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Research article

Concepts, applications, uses and evaluation of environmental enrichment: Perceptions of zoo professionals

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Abstract

It is imperative that zoo-based Environmental Enrichment (EE) is underpinned by an evidence-based approach, yet research suggests considerable taxonomic bias in EE provision and a tendency for keepers to rely on food-based EE despite multiple EE categories being available. To better understand potential barriers to the dissemination of information on EE for underrepresented taxa and categories of EE, a workshop was run at the 19th BIAZA Research Conference in summer 2017. Six taxa (domestic species, non-parrot birds, small mammalian carnivores, reptiles/amphibians and fish/invertebrates) plus non-food-based EE were discussed by six focus groups who answered a standardised set of questions as part of a semi-structured interview. Deductive thematic analysis and Principal Component Analysis were applied to coded themes from the delegates' discourse. Results suggest that delegates were focused upon two underlying themes: measures of animal quality of life and the use or lack of information. Both themes were evidenced in the discourse of all focus groups for all five EE subject areas (EE concept and terminology; need for EE; barriers to EE; use of literature; evaluation of EE). Results suggest that zoo professionals have: i) a holistic view of animal welfare that relies on species' behavioural ecology to inform practice, ii) a multifactorial view on EE concepts, iii) an approach that sees EE as core husbandry but in practice a luxury due to barriers in implementing it and iv) an understanding that literature provides ideas for EE. Delegates note that effort to diversify provision is required and research into EE use can overcome barriers to implementation, determine an animal's need for EE and help measure the success of EE. Delegates discussed the lack of literature on EE across categories and taxa, supporting conclusions of previous published research in this area of husbandry. Further research on how EE can be used for underrepresented animal groups is required if zoo-based practice is to continue to progress.

Introduction

Environmental Enrichment (EE) is a well-known zoo husbandry tool involving the provision of inanimate objects, social agents (conspecifics or contraspecifics) or sensory material (e.g. scent trail or alarm-call playback) to encourage the performance of normal or natural behaviour patterns (Mellen and Sevenich MacPhee 2001). EE increases the biological relevance of an enclosure (Newberry 1995) and enhances the welfare of captive species (Melfi and Hosey 2011) by reducing performance of abnormal repetitive behaviour (Swaisgood and Shepherdson 2005). Targeted use of EE can enhance behavioural diversity in animals that are part of conservation programmes (Rabin 2003) and promote the educational relevance of zoo-housed species (Moss and Esson 2010). Finally, EE can encourage zoo animals to participate in their daily husbandry and management regimes (Melfi 2013).

Multiple EE classification systems are apparent in the literature (de Azevedo et al. 2007; Shepherdson et al. 1998; Young 2003) but the five-categories classification system (nutritional, physical, sensory, occupational and social) denoted by Bloomsmith et al. (1991) is commonly used when deciding what form of EE to provide to zoo-housed species. The categories of this classification system are not always mutually exclusive; one specific type of enrichment may be classified as several different categories affording the animal multiple ways of interacting with the EE. For example, a food puzzle where the animal must extract food from a plastic tube may provide nutritional, sensory, occupational and (indirectly) social enrichment.

In the UK, there is a legal requirement to provide "each animal with an environment well adapted to meet the physical, psychological and social needs of the species to which it belongs" ("Zoo Licensing Act" 1981), while industry

accreditation/membership organisations specifically require their members to provide EE. For example, the Standards for the Accommodation and Care of Animals in Zoos and Aquaria, published by EAZA (European Association of Zoos and Aquaria) documents an expectation that members will "provide appropriate environmental and behavioural enrichment" (EAZA 2014).

A preliminary analysis of 744 EE-themed scientific (peer-reviewed) papers showed that in 90% of cases enrichment was provided to mammals, particularly primates and carnivores (de Azevedo et al. 2007). A focus on laboratory animals was evident in the majority of studies reviewed by these authors, with zoo papers making up less than 10% of the research reviewed. A mismatch may occur between EE topics that appear in peer-reviewed literature and the zoo industry's wider philosophy, particularly as industry standards, like the aforementioned EAZA standards of animal care, expect every animal housed at a member zoo, regardless of how much is known about the species in the scientific press, to receive appropriate enrichment to meet its biological and psychological needs. This is certainly suggested when the scientific literature is compared to the "grey literature" (i.e. non-peer reviewed but read by practitioners), such as the Association of British & Irish Wild Animal Keepers (ABWAK)'s newsletter, RATEL (ABWAK 2018), where non-empirical articles that cover a wide range of taxa, and a diverse array of EE categories may be found. For example, the September 2017 edition of RATEL, discusses the application of psychological enrichment (crate training) with swamp wallaby (*Wallabia bicolor*) (Pengelly 2017). A Web of Science© search for "swamp wallaby" in September 2019 revealed 125 papers none of which focused on enrichment. Such "grey literature" may be read by zoo keepers more frequently than peer-reviewed articles as it is more accessible, does not need institutional subscription fees, and may be perceived as less intimidating; therefore, it is an important outlet for ideas for EE as well as practical applications not covered in scientific journals. Organisations, such as the Shape of Enrichment, encourage zoos globally to provide EE to all animals in their care (Shape of Enrichment 2013) and the international and regional conferences run by the Shape of Enrichment are excellent platforms for the explanation of EE techniques and practices to a wide audience. Potentially, de Azevedo et al. (2007) provides a reliable picture of the output on zoo-based EE research in the scientific literature because of the logistics of evaluating and publishing about EE in the zoo. Peer-reviewed papers may be skewed towards laboratories as this industry is more likely to have dedicated research staff with the resources to actively pose hypothesis-driven study and disseminate findings.

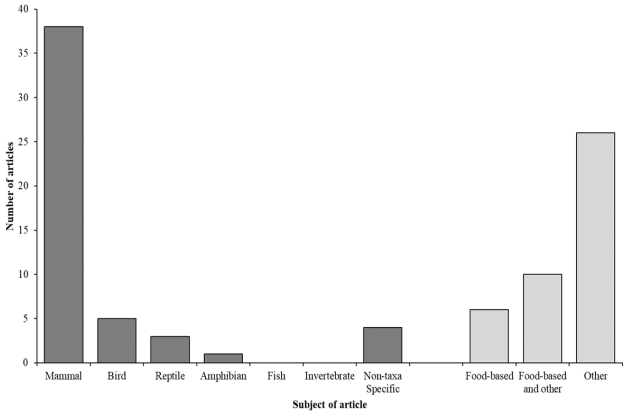

Figure 1. Number of articles relating to specific taxa (dark grey) and type of enrichment (light grey) published between 2013–2017 from a Web of Science search.

