

There Are Big Gaps in Our Knowledge, and Thus Approach, to Zoo Animal Welfare: A Case for Evidence-Based Zoo Animal Management

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There are gaps in knowledge that hinder our ability within zoos to provide good animal welfare. This does not mean that zoos cannot or do not provide good welfare, only that currently this goal is hindered. Three reasons for these gaps are identified as: (1) there is an emphasis on the identification and monitoring of indicators that represent poor welfare and it is assumed that an absence of poor welfare equates to good welfare. This assumption is overly simplistic and potentially erroneous; (2) our understanding of how housing and husbandry (H&H) affects animals is limited to a small set of variables determined mostly by our anthropogenic sensitivities. Thus, we place more value on captive environmental variables like space and companionship, ignoring other factors that may have a greater impact on welfare, like climate; (3) finally, whether intentional or not, our knowledge and efforts to improve zoo animal welfare are biased to very few taxa. Most attention has been focused on mammals, notably primates, large cats, bears, and elephants, to the exclusion of the other numerous species about which very little is known. Unfortunately, the extent to which these gaps limit our ability to provide zoo animals with good welfare is exacerbated by our over reliance on using myth and tradition to determine zoo animal management. I suggest that we can fill these gaps in our knowledge and improve our ability to provide zoo animals with good welfare through the adoption of an evidence-based zoo animal management framework. This approach uses evidence gathered from different sources as a basis for making any management decisions,

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as good quality evidence increases the likelihood that these decisions result in good zoo animal welfare. *Zoo Biol* 28:574–588, 2009. © 2009 Wiley-Liss, Inc.

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WE'RE NOT ASKING THE RIGHT QUESTIONS

Problems associated with poor welfare in zoo animals have been noted since the earliest zoological collections were established. For example, high levels of mortality were recorded in early animal collections, such as the London menagerie [Kisling, 2000]. This is not surprising given the specialist and diverse needs of the many exotic animals housed in zoos. Hediger [1950] was one of the first to highlight that the needs of exotic animals might not be met by the zoo environment provided. This was pioneering work at a time when the study of animal welfare as a science was still relatively new. Developments in animal welfare science have been biased toward the agricultural industry and much of the data collected have been used to guide zoo animal welfare initiatives. Our knowledge and approach to zoo animal welfare has thus been founded on resolving issues not necessarily applicable to our industry, namely, attempting to mitigate insults to animal welfare resulting from ever increasing intensification in production. Nevertheless, regardless of the different goals of the two industries, much can be learnt from generalizing principles founded within agricultural animal welfare to the study of zoo animal welfare. However, there remain gaps in our knowledge of zoo animal welfare that need to be identified so that they can be filled and the welfare of zoo animals enhanced. So what gaps exist?

Gap: We Do Not Know What Great Welfare Is Because We Tend to Emphasize Only the Avoidance of Poor Welfare

Animal welfare science has been largely based upon the identification, validation, and then monitoring of indices that represent poor welfare. This approach underlies our attitude toward animal welfare; in general, animal welfare is only considered (studied or monitored) if signs of poor welfare are evident. In zoo animal welfare, the most frequently used indicators of poor welfare are behavior, health, and physiological measures. Behavioral indicators of poor welfare include: self-injurious behavior [e.g. Hosey and Skyner, 2007]; stereotypical behavior [e.g. Mason and Latham, 2004]; self-directed displacement [e.g. Maestriperi, 2003]; and deviations from “wild type” behavior in captive animals, for instance, the absence of specific behaviors, noncongruent activity budgets, or behavioral restriction [reviewed by Hosey et al., 2009]. Health indicators of poor welfare include reduced longevity and/or fecundity [e.g. Clubb and Mason, 2002; Clubb et al., 2009] and higher than expected prevalence or frequency of disease or parasite burdens. The most frequently used physiological measure of welfare is hypothalamic-pituitary-adrenal axis activity, which is usually monitored through noninvasive assessment of cortisol or corticosterone and its metabolites [reviewed by Wasser et al., 2000]. These welfare indices, adopted after the study of welfare in agricultural animals, are correlated with production performance. Intensive farming is associated with compromised welfare and production, as such improved welfare, determined through reducing or eliminating these negative welfare indices, often results in improved animal production performance [Gregory, 1998]. It makes sense, therefore,

