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Concepts in the care and welfare of captive elephants

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Zoos are duty bound to maintain a high standard of welfare for all animals for which they are responsible. For elephants, this represents a greater challenge than for many other species; their sheer size, sophisticated social life, high level of intelligence and large behavioural repertoire, combined with their origins in tropical and subtropical climates mean that replicating the physical, social and environmental requirements needed for a high standard of welfare in captivity is a significant challenge. This is compounded by the difficulties in measuring welfare generally, and specifically for animals such as elephants within zoo environments. Evidence does exist relating to the longevity, reproductive success and the health status of captive elephants which suggests that their management is not at as high a standard as it is for many other species kept in zoos, and that elephant welfare is likely to be compromised as a result. It is suggested that for as long as elephants remain in captivity that their management should be based around the requirements of the animals themselves taking into account an understanding of their biology and behavioural ecology. Given the difficulties in measuring welfare, it is suggested that those responsible for elephant management should not rely on proof of suffering prior to making adjustments to their programmes, but in the first instance consider the likely physical and behavioural needs of the elephant. As a minimum, facilities should provide for those behaviours and contingencies which are biologically significant in terms of survival and reproduction in the wild, which take up a significant proportion of an elephant's time in the wild and are not necessarily triggered by external stimuli alone. It is suggested that a high standard of captive elephant welfare is theoretically attainable and that significant improvements in welfare are likely to be achieved by addressing inadequacies in the physical environment which predispose captive elephants to trauma and by providing for appropriate social and foraging opportunities.

Key-words: digestive strategies, elephant care, elephant welfare, facilities, guidelines, health, husbandry, management, social groups, standards, zoos

The welfare of elephants in captivity is perhaps one of the greatest management challenges facing zoos both from an animal husbandry and a public perception perspective. This document is not designed to be a formula for elephant welfare in captivity because there are still too many un-answered questions, rather it is intended as a discussion of some of the concepts relating to captive elephant welfare, which it is hoped, might encourage people from a variety of viewpoints to consider elephant welfare in a different way. I will not go into the issue of whether or not elephants should be in captivity because this would be a not inconsiderable document in its own right, but I will work on the assumption that whilst elephants are in zoos, elephant holders are duty bound, as they are with all other species, to optimize the welfare of these animals without unduly compromising appropriate conservation and educational aspirations for the herds. With this in mind, I will attempt to explain what welfare is and what it is not, and how it is measured. I will then give my personal opinion on why the management of elephant welfare in captivity is a challenge and provide some suggestions of how zoos might overcome these challenges in the future. As will become apparent, there is a dearth of 'facts' when it comes to the issue of captive elephant welfare, and as a result, what I present here, is very much a personal opinion, but one I hope that is as objective as possible, and one for which, I give elephants the benefit of any doubt I may have when hard evidence is lacking.

WHAT DO WE MEAN BY WELFARE?

Animal welfare relates specifically to an animal's state of psychological wellbeing, in other words what it feels, rather than what it does. In practical terms, one might consider good welfare to be a state in which an animal experiences positive emotional states and an absence of suffering. However, because an individual's experiences, thoughts and feelings are largely inaccessible, particularly in the absence of a common language, we are reliant upon indirect indicators of an animals' mental state and hence its welfare. As a result, what are commonly referred to as welfare measures, are in fact welfare indicators, and none should be considered as reliable in isolation as will hopefully become apparent.

Having very briefly defined what welfare is, it is equally important to understand what welfare is not. Although the health status of an animal can affect its welfare, and the welfare of an animal can affect its health, health and welfare are distinguishable. Health refers to the physical rather than the psychological wellbeing of an animal and so, if a disease causes pain, reduces mobility or the ability of the animal to interact with conspecifics it may reduce the individuals' welfare but an ailment that does not (yet) impact upon the behaviour or pain receptors of the animal, may not necessarily impact upon welfare at that time. One such example of this might be an intracerebral aneurysm where a weakness in blood vessels within the brain has no impact on welfare until such a point that the aneurysm bursts killing the individual concerned. Thus an individual possessing such a defect must be considered to be in poor health, without actually suffering as a result of the defect, unless health itself is defined in such a way as incorporates a welfare component. It should be noted that this view is contrary to some who relate genetic fitness (that is to say, the extent to which an individual is able to increase the frequency of its genotype) to welfare (see Fraser & Broom, 1990). Whilst it is clear that reduced welfare can decrease reproductive output and genetic fitness (Archer, 1979), this is not always the case, it would be incorrect for example to assume intensively managed livestock benefit from their markedly increased reproductive output over and above wild relatives or to assume that their welfare is definitively acceptable just because they are reproducing.