Evidence for a research need

Mimicking the methods employed by de Azevedo et al. (2007), a Web of Science© search for papers between 2013 and 2017 using the terms "environmental enrichment" and "zoo*" reveals the persistency of a mammal bias in published literature (Figure 1). For papers where the type of enrichment was stated in the abstract (food-based, food-based plus other form of EE, or other form of EE), nutritional enrichment was a principal factor in 38% of studies (n=16), and the four other forms of EE make up the remainder (n=26) of papers. This suggests further investigation into each "other" type of EE is needed to see how widely they are applied and to what taxa.

To increase the output of EE-focused research for taxa with few to no publications in Figure 1, capacity building within the zoo system is needed. Gathering together zoo staff who have the daily responsibility for species care can generate numerous ideas that can drive forward the design and implementation of EE. Such exchanges of information can increase understanding of enrichment for good welfare even in a commonly-enriched species such as primates (Melfi and Hosey 2011) as well as for species where the relevance of EE might not be immediately obvious, for example reptiles (Rose et al. 2016). Forms of husbandry or integral enclosure features maybe highly enriching to the inhabitants of the exhibit but not considered as such by zoo staff. Differences in opinion on what EE actually is may be responsible for the limited number of publications on non-mammalian taxa.

Aims

The yearly BIAZA research conferences (BIAZA 2018) aim to promote zoo science to a wide audience of zoo-based professionals and those with an interest in the field. These conferences are excellent events to gauge the opinion of people working in or with zoos (both scientists and zoo practitioners) on current areas of husbandry, management or zoo science. By running an EE-themed workshop at the BIAZA research conference held during the summer of 2017, the aim of this study was to determine how zoo professionals consider, across a range of taxonomic groups, EE (their concepts and terminology), barriers of EE implementation, the need for EE (and availability of information) and evaluation that EE has been successful. Implementation of non-food-based EE within the zoo was also reviewed, with specific consideration of cognitive enrichment, a specific form of psychological occupational enrichment designed to improve welfare by the provision of protracted cognitive challenge (Clark 2017; Riley 2018). By understanding what may limit EE from being implemented, as well as the factors that may cause knowledge or experience with EE to not be disseminated further, we hope to show where there is a need for EE to be utilised in specific areas of zoo animal husbandry.

Methods

Participants and data collection

Delegates attending the 19th annual BIAZA Research Conference, July 2017, selected to attend one focus group with a specific topic: enrichment of domestic animals in the zoo; enrichment of non-parrot birds; enrichment of reptiles and amphibians; enrichment of fish and invertebrates; enrichment of small mammalian carnivores; provision of non-food-based enrichment.

The self-selected sample formed a focus group for each topic comprising between six (Fish and Invertebrates group) and 25 (provision of non-food-based enrichment group) delegates, including two facilitators. Other demographics were not recorded but each group contained both academics and zoo practitioners. As part of a semi-structured interview the lead facilitator asked their respective focal group six standardised questions in order:

1. In practice, what does Environment Enrichment (EE) mean to you? Is it a luxury or essential practice? (As an extension to this question, focus groups also discussed if EE practices were reactive or routine.)
2. With reference to the focus taxa or type of EE, what barriers do you encounter which stop you from implementing EE?
3. In the past six months approximately how many articles (industry or peer-reviewed) have you read involving EE with the focus taxa/non-feeding enrichment? Include exact details such as the species focus, or where the article was published.
4. Please document how you know the focus taxa needs EE or how you know that non-feeding EE is needed?
5. If you have implemented taxa-specific EE or a type of non-food EE how did you evaluate its efficacy?
6. Please share examples of good practice in these taxa or for this type of EE. Good practice means specific EE design/ implementation, small-scale "study" where data were collected before and during/after implementation.

The lead facilitator was allowed to prompt, ask for reiteration, clarification and expansion of answers as they deemed necessary using the phraseology and language they considered appropriate. The lead facilitator also encouraged all members of the focus group to contribute an answer but were also permitted to curtail a line of discussion when they considered sufficient information had been gathered. The workshop session lasted a maximum of 90 minutes. The second facilitator acted as a scribe recording, on a standardised answer sheet, the discourse of the focus group (key words and phrases agreed with the group and individual responses). Discourse was not recorded verbatim. Verbal feedback was provided by each lead facilitator to all delegates once they had reconvened in the main lecture theatre following a short break.

Participants were informed, at the start of the conference in the welcome statement from the workshop organisers and again at the start of the workshop itself at this BIAZA conference, that the information provided would be used in a scientific publication. BIAZA workshops are commonly used to gather information for a specific chapter in the Zoo Research Handbook or similar style of document. Participation in the workshop was voluntary and delegates were given the choice to attend whatever focus group they liked. Delegates had a sign-up sheet to allocate themselves to a group however no names or personal details were collected during the workshop and all data were anonymised.

Qualitative analysis and coding

The authors collated all answer sheets from lead facilitators within two months of the conference, after information had been word processed. Data from questions 1-5 were analysed and evaluated in this paper, therefore information on the following five subjects was analysed:

1) Concepts and terminology of EE
2) Barriers to EE
3) Availability of EE information
4) Indicators of EE success
5) Evaluation of the outcomes and efficacy of EE

Subjects 1, 2, 4 and 5 were analysed using deductive thematic analysis (Joffe 2011). Each author independently coded all transcripts. A standardised process was followed whereby each author read a focus group's transcript in its entirety once. Then the same transcript was read up to a further three times by the author to highlight and group together key words to create a code or theme. If needed, themes were then subsequently grouped into major, secondary and (for Subjects 1 and 2) minor themes depending upon the number of times they were discussed and the focus of discussion. Each focus group's transcript was coded in turn. Once the initial coding was complete, the two authors discussed and agreed upon all major, secondary and minor themes. Triangulation with a naïve third person was not necessary as agreement between authors was always reached. A thematic dendrogram, showing the relationship between minor (where relevant), secondary and major themes, was drawn for each subject.