to use these indices to monitor zoo animal welfare. Their usefulness is limited, however, as zoos have different and additional goals for their animals. For example, zoo animals are expected to live a full life and, as this is not true of most agricultural animals, data are not available about the welfare implications of geriatric issues. Most zoos also manage their animals, to ensure behavioral and genetic integrity are preserved so they will be good candidates for conservation schemes. But little is known about the impact of these measures on welfare. Because the goals for zoo and agricultural animals are different, it is likely that we could and should be using additional or different indices to monitor the welfare of zoo animals; alternatives are suggested below.

Currently, when zoo animals exhibit indicators of poor welfare, remediable steps are taken to modify the animal's environment in an attempt to reduce or eliminate these indices. This approach to zoo animal welfare is limited for a number of reasons. First, there is a prerequisite that indices representing poor welfare are known, which is not true for many exotic species. The majority of welfare indicators are validated in domestic species and the generalization of these to exotic may not be reliable. The "welfare by analogy" concept suggests that knowledge of welfare in one species can be used to inform us about the welfare of related species [Sandøe and Simonsen, 1992; Sherwin, 2001]. The concept assumes that closely related species will have similar needs, for instance, animals that share similar psychological or physiological function, and/or have evolved and adapted to similar ecological pressures. Unfortunately, many of the species held in zoos are not closely related to the domestic species upon which welfare indicators have been validated. Second, this approach is based on an overly simplistic assumption that an absence or reduction in indicators of poor welfare equates to good welfare [Boissy et al., 2007]. The welfare of an animal can be experienced along a continuum (Fig. 1) and a reduction in indicators of poor welfare may improve welfare; for example, from bad to satisfactory but not necessarily result in animals with good welfare. Third, this approach recognizes compromised welfare on the basis that indicators of poor welfare are visible but, unfortunately, many exotic species do not seem to display these. The expression of poor welfare indicators would simply not evolve unless they conveyed a selective advantage. For many exotic species, the expression of poor welfare indicators would be deleterious as it would communicate that the animal was somehow compromised and thus likely to fall victim to predation or be an unsuitable mate. Finally, many frequently used indicators of poor welfare take time to develop and as such welfare can be compromised for some time until these indicators are recognized.

Solution: Consider and Act to Ensure That Animals' Needs Are Met and They Experience Positive Welfare in Captivity

We could use indicators of positive welfare to monitor and interpret zoo animal welfare. Unfortunately, few attempts have been made to identify and validate indicators of positive animal welfare regardless of the industry the animals are



Fig. 1. Animal welfare can be viewed and judged along a continuum, with the extremes representing great and extremely poor welfare. These states are associated, respectively, with animals that are thriving in their environment or may die because they are no longer able to cope.

associated with. Boissy et al. [2007], have suggested that positive welfare is “primarily the presence of positive experiences such as pleasure”. According to this definition, positive welfare is a measure of the animals’ perception of their condition. Whether they have a positive or a negative “opinion” of their situation, requires us to measure animals’ emotions. Consideration of emotions in animal welfare science has been neglected or avoided for some time, as emotions are more difficult to identify and quantify than measures of the animal’s ability to function or the degree to which species specific behaviors are affected [Hosey et al., 2009]. Boissy et al.’s [2007] review suggests that emotions can be monitored by measuring the animal’s cognitive bias, and this has been supported by physiological data. These measures help us determine whether animals view the world positively or negatively and provide an insight into their emotions.