In the same way that health, reproduction and welfare are not equivalent, death also has to be differentiated from welfare because death can effectively be defined by the cessation of brain activity, and welfare is essentially a function of brain activity. However, this does not prevent death being an ethical issue, and by ethical I mean relating to prevailing moral standards, nor does it mean that the causes of death are inevitably without a welfare dimension. How an animal dies, and what factors precipitated its death; whether it was caused by inadequate care or resulted in suffering, etc, must be considered as relevant to a welfare discussion.

HOW DO WE MEASURE WELFARE?

If we accept that welfare is a measure of an animals' mental wellbeing, how is this measured? Like the challenge zoos face in managing elephant welfare, the challenges scientists face in assessing animal welfare is also a considerable one (see Mason & Mendl, 1993). The methods of assessing welfare can be grouped into three broad categories, those that involve measuring behavioural and physiological responses to stressors which reflect the animal's mental state, and those that involve measuring variables external to the animal that we might reasonably assume will affect the animals' mental state and correlate with, or indeed cause reduced welfare in the species concerned. Rarely are these techniques used in isolation, and variables that may precipitate poor welfare, such as certain aspects of the animals' physical or social environment, can be mitigated by

management practices for example, such that welfare standards can be upheld. As a result, every measure has to be considered in a broader context.

Both behavioural and physiological responses to the suboptimal circumstances that reduce welfare are typically what we would view as adaptive in that they represent attempts made by the animal to improve its welfare by coping with, or eliminating stressors, although in cases of chronic stress, the prolonged activation of short-term coping responses may not appear adaptive. The greater the animal is required to cope, or indeed the greater the animal is motivated to avoid or escape the stressor, the more its welfare is likely to be compromised, and the greater the coping response that is likely to become manifest. As a result, the magnitude of the animals' response will give an insight into the degree to which its welfare is compromised.

PHYSIOLOGICAL MEASURES

Physiological responses to stress are complex, multifaceted and vary according to the nature of the stressor. In the crudest terms, the stress response is characterized by an elevation in glucocorticoids secreted by the hypothalamic-pituitary-adrenal (HPA) axis (Carlstead & Brown, 2005). The secretion of these steroid hormones facilitates the mobilization of energy reserves and an acceleration of cardiovascular tone to prepare the animal for a coping response; fight or flight.

Physiological welfare indicators primarily involve measuring the compounds released by the animal in its blood, and to a lesser extent in excreta and saliva when these systems are activated, and also short-term changes in rates of respiration, etc. These measures have to be treated with caution because an elevation in glucocorticoids can be activated in a manner comparable to a 'stress response' when an animal is excited or has exerted itself, and indeed the sampling procedure itself, particularly if this involves taking blood, may activate an acute 'stress' response, potentially invalidating any worthwhile conclusions. In situations of chronic stress, the HPA response can also be depressed. It should also be noted that in the UK at least, invasive procedures such as 'experimental blood sampling' are likely to require approval from governmental agencies.

If the 'stress response' is not successful in eliminating the stressor, long-term activation can ultimately reduce the health of the individual, and these chronic physiological stress responses can also be measured. These include immunosuppression, reduced fecundity, reduction in protein synthesis (body-mass loss), elevated blood pressure, ulceration, thickening of the arteries, premature death, etc. These chronic stress reactions may be particularly useful in assessing the level of everyday welfare of zoo animals because they should reflect welfare status under the prevailing conditions rather than the animals' state of mind at the point of measurement. However, there are problems with these measures; firstly, these chronic stress indicators are difficult to measure in live animals, secondly, it is very difficult to determine what caused the reduction in welfare that resulted in these changes.