Quantitative analysis

For all subjects, once themes had been coded, responses were coded for each focus group as 1 (yes, theme discussed) or 0 (no, theme not discussed) for each secondary theme, which was considered the most meaningful level of coding given the delegates discourse. The total number of responses (one per focus group) coded yes for a secondary theme was calculated. In addition, for Subject 1, each focus group was classified according to if the majority of the group agreed EE was a luxury or essential activity, and if EE was reactive or routine. For Subject 3, the total number of EE articles read per focus group was categorised as 'Limited' (≤5) or 'Some' (>5–<10) and the focus of the articles was classified as 'Yes' (mainly zoo-based), 'Mainly farm/lab papers', or 'Mixture of lab-based with some zoo'.

For Subjects 2, 4 and 5, data were analysed in Minitab v. 18 and a Principal Component Analysis (PCA) was run independently for each subject using secondary themes to identify variables that are more likely to impact on the use of EE. Variables were sorted in order of highest to lowest number of responses for that variable. Only Principal Components (PCs) with eigenvalues of above 1 were considered as reliable. For barriers to EE and for indicators for EE use, the first four PCs explain 88% of the variation in these data. For evaluation of EE the first four PCs explain 97% of the variation in these data.

For evaluation of EE, as all participants noted that changes to animal activity budgets or space utilisation was used as a means of evaluation this variable was not included in the PCA as it became a constant.

For Subject 1, EE Concept and Terminology a PCA was deemed unhelpful due to the vast divergence of answers across the focus groups. Some groups answered only the specific questions while others explored the nuances in EE definitions, many times a single person put forward a single point and if included in the PCA analysis this seemed unrepresentative of the entire group's views.

Results

The delegates had divergent views on EE concepts and terminology (Subject 1) with five major themes coded: Importance; Affect; Diversity; Limitations; Implementations (Figure 2). The diversity of concept was clear: EE is not simply classified on type, zoo practitioners and researchers primarily classify according to importance – the significance of EE to husbandry and management, and anticipated affect. Delegates consider EE both a remedy for existing welfare and health problems and a preventative measure to safeguard welfare. The wider concept of EE considers the specific types of EE and species needs but the limitations to implementing EE are also an important theme discussed by delegates with reference to what EE is. The Importance of EE typically received the most discussion as each focus group discussed whether EE is a luxury activity or an essential husbandry practice. Table 1 shows that groups differed in how they considered EE as part of zoo animal husbandry. Whilst the 'essential' importance of EE was

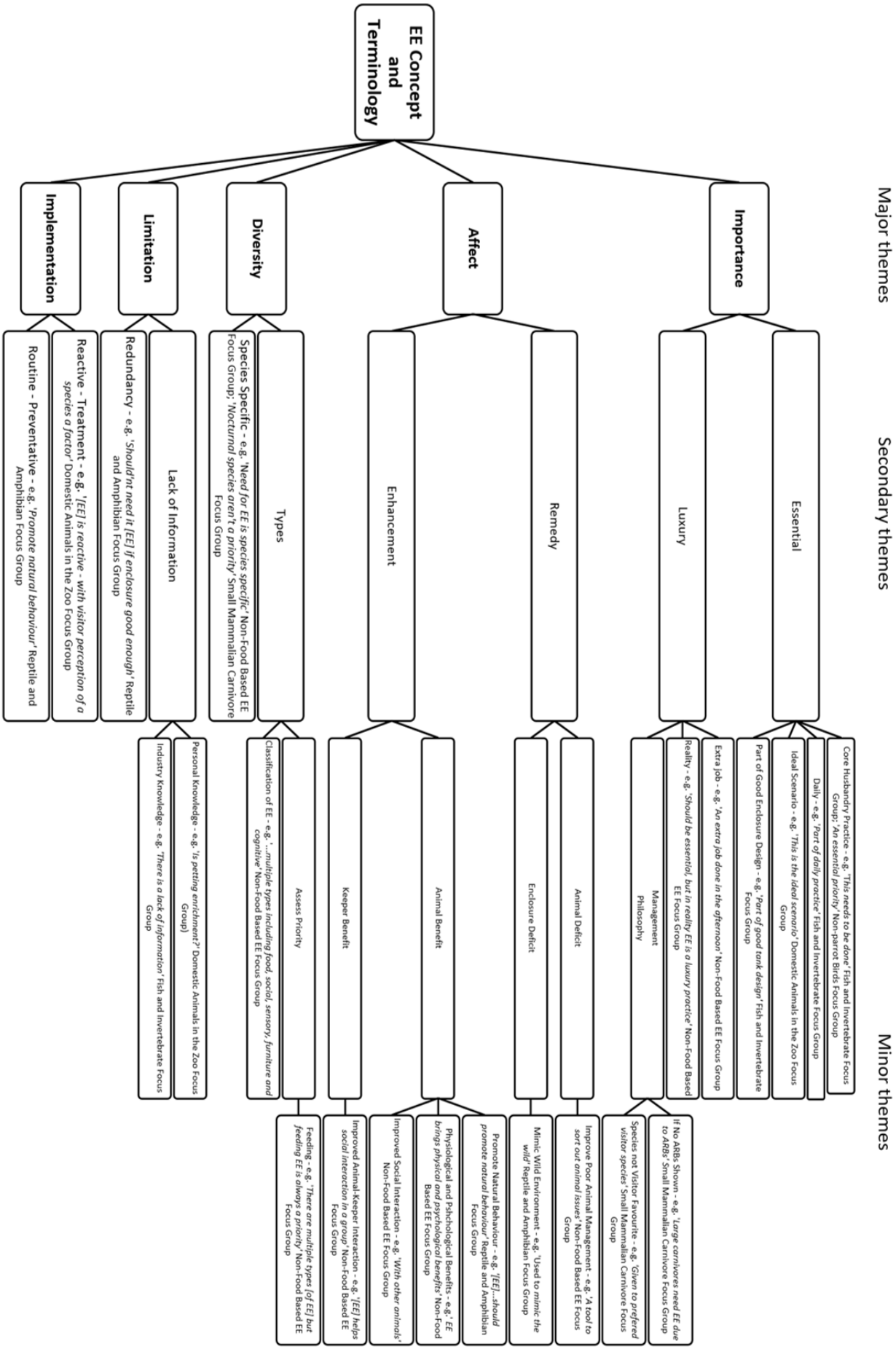

Figure 2. Environmental Enrichment (EE) concept and terminology according to delegate focus groups. Major, secondary and minor themes are shown.