Given that the study of positive welfare indicators is relatively new, there is little scientific evidence on which to initiate implementation of zoo animal management regimes using this approach. I would like to suggest that a positive approach to zoo animal welfare can still be achieved and should include two components. The first is to identify the needs of zoo animals and ensure zoo animal management protocols are designed to accommodate these (discussed below, “asking them what they want”). The second component is to identify animals that are thriving in zoos and replicate the conditions they are kept under to manage their conspecifics in zoos. A zoo animal can be considered as thriving if it expresses positive welfare indices, such as those described by Boissy et al. [2007], and/or has its needs met by the animal management routine. Evidence of animals’ needs being met could be gained by providing animals with “what they want” (as determined from preference tests, etc.) or from using welfare indices. As previously described, indices representative of poor welfare have some shortcomings; however, it is also possible to look for indicators of good welfare, such as adequate growth of neonates. The replication of “positive” animal management regimes is a “top-down” approach to animal welfare. It considers the impact that a combination of environmental factors has on welfare. The “bottom-up” approach of making management changes after the recognition of negative welfare indices, and until these are reduced or eliminated, considers the impact of single factors individually. This latter approach is ineffective as changes are made by trial and error, and so the first change or last of many may lead to the desired goal.

Indirect measures, such as those above, which consider whether animals’ needs that are met are useful and can be combined with direct measures of animal needs to develop a proactive approach to welfare. We can measure the needs of animals through observation and experimentation. Yeates and Main [2008] suggested that asking animals “what they like or want” provides a good indication of their mental state and their motivation, both of which are necessary if we are to consider positive welfare. By determining an animals’ emotional state and motivation, we can then determine what their needs are and work to ensure the zoo animal management regime is designed to satisfy these needs. Determining the needs of animals can be achieved in a variety of ways, including: (1) wild captive comparisons; (2) preference testing; and (3) strength of motivation tests (termed behavioral economics).

Replication of wild conditions and the stimulation of wild-type behaviors and biology in zoo housed animals has been a long-held goal for many zoos [Hediger, 1950]. The idea that “wild is best” makes intuitive sense, as animals have evolved to

live in “wild conditions” and expression of “wild” behaviors is associated with positive affective experiences [Spinka, 2006]. Furthermore, animals who deviate from “wild” behaviors may develop abnormal behaviors in their place [Chamove, 1988] or are considered to be behaviorally restricted [Redshaw and Mallinson, 1991]. Therefore, if given the correct surroundings and enabled to live “wild” but within captivity, then surely animal welfare would be optimal? But, there are concerns about the reliability and validity of comparisons made between wild and captive conspecifics [Veasey et al., 1996a,b] and whether, indeed, a dichotomy between these situations exists [Carlstead, 1996; Hosey, 2005]. Wild animals’ have certainly adapted to selection pressures present in the wild. However, it is highly unlikely that we would consider animals that are diseased, in pain, starving, or competing on a daily basis just to survive to represent those with optimal welfare; so using “wild” as a template for good zoo welfare management seems erroneous! There is no doubt that some facets of the “wild is best” assumption do hold true, and some “wild” conditions and/or behaviors may represent good welfare. But there are many wild animals on the cusp of survival and, therefore, probably suffering from very poor welfare. We need to know better how to apply knowledge gained from wild animals to captive animal management (see Wells in this issue).

Experiments can be set-up that attempt to “ask the animal” what they want from their environment. The most simplistic way this can be achieved is by offering animals a choice between simultaneously presented resources [Duncan, 2005]; such scenarios have been provided to a multitude of species, to assess which types of food, flooring substrates, enrichment items, and other resources they prefer [e.g. Ogden et al., 1993]. These data can provide information about the animals’ priorities, and potentially how they may change over time, with experience or in different circumstances [Duncan, 1978]. However, care is required when designing preference tests and interpreting the results, as the value of the results is determined by the number and appropriateness of the resources offered [Fraser and Matthews, 1997]. For example, if an animal is offered two resources but would in fact much prefer a third missing resource, its preference has not been fully realized. There are logistical limitations to the number of resources that can be offered to an animal simultaneously; that is why measuring the strength of an animals’ motivation can be useful.

