of the home range of elephants, whereas zoo director/managers and AWORs may have less knowledge in this area. Many animal welfare and veterinary scientists have insisted that a high level of experience and knowledge of keepers is essential for the evaluation of animal welfare (eg Wemelsfelder & Lawrence 2001; Whitham & Wielebnowski 2009). Evidence indicates that keepers are vital in assessing this as they are more familiar with animals' temperament, preferences and behaviour (Serpell & Hsu 2001; Morton 2007; Taylor & Mills 2007; Timmins *et al* 2007; Meagher 2009). Evidence from other species has demonstrated that the amount of time and quality of keeper interaction with felids (Mellen 1991; Wielebnowski *et al* 2002; Carlstead 2009) and increased social interaction with chimpanzees (*Pan troglodytes*) (Baker 2004) increases reproductive success and positive social behaviours.

Enclosure security, which is more a public protection issue, was rated very high by AWORs, probably the group most able to represent the public in their rating of importance of Attributes. Keeper contact method was rated very high by the zoo keepers/mahouts group. Training methods are a controversial issue for elephant experts, handlers and animal welfare groups (Buckley 2001; CAPS 2001; Poole 2001). This is due to the nature of the training techniques used, which tend to be based on traditional 'mahout-style' training methods, requiring dominance and the use of physical punishment by the handler (Fernando 1989; Koehl 2000). Zoo keepers and mahouts may have concerns about their safety when in contact with elephants. This has been acknowledged previously:

> ...the animal sees the keeper as a rival of the same sex and this leads to aggressive behaviour, or it sees in him a potential mate and this may present a danger to the keeper owing to importunate attempts to mate with him (Hediger 1970; p 83).

However, the high ranking of this Attribute by keepers was due to high ratings for the Levels that pertained to unrestricted keeper contact, ie free keeper contact (33) and protected keeper contact (31). Thus, keepers genuinely appeared to recognise the benefits of prolonged contact, with strongly negative values given for no keeper contact (–66) and an intermediate value to limited contact (2).

These results can be utilised to create an index of elephant welfare that can be adopted by individual zoos to benchmark their performance against other zoos, and introduce improvements in the most effective way. To achieve this, Utility Values and Importance Values should both be included and the following formula is proposed as the basis of a Captive Elephant Welfare Index. The production, validation and use of such an index in worldwide zoos will be described in a subsequent paper.

https://doi.org/10.7120/09627286.23.1.011 Published online by Cambridge University Press

$$CEWI = \sum_{i=1}^{15}\left(\frac{UV_i - Min_i}{Max_i - Min_i}\right)\frac{IS_i}{100}$$

Where:

$CEWI$ = Captive Elephant Welfare Index; UV_i = Individual Utility Value; Min_i = Minimum Utility Value; Max_i = Maximum Utility Value; and IS_i = Attribute Importance Score.

Animal welfare implications

The exploration of the major welfare issues for captive elephants can be used to inform the development of standards by providing the breadth of coverage that is necessary for effective monitoring of welfare. The identification of differences in Utility between Levels of the major issues can also inform the focus of the standards. From these results, a mathematical index that incorporates both the relative merits of each issue and Level is proposed, which could be used to rate the welfare of elephant enclosures in zoos and sanctuaries.

Conclusion

The stakeholders in captive elephant husbandry ranked the Attributes consistently in order of importance; however there were some individual stakeholder group differences in accordance with their professional preferences and experiences. Two key aspects recognised to be of major importance were keeper husbandry methods and the ability of the elephants to be active. Three principal groups of respondents were identified: the first being mainly scientists and veterinarians which focused more on elephants' conditions and less on interaction with the public; the second included mainly keepers, which focused on keeper contact method, feeding and knowledge of elephants; and the third included mainly animal welfare organisation representatives and zoo directors and focused on enclosure security. The diversity of views is considered important in using the results to formulate an index of elephant welfare in zoos.

Acknowledgements

We thank the respondents who participated in the survey, the experts who helped develop the Attributes for the survey, Mr Allan Lisle, faculty statistician, and Mr. Hung Vu, Information Technology services, the University of Queensland, Australia.

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https://doi.org/10.7120/09627286.23.1.011 Published online by Cambridge University Press