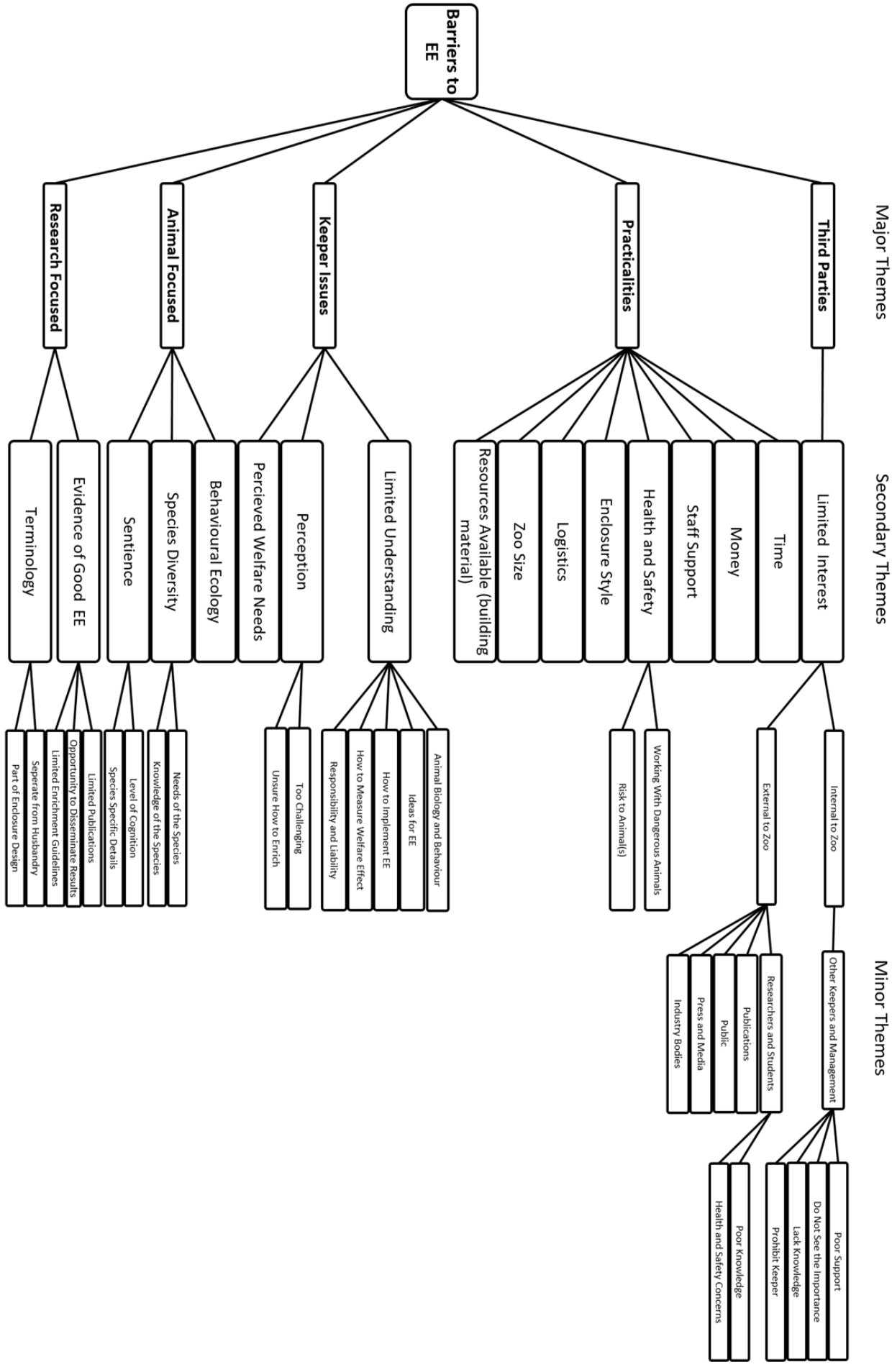

Figure 3. Barriers to Environmental Enrichment (EE) according to delegate focus groups. Major, secondary and minor themes are shown.