Through a series of elegant experiments, it can be established “how hard an animal is willing to work” for a resource. In these experiments, “work” is equated to the strength of motivation the animal has for the resource, that is, how much they want it. So, an animal is expected to work harder for a resource they really want, and thus it is possible to determine a hierarchy of their needs according to their apparent motivation for different resources [Mason et al., 1998]. This technique, unlike standard preference testing, uses a standardized unit to measure the animals work and, as such, results can be compared across different experiments. There are a variety of ways in which we can measure how hard animals are willing to “work”. For example, we can measure whether animals will: learn a new behavior; expend energy to overcome an obstacle, such as push a door or climb a slope; or endure something aversive. These types of studies have identified what resources animals “really want” in their environment; for example, mink will work for access to swimming opportunities [Mason et al., 2001] and dormice will push against a door that weighs more than their body weight to gain access to a piece of apple (personal observation).

Solution: Provide for a Luxurious Life Not Just Survival

Another result from adopting a “negative” approach to animal welfare is the creation of minimum standards, which could better be translated as “could do better!” The “gold standard” within animal welfare is the five freedoms that represent a widely acknowledged set of minimum standards, and when adhered to are considered to ensure that welfare is not compromised [Webster, 1994]; animals should be free from (1) hunger and thirst; (2) discomfort; (3) pain, injury, or disease; (4) fear and distress; and they should be free to (5) express natural behavior [FAWC, 1979]. Within the zoo industry, more specific minimum standards and recommendations for best practice are set at an international level [e.g. the World Zoo and Aquarium Conservation Strategy, WAZA, 2005] and at regional or national levels [e.g. Secretary of States Standards for Modern Zoo Practice, DEFRA, 2004]. Often standards are created for particular species as H&H guidelines. Minimum standards are restrictive because they generally aim to ensure that animal welfare is satisfactory, and once in place, it is difficult to motivate the implementation of conditions that are over and above these requirements and ensure great animal welfare. It is recognized that in many situations, minimum standards limit growth and development within a field. In part, this is because minimum standards usually aim to be inclusive of the industry they are set up to serve and goals are created that all members can achieve, that is, H&H guidelines often consider the current animal management regimes used as acceptable, despite the fact that some are suboptimal. Standards that are more helpful would require organizations to demonstrate improvements and those that complied would either provide animals with a brilliant life rather than just a satisfactory one or be actively moving toward this goal.

So how do we go beyond the minimum requirements? Koene and Duncan [2001] suggested that we should aim to provide zoo animals with a luxurious life, not one in which they simply survive. This is, in essence, another argument for considering positive animal welfare and spinning the concept of minimum standards around and instead attempt to provide conditions in which zoo animals thrive rather than just survive. This is a challenge that can be better achieved with a greater appreciation of the impact of H&H on zoo animal welfare. Understanding the impact of captive environmental factors on zoo animal welfare, providing animals with conditions that meet their needs, and promoting the use and expression of positive welfare indicators will take us a long way to meeting the goal of providing zoo animals with a luxurious environment.

Gap: Current Housing and Husbandry Practice Is Based Largely on Promulgation of Myth and Tradition

A review of national and regional zoo association H&H guidelines found that most recommendations for best practice are based on “current” practice and not supported by empirical evidence [Melfi et al., 2007]. This means that much housing and many animal management regimes are based upon tradition; practices that have been implemented previously, but not necessarily systematically, tested for their efficacy. This approach follows the “if it ain’t broke, don’t fix it” principal, whereby the impact of H&H is only investigated if problems arise; problems are usually determined using indices of poor welfare and, therefore, may fail to recognize the “true” impact of H&H (as discussed above). This principal can “weed” out methods of H&H that are

associated with highly deleterious impacts, that is, very poor welfare, such as fatalities. But, it can be difficult to determine which element of H&H is the cause of detrimental welfare, as there are so many variables included in most H&H systems. For example, systematic evaluation of the impact of H&H variables on the behavior of Sulawesi crested black macaques, *Macaca nigra*, has shown that different captive environmental variables affect individuals differently and impact can also be affected by different combinations of variables [Melfi, 2001]. Without empirical study it is hard to truly understand the impact of much H&H on the welfare of the incumbent animals.