BEHAVIOURAL MEASURES

Largely as a result of the problems previously outlined, behavioural studies are a popular approach to welfare assessment, particularly in non experimental conditions such as those in zoos.

Time budgets and comparisons with the wild Time budgets are essentially behavioural measures of how animals allocate their time. Captive time budgets can be used as a baseline against which to assess the affects on behaviour of changes in management, or in the animals' physical and social environment. Time budgets from wild animals can also be used to indicate areas of possible concern in cap-

tive animals, in fact, some have argued that merely demonstrating a difference between wild and captive behaviour is sufficient to assume a reduction in welfare (Thorpe, 1965, 1967; Martin, 1979), or that there is an inherent welfare value in the state of wildness (Wuichet & Norton, 1995), notwithstanding the welfare challenges regularly experienced by wild animals over and above those experienced by most zoo animals, such as predation and risk of predation, territorial aggression, disease, injury, starvation, climatic extremes, etc. In reality, there should be measurable welfare consequences, or additional evidence prior to making 'welfare judgements' between qualitative and quantitative differences in behaviour between wild and captive conspecifics (Veasey *et al.,* 1996a). However, *an absence of proof of suffering cannot be viewed as a proof of an absence of suffering,* and as a result, it may be reasonable to take a precautionary approach to welfare in certain circumstances as I hope will become clear.

Behavioural needs and preference tests Animals can also provide an insight into their welfare by expressing preferences for certain variables. Preference tests have been used to indicate what animals like, chickens have for example been shown to prefer larger cages with a substrate to smaller cages with a wire floor (Dawkins, 1983), which would appear to suggest that chickens denied access to space and a substrate may have impoverished welfare. However, there are of course limitations; firstly preference tests only indicate a relative preference not a measure of the strength of a preference, secondly simply because an animal expresses a preference for a certain variable, does not mean it will inevitably suffer in its absence, and lastly animals do not always make choices that are in their best interests as can be most clearly understood in the selection of diet and exercise regimes.

The strength of preferences can be measured by applying Consumer Demand Theory and making the animal give up resources; sacrificing food, comfort resources and social contact or working to gain access to their preferences; pressing levers, swimming through cold water, pushing open heavy doors, etc. The harder the animal is prepared to work or the more it is willing to sacrifice, the greater the preference, and as a result the greater the likely welfare compromise if denied access to that resource/opportunity. Such an approach in giving an insight into the relative preference for certain resources can be used to assist in facility design and can also give an insight into the relative importance of behavioural variables because animals can be made to work to perform certain behaviours such as 'working' to gain access to conspecifics with which to groom, mate or interact with, or features needed to trigger specific behaviours, such as rubbing posts, dust bathing sites or pools, etc.

Evolution will have led to behaviours of a high survival or reproductive value being rewarding to perform and/or make the animal highly motivated to perform them, and so it is not unreasonable to assume, that denying animals the opportunity to perform these behaviours may have welfare consequences. The degree to which an animal is motivated to perform specific behaviours can be assessed experimentally (see Dawkins, 1983) but can also be informally assessed in non-experimental situations. For example, elephants which sacrifice feeding opportunities to spend time in close proximity to confined members of the herd are suggesting a relative preference for social contact at that time and as such we might reasonably assume that companionship is potentially an important component of the welfare of that individual.

When animals demonstrate a willingness to sacrifice resources or work hard to express particular behaviours, it is more likely that these will qualify as 'behav-