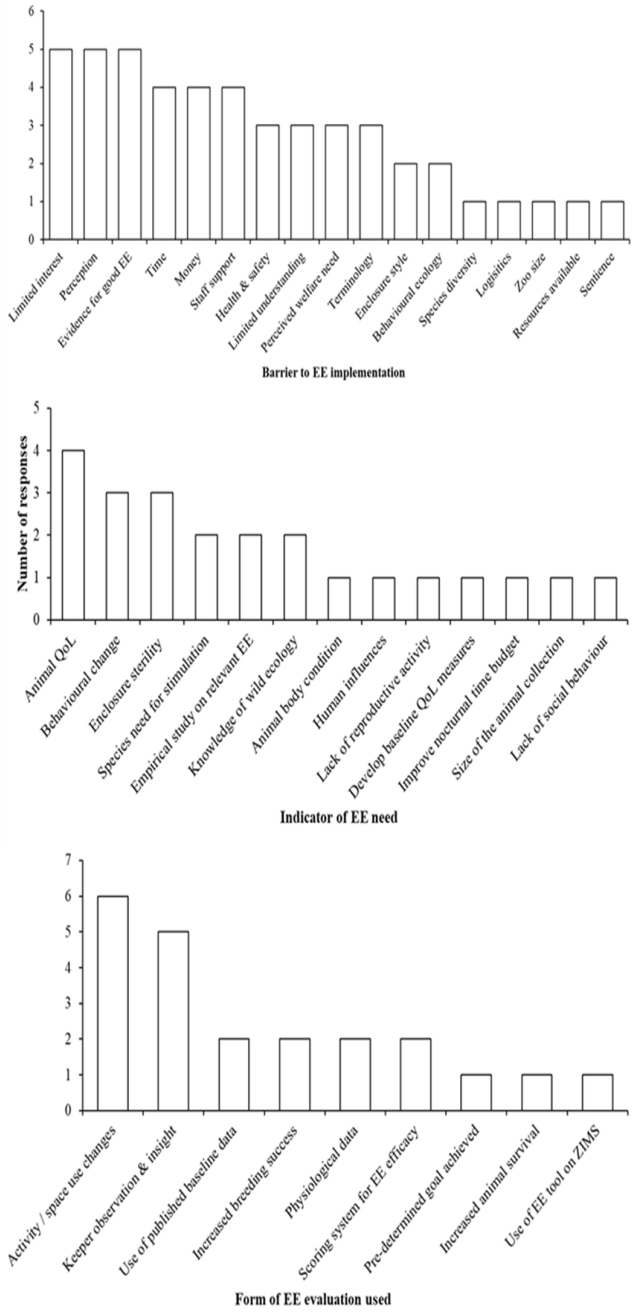

Figure 4. Barriers to EE usage (top), indicators for EE need (middle), and ways of evaluating EE efficacy (bottom) in these scenarios as reported from the focus groups.

noted by all focus groups, many commented that in reality it was a luxury undertaken when time was available. Groups were split 50-50 on how they considered EE to be used (routine or reactive). The Small Mammalian Carnivores focus group stated that whilst EE for small carnivorous mammals tended to be luxury it was done routinely when time was available and not solely when an animal welfare problem was identified (e.g. to remedy the performance of abnormal repetitive behaviour).

Table 1 also shows the results for Subject 3. No focus group had read more than 10 relevant journal articles and most (four out of five) had read fewer than five relevant journal articles. When deciding on a type of EE to implement for a specific type of animal, either zoo professionals do not consider peer-reviewed journal articles, or it can evidently be difficult to find or access information in the peer-reviewed literature that has shown whether the EE was effective for the particular taxa and whether EE has been evaluated for that taxa. Only for non-food EE were several example papers, from across multiple taxa (and for other, more "popular to enrich" species) mentioned and described by delegates.

Barriers to EE (Subject 2) was classified into five major themes: Third Parties; Practicalities; Keeper Issues; Animal Focused; Research Focused. Major themes were comprised of 17 secondary themes (Figure 3). It is clear that zoo practitioners feel constrained not by a lack of motivation or personal interest but by a lack of institutional support and interest from the wider community. This was particularly evident for the Non-Food-Based Enrichment focus group who commented that food enrichment was widely considered a priority while cognitive enrichment was given no priority at all by others inside the zoo making the justification for working on enrichment other than feed enrichment difficult, especially given the extensive list of Practicalities. The delegates also described a lack of information from general behavioural ecology to husbandry guidelines and peer-reviewed research leading to a lack of ideas how to enrich the animals. Figure 4 shows that five from the six focus groups discussed lack of interest from others, and their own perception of EE characterised by a lack of ability or knowledge.

Delegates described Animal Centric, Species Centric and Other Focus themes when discussing how they know there is a need for EE (Subject 4), with 13 secondary themes also identified (Figure 5). Most of the focus groups discussed Animal Quality of Life measures and Behavioural Changes as key indicators of a need for EE as well as Enclosure Sterility (Figure 4). The measures used to evaluate EE (Subject 5) echo the animal focused indicators of the need for EE as Specific Animal Responses was the first major theme categorised (Figure 6). All six focus groups discussed changes in Animal Activity or Space Use (Figure 4) giving specific examples in a range of taxa from otters to snakes. In addition to a range of animal-focused indicators (both physiological and behavioural) delegates also discussed a range of Wider Focus indicators including Keeper Observations and Insight, Scoring Schemes of EE Efficacy, Use of Published Baseline Data, and Use of EE Tools on ZIMS (Zoological Information Management System).

The PCA outputs (Figure 7 and) reveal a central theme (reliance on published information) in the first Principal Component identified for barriers to EE, indicators of the need for EE and evaluation of EE. This manifests as limited evidence for the best type of EE (PC1 for barriers to EE), the need for empirical evidence and baseline information (PC1s for the need for EE and evaluation of EE). When assessing barriers to EE (Table 2), a lack of published information is an important theme along with lack of other resources, while for indicators of the need for EE published information on effective use of specific EE is as important as information on wild ecology and information from the animal being enriched (changes in behaviour). For evaluation of EE, published information is as important as key measures of animal welfare, breeding success and survival. The second Principal Component for evaluation of EE is also focused on published information on baseline data and physiology of the species, while PC2 for indicators of the need for EE is specifically focused on species and animal needs and for barrier to EE PC2 focuses on the influences of the wider zoo community, both within the zoo and beyond.

Table 1. Perception of EE from participants in each focus group.

Theme	Is EE luxury or essential?	Is EE reactive or routine?	Is recent* literature available when making decisions about EE use in this scenario?	Of recent literature found, are there zoo-focused papers available?
Domestic Animals in the Zoo	Luxury	Reactive	Limited (<5)	Mainly farm/lab papers
Non-parrot Birds	Essential	Routine	Limited (<5)	Yes
Reptiles and Amphibians	Luxury	Reactive	Limited (<5)	Yes
Fish and Invertebrates	Essential	Routine	Limited (<5)	Mixture of lab-based with some zoo
Small Mammalian Carnivores	Luxury	Reactive	Limited (<5)	Yes
Non-Food-Based EE	Luxury	Routine	Some (>5 - <10)	Yes

Discussion

Results collectively suggest that zoo practitioners and researchers consider the concept of EE as multifactorial and fundamental to good husbandry. This concept includes the diversity of EE types and the use of EE to treat or prevent poor welfare; however, there was almost universal acknowledgement of how difficult EE is to achieve in routine practice due to lack of support, resource or information. Barriers to EE underpin the zoo practitioner's concept of EE. Delegates were aware of the need for EE by considering animal-focused indicators like behaviour and body condition score or because they had read about the need in a specific species or situation. Delegates evaluate the use of EE via animal indicators like breeding success and longevity or relying on published baseline or physiological data. Overall, when discussing EE, delegates were focused upon two underlying themes: Animal quality of life measures and use or lack of information.