It is a concern that H&H practices, which have not been monitored systematically for their impact on zoo animal welfare, are perpetuated within the zoo community. But, because they have been implemented for some years and adopted by several zoos, it becomes generally accepted that they are “tried and tested” methods and become part of zoo tradition. Furthermore, there is an expectation that elements of H&H that are implemented frequently and by different zoos have a benign effect, and so their impact on welfare is not questioned and studies of their impact on welfare not initiated. Interestingly, when the impact of H&H is studied it is rarely found to have a benign impact on welfare. Some conditions are good, some are bad. It is, maybe, a ubiquitous retort of all scientists “that more research is necessary,” but to have a greater appreciation of the impact of H&H on animal welfare this is certainly the case. However, I would argue that we need to start redirecting our research directions to better appreciate how captive H&H affect the welfare of a broad spectrum of species.

The majority of the studies carried out on H&H seem to be heavily biased by anthropogenic views of which species are considered to be in greatest need (see taxa bias below) and which conditions are considered by humans to be either necessary for animals to thrive or to be detrimental to welfare. Consequently, studies concentrate on the animals’ structural, social, and visual environment; notably, many studies investigate the effect of enclosure size [e.g. Alexander and Roth, 1971; Elton and Anderson, 1977; Waal de, 1989; Shepherdson et al., 2004], enrichment [having something to do, e.g. Burghardt et al., 1996; Azevedo et al., 2007], the impact of rearing [e.g. Abello and Colell, 2006; Martin, 2002, 2005], and visitors [e.g. Hosey and Druck, 1987]. There appears to be surprisingly few empirical studies into the effect of routine husbandry procedures [exceptions include: review of potential zoo stressors, Morgan and Tromberg, 2007; husbandry training, Melfi and Thomas, 2005; climate, Rees, 2004] or the animals’ environment as perceived through nonvisual modalities, such as, olfactory, auditory, electromagnetic, and, sadly, most nonmammal species [exceptions include: Clark and King, 2008].

Solution: Systematically Evaluate the Impact of Captive H&H and Aim to Consider the Animal’s Perspective

An alternative to using myth and tradition as the foundation for zoo animal management is to use the results from systematic empirical studies that evaluate the impact of H&H on zoo animals and their welfare; this is the foundation of evidence-based frameworks that are described fully below. It is of particular value to evaluate the impact of many H&H variables acting simultaneously on animals [e.g. Carlstead et al., 1999, 2005; Montaudouin and Pape, 2004, 2005]. Efforts should also be made to consider the world from the animals’ perspective. It is likely that for highly social species, reduced risk of injury and enhanced health are probably no compensation

for being maintained on their own. Similarly, being unable to see or hear or smell the environment in the same way as many of the animals we maintain does not mean that these factors have less of an effect on their lives and welfare than factors more obvious to us, like enclosure size or fixtures. It follows that again we should be asking animals what they want and doing what we can to provide for these needs.

Gap: Very Little Is Known About the Biology of Many Species and What Is Known Is Generalized Across Species

As has been acknowledged in previous sections of this article, an appreciation of animal welfare requires a full understanding of the animals' needs in order to determine whether the variety of captive conditions currently being provided meet their needs. This is a huge task that is not going to be satisfied if research interests continue in their current direction. A review of zoo research, undertaken in British and Irish Association of Zoos and Aquariums (BIAZA) member zoos since 1998, demonstrates that the majority of studies undertaken are on just a few species (Table 1 and Fig. 2); there is a distinct lack of research being undertaken on certain taxa, notably all nonmammals! These data show that 690/774 projects were undertaken on mammals and of these 490 focused on primates. A similar trend is also apparent in a review of zoo research undertaken in Association of Zoos and Aquariums (AZA) member zoos, reported by Stoinski et al. [1998], where a heavy emphasis on mammal research is again noted; studies were highest in primates > carnivores > hoofstock > birds > reptiles > amphibians > fish. Furthermore, studies in welfare related fields also display this bias in the species studied. At its most simplistic, environmental enrichment aims to enhance the captive environment of animals with the goal of improving welfare. A review of 744 environmental enrichment studies published between 1985–2004 carried out by Azevedo et al. [2007] noted a clear and dramatic taxa bias; most studies were undertaken on mammals (92.2%) > birds (8.2%) > fish (0.4%) > reptiles (0.57%) > amphibians (0%) > invertebrates (0.57%). This bias toward primates and charismatic megafauna hinders our understanding of the biology and welfare needs of many different species.