Measures of a good quality of life (consideration of positive welfare indicators and a life worth living) are established in the literature (Mellor 2016) but are rarely applied in the real world where validated methodologies for investigating indicators of poor welfare are most frequently used. Welfare has long been considered multifactorial and individual to an animal (Broom 1986; Broom and Fraser 2007; Fraser 2009; Webster et al. 2004) and delegates show a clear understanding of this (Figure 5). Given the usefulness of targeted EE to upholding higher welfare states of zoo animals—and how it can make a keeper's experiences more positive too (Carlstead et al., 2019)—and how including species-specific EE can increase the quality of life for difficult-to-cater-for species (Yon et al. 2019) more consideration of the relevance of EE across an animal's life stages and at different temporal or seasonal times could reduce negative states that may be caused by specific management conditions. A lack of space at night, for example, that may result in frustration or boredom can be rectified by species EE practices. Knowledge of behavioural ecology can be used in EE planning to determine the best form of EE for such occurrences. For example, research that documents increases in activity, foraging and pool use of flamingos (Phoenicopteridae) in the early morning and over-night (Rose et al. 2018) is vital information for planning EE interventions for when birds need to be confined inside due to bad weather or disease outbreaks.

Multiple physiological and behavioural indicators of welfare are noted (Broom 1996) but more modern research on sentience and emotion require psychological indicators to also be considered (Mellor and Beausoleil 2015). Delegates considered breeding success alongside happiness, and mortality alongside abnormal behaviour (Figures 2 and 5) when discussing the concept and need for EE. Therefore delegates discuss welfare in relation to EE within the context of the Quality of Life model (Mellor 2016) and the Core Affect model of emotions (Mendl et al. 2010). This suggests that zoo practitioners and researchers consider EE and welfare holistically.

Increasing the capacity in zoo staff to create positive welfare situations within the zoo is an essential requirement if overall quality of life in zoo animals is to improve (Melfi and Hosey 2011). Delegates were able to identify that zoo husbandry becomes evidence-based, as per Melfi (2009), when management practices consider key aspects of a species' ecology and evolution. Both

Table 2. Amount of variation explained by the first two PCs for barriers to EE, indicators of EE need and evaluation of EE.

Barriers to EE	Indicators of Need for EE	Evaluation of EE
PC1	PC1	PC1
Time: 37%	Wild ecology: 39%	Breeding success: 44%
Money: 37%	Change in behaviour: 28%	Increased animal survival: 30%
Limited evidence for EE: 34%	Empirical evidence on EE use: 28%	Published baseline data/physiological data: 29%
PC2	PC2	PC2
Lack of interest: 50%	Species' need to be stimulated: 51%	Keeper insight: 49%
Health and safety: 25%	Developing nocturnal activity: 38%	Published baseline data: 48%
Perceived welfare need: 25%	Developing social behaviour: 21%	Physiological data: 48%

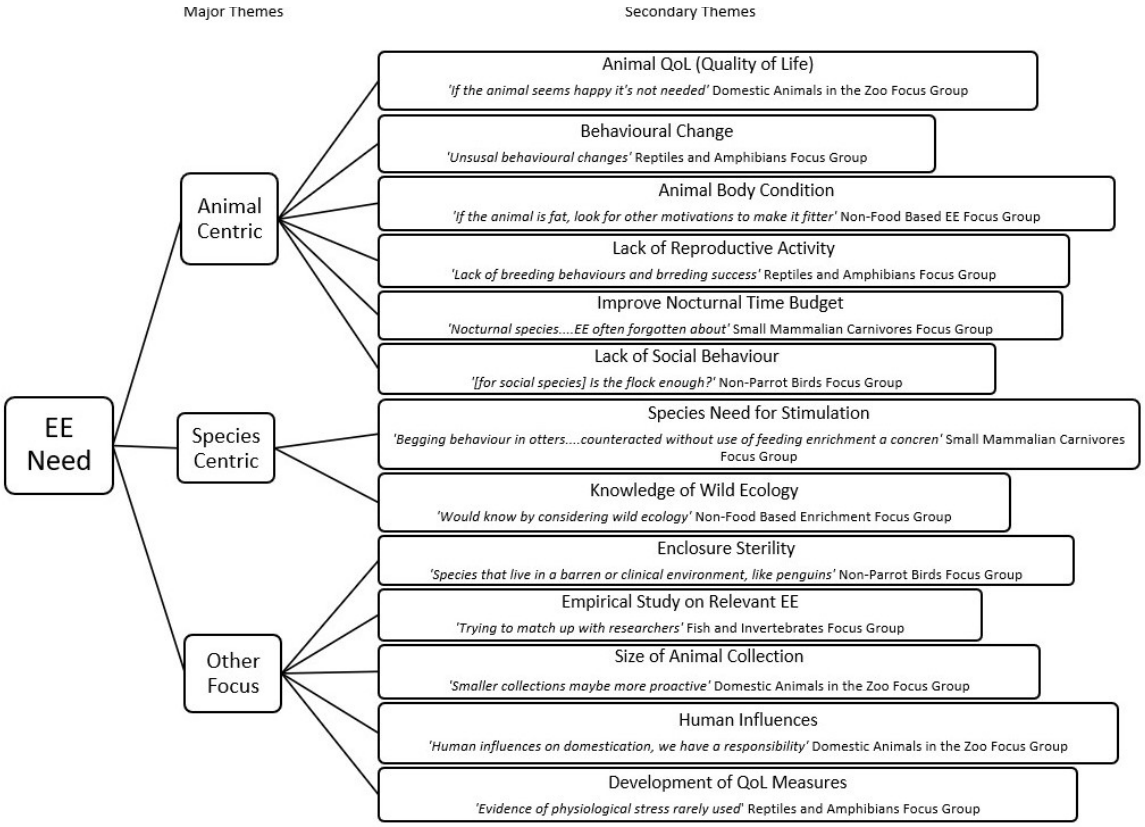

Figure 5. The Indicators that Environmental Enrichment (EE) is needed according to delegate focus groups. Only major and secondary themes are shown for ease of understanding.

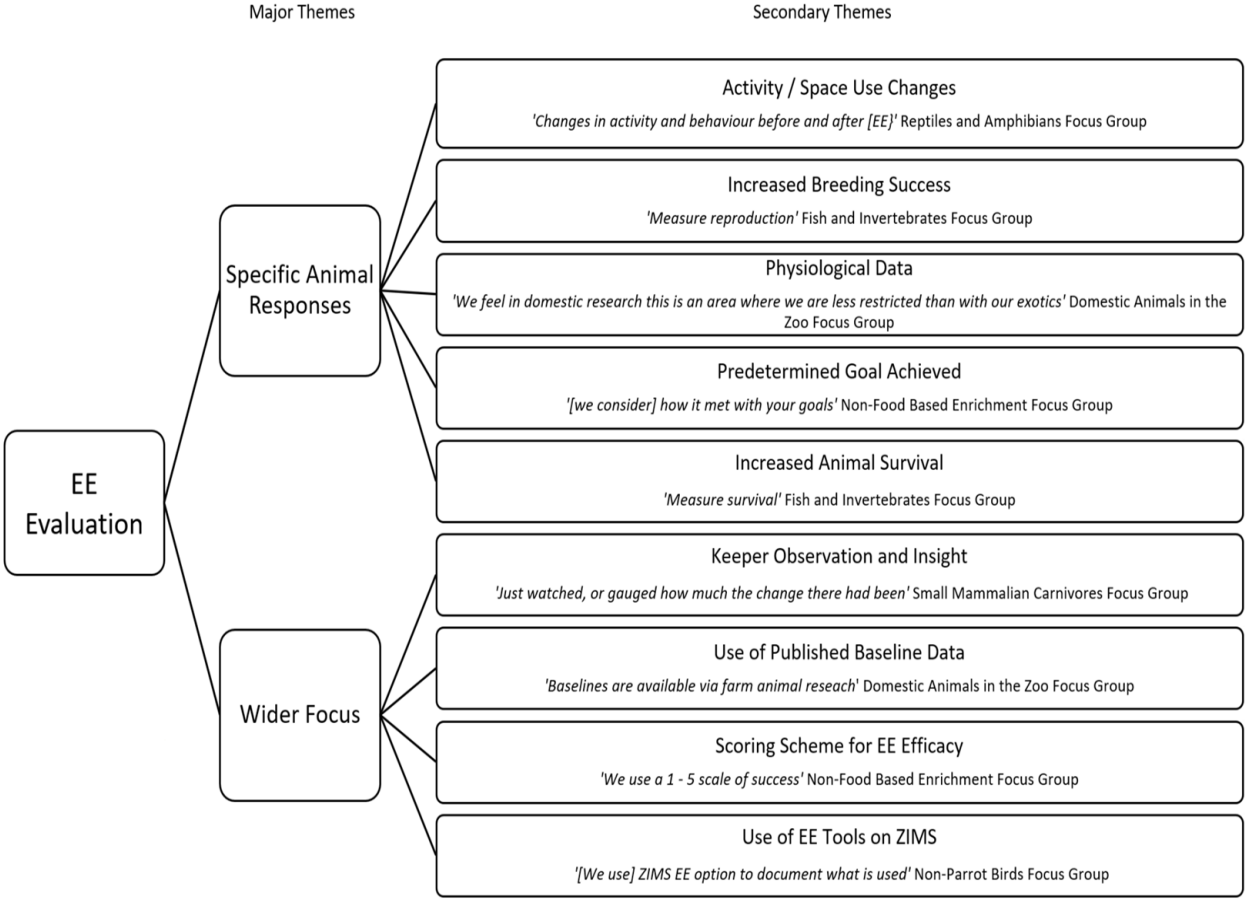

Figure 6. Measures of Environmental Enrichment (EE) evaluation according to delegate focus groups. Only major and secondary themes are shown for ease of understanding.