TABLE 1. The number of studies carried out in BIAZA member zoos (from 1998–2008) are highly biased towards mammals; there are more studies undertaken on two mammal species ($N = 90$, *Pan troglodytes* and *Pan paniscus*) than on the non-mammal taxa of birds, reptiles, fishes, amphibian and invertebrate ($N = 84$)

Taxa	# projects	# species studied
Mammals	690	
Primates →	415	
Great apes → →	152	
Cercopithecidae → →	94	
New World Monkeys & Callitrichids → →	84	
Lemurs → →	27	
Carnivores →	89	
Felids → →	43	4
Elephants & giraffes →	56	2
Birds	62	40
Reptiles	14	11
Fish, invertebrates and amphibians	8	3

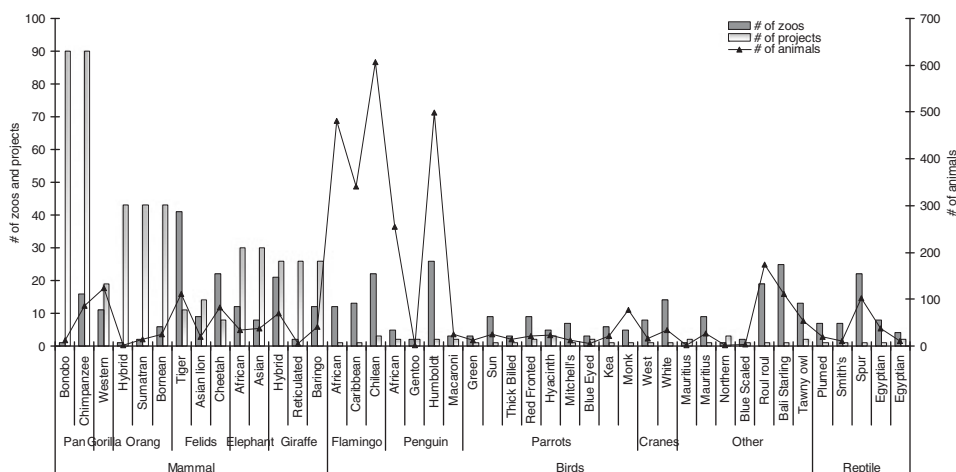


Fig. 2. A summary of the number of animals and BIAZA member zoos that house the most frequently studied species in zoo BIAZA research [data were estimated from records collated by ISIS, 2008].

The taxa bias does not reflect the number of animals available for study or the number of zoos that house them. Figure 2 summarizes the number of animals of species studied that are housed in BIAZA zoos (data are collated from the BIAZA research database). It is clear from this figure that despite mammals being the most highly studied taxa, other taxa are more abundant in BIAZA zoos. Similar findings were reported in Melfi [2005], which highlighted that within the study of primates in zoos there is a distinct bias toward the study of great apes, though many more cercopithecines are housed in zoos (both BIAZA and AZA member zoos).

It is obvious a large taxa bias exists in our study of zoo animals and also, it seems, in our assumption that some species have greater welfare needs. This bias opens gaps in our knowledge and seriously impacts animal welfare as it hinders our understanding and assessment of the welfare and husbandry needs of many different species. To compensate for this lack of knowledge, “rules of thumb” are created and attempts made to mimic the animals’ wild environment; the latter works on the assumption that animals in the wild have good welfare and simulation of a “wild habitat” will provide for the animals’ needs and result in animals with good welfare (the merits of this assumption are debated and briefly outlined above). Rules of thumb suggest standard procedures for given taxa but can be limited due to the different reactions of individuals or species to H&H variables. For example, it is well recognized that many of our animals benefit from stimulation in the captive environment; hence, the widespread appeal of providing environmental enrichment. However, some animals are timid or neophobic and over stimulation can have negative ramifications [e.g. Wemelsfelder and Birke, 1997].