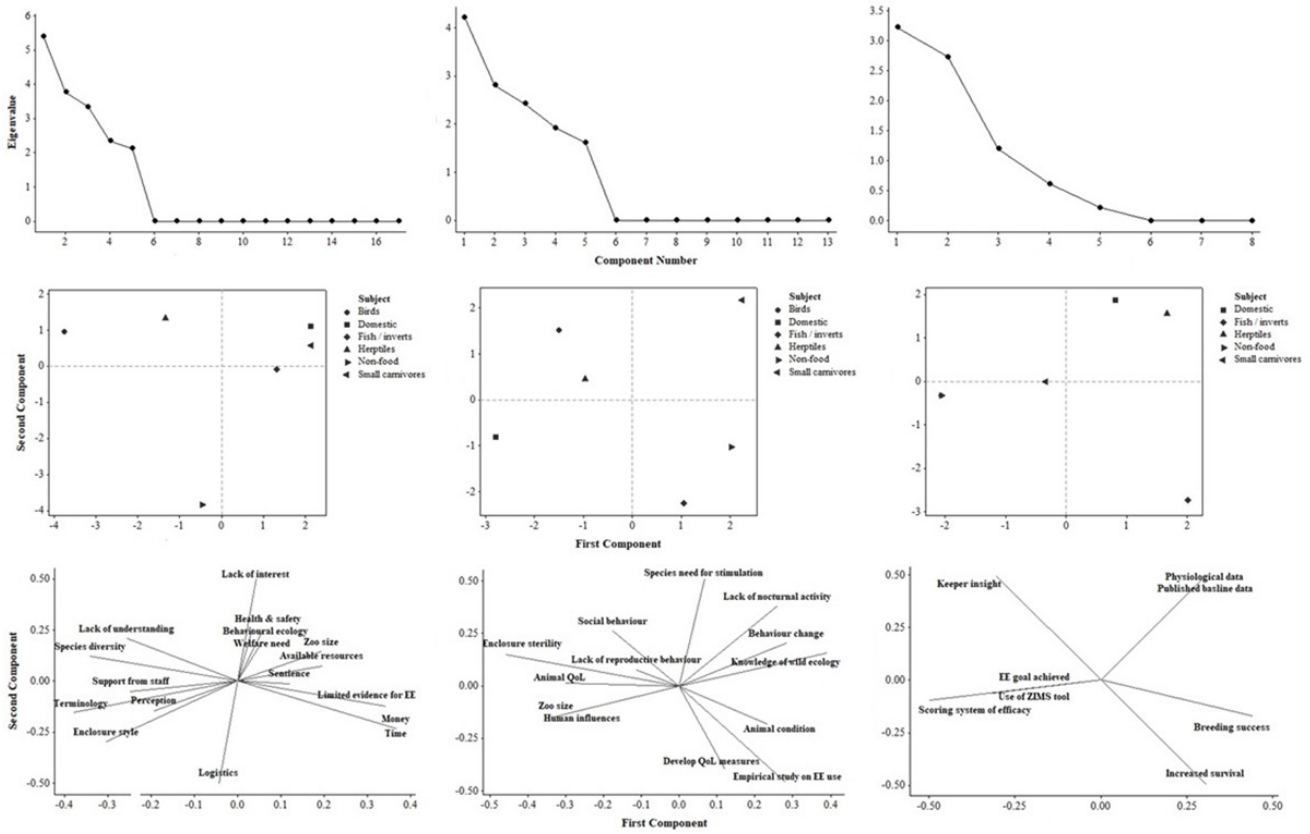

Figure 7. Output from PCA for three subjects. Barriers to EE (left), implementation of EE (middle) and evaluation of EE (right). Scree plots (top line) show the influence of the first component for barriers and implementation, and the first and second components for evaluation. Score plots (middle line) show the grouping of subjects with similar influences of the first and second components. The first two components are not calculated for birds in the evaluation score plot. Loading plots (bottom line) highlight the similarity between variables for these six themes (those themes that are grouped closely in the same section of the graph.

Clubb and Mason (2007) and Rose (2018) advocate the use of behavioural ecology to inform welfare practices, and delegates clearly consider ecology, biology and behaviour as part of the EE concept, to identify the need for EE and to evaluate the success of EE. The loading plot for "indication of EE need" (Figure 7) shows that species' need for stimulation, knowledge of wild ecology and promoting positive behaviour change (both during the day and during the night) are all positively associated. Given this and the discourse of delegates it appears zoo professionals are evidence-based regarding their concept of EE, understanding the need for EE and evaluation of EE, as they consider the species and individual animal's behaviour, physiology and psychology. Delegates substantiate this with knowledge gleamed from scholarly research.

For all five subjects considered, the focus groups discussed the use of or need for literature. Table 2 shows zoo professionals are clearly looking towards the published literature in their efforts to identify and research relevant EE, how to implement the EE, and the importance of published baseline data and physiological data on positive welfare states (and therefore EE evaluation). As Figures 2, 3, 5 and 6 demonstrate delegates feel there is an overall lack of literature to inform practice—this was voiced most strongly in the Fish and Invertebrate focus group who stated how difficult it was to find information on any relevant taxa in a zoo setting. The delegates discourse on evaluation of EE shows that zoo science is able to make a difference in the perception of EE in the zoo as use of wild and/or previous data can help benchmark against what they currently see their animals doing, and what they want to see their animals doing.

Increasing the amount of scientific research published on zoo EE may help promote how to provide EE to a wider range of captive wild species. Several delegates noted that, for species such as birds and herptiles, where EE may not have an immediate response from an animal that is good for marketing, EE is prioritised to species that can provide better opportunities for good zoo public relations. Increasing research into wild behavioural ecology of zoo-housed species, which can then drive EE plans that promote interesting or unusual behaviour could help showcase more species using EE to the general public and to zoo visitors. Even for mammals, research shows that enrichment is not always implemented if it is time and resource costly (Hoy et al. 2010); findings echoed by the discourse of the Small Mammalian Carnivores and Non-Food-Based EE focus groups. Sharing good practice (particularly of EE types/design, implementation and evaluation) through dissemination of ideas and data in peer-reviewed journals may help zoo professionals develop more effective EE and convince uninterested individuals in the wider zoo community (noted in EE concepts) that EE is vital for the welfare of all taxa.

The current research supports the findings of de Azevedo et al. (2007)—many taxa are underrepresented in the EE literature

and the body of literature with specific zoo EE focus is small or poorly accessible. The perception of enrichment on various online media, such as the results of a Google© Images search for "zoo environmental enrichment" (accessed 11th March 2018) highlights the bias towards large, charismatic mammalian species and feeding enrichment. Whilst this is purely anecdotal evidence, it demonstrates the narrow field of enrichment that is presented to people outside of the zoo (and the wider zoo community inside the zoo) who may be searching for this topic online, and therefore provides a skewed and incorrect view of the breadth of good practice that keepers are engaged in and substantiates the findings de Azevedo et al. (2007). In the decade since this research the perceptions of zoo professionals suggest the evidence gap persists just as it did then.

Whilst the current study represents one case study, conducted at one zoo-themed conference, these results show that more work is needed to promote EE within the zoo for species that may be less likely candidates for EE and to promote non-food-based EE. The lack of published information may be a barrier to the implementation and evaluation of EE in species with more fastidious or technical husbandry regimes. Increasing the output of EE analysis and evaluation into the zoo-based literature could increase the confidence that zoo staff have in the use and relevance of EE to certain "hard-to-enrich" species (that may not be enriched due to perceived difficulties in delivering appropriate EE in a given managed environment).

Conclusions

1. Zoo professionals have an evidence-based concept of EE which recognises its importance as a husbandry tool whilst considering limitations, mostly concerning implementation (e.g. time and money). A holistic and "modern" (evidence-based) understanding of welfare is also apparent.
2. Zoo professionals consider the use of literature or are aware of a lack of evidence concerning the concept of EE, barriers to its use, the need for EE across taxa and its evaluation. More zoo biologists should analyse, evaluate and publish information on EE across species to build this bank of available information.
3. Zoo professionals are aware of the importance of EE use in species that may be over-looked as candidates for EE in the zoo but can identify barriers that restrict the wider use of EE in these situations.
4. Non-food EE is not a forgotten subject, with some representation in the scientific literature. In industry food-based EE appears to be frequently used but practitioners are aware of the need to focus on all five types of EE (remembering they are not mutually exclusive).
5. The creation and usage of EE on a species-specific level should be undertaken with knowledge of that species' behavioural ecology and behavioural needs.
6. The logistics of carrying out EE for all species in the zoo can limit its application, and misconceptions about the welfare needed of certain taxa influence whether EE is used with all species: EE can become a luxury though zoo professionals recognise it is essential husbandry.

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