Solution: Adopt Evidence-Based Zoo Animal Management

Thus far, arguments have been presented that suggest where there are gaps in our knowledge of zoo animal welfare. Some solutions have also been suggested that could directly mitigate each of these gaps. I would like to suggest that a new system of zoo animal management be adopted to initially fill gaps that currently exist. More

importantly, this system will help to reduce the likelihood that gaps will be created in the future. The proposed system is evidence-based zoo animal management. “Evidence-based” frameworks (EBF) are founded on the basic tenet that decisions [termed interventions within the literature, e.g. Kilbourne et al., 2007] should be made on the basis of evidence; implementation of EBF are probably most familiar within the medical profession (evidence-based medicine), though adoption of the concept is becoming much more widely accepted, notably, in the emergence of evidence-based conservation and environmental enrichment [e.g. Sutherland et al., 2004; Melfi, 2008]. Dawkins [2006] has also previously provided guidelines by which an evidence-based framework could be used to better inform policy makers about animal welfare issues.

There are three main components to EBF. First, it is recognized that there are many types of evidence that can inform decisions, but the reliability of that evidence can differ, that is, evidence that is not reliable should probably not lead to interventions without due consideration and careful monitoring. Second, the impact of all decisions should be monitored, so that evidence can be gathered about successes and failures. Finally, emphasis is placed on using the abilities and skills of practitioners (i.e. zoo professionals) to collate and interpret evidence and hence progress the field.

There are different ways evidence can be valued. The reliability of any type of evidence can be viewed along a continuum, from highly reliable, for example, the results of systematic empirical study, to less reliable, including an anecdote (Fig. 3). Even the reliability of anecdotal evidence is varied according to the expertise and experience of the observer. For example, more weight might be given to the informed opinion of an expert in the field compared with a man we have a discussion with down at the pub. Objective evidence (empirical data) is usually considered to be more reliable than subjective evidence. A reason for this is that objective evidence is generally unaffected by personal opinion or perception. There are times, however, when other values attributable to evidence may be more pertinent. For example, in establishing an animal’s preferences for flooring substrates preference tests can be undertaken to collect objective empirical data. But given the fact that there are many different flooring substrates that could be offered, the opinion of the keeper who has worked with the animal for many years should be sought about which substrates should be included in the preference test. Thus, the keeper’s opinion is highly valuable evidence though subjective and can fine-tune the empirical approach.

It cannot be overstated how important it is to monitor the impact of decisions made about zoo animal management. In this way, it is possible to ensure that the desired effect is achieved. A good example where monitoring has been integrated

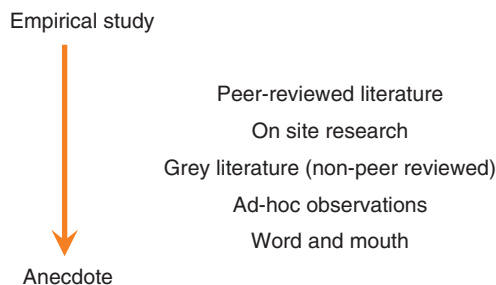


Fig. 3. Evidence can be viewed according to its level of reliability, which extends from highly reliable when gained from empirical study, to less reliable when it comes from anecdote.

into the process of implementation is environmental enrichment. It has been stated many times that responses to objects (or similar), provided to animals with the intention of enriching them, need to be monitored to ensure they have the desired effect on the animals' behavior [Plowman, online; Hawkins, 2009]. Indeed, some suggest that "attempts to enrich" can only be considered enriching when evidence is provided to demonstrate that the goals of enrichment have been achieved [Young, 2003]. As a consequence, the Shape of Enrichment [Ingle-Moller 2009] and SPIDER [Sevenich and Mellen, 1999] models suggest that a series of steps should be followed when implementing enrichment; these steps include clearly defining the goal of the putative enrichment, provision of enrichment to meet this goal, monitoring animal behavior to check whether the goal is attained, and making changes to the enrichment if the goal is not attained or to improve efficacy. Similarly, the impact of enclosure variables on zoo animal behavior and welfare can be evaluated using "post occupancy evaluations" (POE). These types of studies measure the impact of new enclosures and enclosure modifications on zoo animal behavior including their use of the space provided [e.g. Maple and Finlay, 1987; Chang et al., 1999; Farmer et al., 2006]. Typically, these empirical studies will provide more reliable information about the impact of decisions made than opportunistic observations will, as the latter often only consider a fraction of the animal's day and might be affected by many other variables, namely, when the observation was made and by whom.

The notion that who makes observations is important to the validity of data brings us neatly to the importance of incorporating practitioners into EBF. Practitioners in zoos are those who are responsible for making decisions about the management of animals and care for them on a daily basis, namely zoo keepers. Practitioners are integral to EBF because they are knowledgeable about the animals, can usually individually identify them, and are familiar with their typical behavior. They are also familiar with the animal management regime and the types of interventions that can be attempted. In addition, because they are the ones who enact interventions, practitioners are always present when interventions are made so they can monitor immediate and long-term effects on the animals. Therefore, achieving "buy in" from practitioners is a key to success if any changes in animal management are to be implemented long-term. Practitioners should also help determine what interventions are needed as well as implement and monitor interventions to determine if more changes are warranted. It is easy to appreciate that if practitioners make changes to zoo animal management and see that they are effective, they will be motivated to continue that work. In summary, practitioners are key to EBF because they are knowledgeable, in a position to measure the consequences of any intervention, and they are implementers, so they will determine whether the interventions occur again in the future.

The final solution to filling the gaps that currently exist in our knowledge and efforts to improve the welfare of zoo animals is that evidence should be directly and proactively integrated into zoo animal management regimes. More often than not, research undertaken and knowledge amassed about zoo animal welfare and the effects of H&H are not connected to or integrated into the decisions that determine captive animal management. Best practice should be based, where possible, on empirical evidence and should be translated into H&H guidelines and recommendations. We also need to gather more evidence and determine a way to combine these new findings with existing knowledge to develop such "best practices."

CONCLUSION: ACCENTUATE THE POSITIVE!

The study of zoo animal welfare is not as advanced as studies of animal welfare in other animal industries. Yet, zoo animal welfare can benefit from the wealth of information developed in studies of animals in different captive situations. For example, a study of stress responses in the scincid lizard, *Eulamprus heatwolei*, to different H&H variables provided very surprising and important data about how these reptiles perceive and respond to changes in their environment. Landgkilde and Shine [2006] discovered that stress responses, monitored using blood cortisol levels and respiration rates, were not highest as a result of toe-clipping [a method sometimes used for individual identification of reptiles, c.f. Hosey et al., 2009], but highest when exposed to heterospecifics and enclosure changes. This is particularly interesting as amputation would almost certainly be “perceived” as the most serious stressor, when in fact some routine reptile management, that is, cleaning or enriching enclosures may present greater challenges to their welfare. Therefore, it is important that we foster more interdisciplinary links, be aware of the tremendous amount of information available in other fields, and utilize this information. To achieve this, greater dialogue is required between those doing the research, those making decisions, and those who will implement recommendations. This requires better communication at various levels, within zoos (between departments) and between zoos and other associated organizations (through zoo associations, e.g. Taxon Advisory Groups).

The conclusion is simple. Gaps exist that restrict our ability to maintain zoo animals in a manner that allows us to be certain that their welfare will be good or even excellent. We can fill these gaps by working toward evidence-based zoo animal management. This can be achieved by following a few relatively simple steps, and it is likely that many organizations have already adopted some of the necessary steps toward this goal, which are:

Start asking some different questions

- What is good welfare?
- What needs do animals have?
- What conditions should we provide to make the lives of our animals wonderful?

Identify what evidence is available

- Consider evidence according to its reliability.
- If evidence is reliable it should drive change or reflect that correct H&H has been implemented. If reliable evidence is missing, we should gather some.
- Improve communication between disciplines, animal industries, and zoo professionals.

Use evidence to inform practice

- Ensure H&H recommendations are based on reliable evidence and aim to provide “great welfare.”
- Enact H&H recommendations.

In summary, changes or creation of zoo animal management programs should be underpinned by evidence and systematically evaluated to ensure that the desired results are achieved.

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