ioural needs' and we can reasonably assume animals are likely to suffer if denied the opportunity to express them. Behavioural needs are essentially behaviours that animals must perform for their welfare to be satisfied. Other than being behaviours animals will often work for to perform, behavioural needs are typically behaviours of high survival or reproductive value, potentially of a long duration, energetically demanding and often internally stimulated (that is to say not necessarily reliant upon triggers external to the animal). For example, given time, many species will become motivated to forage even when food stimuli are not present or when they are nutritionally sated, but predator escape behaviour, although of high survival value, is not considered as a behavioural need because it need only be exhibited in the presence of the appropriate external stimuli, namely the predator or the perception of a predator. An animal given the opportunity to feed for 2 hours in captivity may be satisfied in terms of nutritive requirements, but with regards to behavioural requirements, if they typically graze or forage for 14–20 hours per day in the wild, they may well possess a 'need' to feed/forage more extensively and so may suffer if the void left in their time budget is not appropriately filled. In examples such as this, where the difference in time budget is so substantial, one has to consider, how such a large differential for such an important behaviour could realistically be compensated for in captivity in any other way without there being welfare consequences.

In reality, proof of either negative or insignificant welfare consequences for the non-expression of wild behaviours may not be attainable, and so I would suggest the following approach. Where an animal has evolved to perform a specific behaviour or live in a particular social or physical environment, which would appear to be of high survival value, tend to take up a significant proportion of that animals' time or energy under free-ranging conditions, or to which that animal appears highly adapted and or motivated, then husbandry and housing practices should accommodate for this in captivity wherever possible. With behaviours or environmental factors that fall into these categories, it is best to take a precautionary approach and rely on proof that the absence of these elements does not cause suffering before dispensing with them rather than relying on proof that their absence does cause suffering.

Abnormal behaviours Behavioural measures of welfare can also centre on the frequency and duration of 'abnormal' behaviours, the most obvious of which are stereotypic behaviours. These unvarying and apparently pointless behaviours (Mason, 1991a) do not necessarily cause reduced welfare but have been linked to poor welfare as they are typically seen in animals for which we might assume welfare to be low, such as those in barren or small environments, those suffering pain or distress and those in which other welfare correlates are manifest, such as those with injuries or obvious social stressors, etc. However, stereotypies must also be treated with some caution, because they can also occur when an animal is excited as well as when stressed (Veasey, 1993), furthermore, it is believed that stereotypic behaviours may be satisfying to perform in that they resemble frustrated behaviours or by providing a regular controllable level of stimulation that helps the animal cope with unpleasant or uncontrollable neural stimulation. Thus stereotypic animals often have lower heart rates, higher levels of circulating endogenous opiods and reduced cortisol levels in comparison to non-stereotypic animals in similar conditions (Dantzer, 1986; Mason, 1991a). Thus although it can be argued, that whilst stereotyping, animals may not necessarily be suffering per se, it can also be argued, that the presence of stereotypies indicates the animal has been required to perform a coping response

and as such has experienced a welfare challenge (not withstanding stereotypies induced by excitement/anticipation, etc). One further additional factor complicating the relationship between stereotypies and welfare is the fact that even once conditions have been improved, stereotypies can persist (Mason, 1991b) and so may not reflect the prevailing conditions the animal is subject to. This may be particularly true for elephants in zoos because they often have complex and varied life histories which may include periods in which stereotypies might develop and experience has shown that even once elephants have been removed from these conditions, stereotypic behaviours often persist. Furthermore, it should also be noted that behaviours classified as abnormal in captivity, such as certain stereotypic behaviours, have been described in wild animals (Veasey *et al.,* 1996b) though on generally on a far less frequent basis.

Other 'abnormal' behavioural indicators often linked to welfare might at first appear more straightforward, these may include excessive signs of distress (vocalizing, extreme timidity or aggression, escape behaviours, etc), self mutilation and reduced performance of behaviours critical to survival and reproduction, such as grooming, mating, foraging/feeding, etc. However, once again, the context of these behaviours needs to be carefully considered when attempting to attribute a cause for these behaviours.

ENVIRONMENTAL WELFARE CORRELATES

This final set of welfare indicators are external to the animal. They are factors that based on a number of studies have proven to be correlated with other welfare indicators, and for which, we can intuitively see a link between their existence and a reduction in welfare. Such factors, which are commonly associated with indicators of reduced welfare, include small, barren environments and or the restriction of the animals' movement, uncontrollable stressors, lack of behavioural or social opportunities, the restriction of feed, lack of choice and control, etc. These correlates can be adapted for different species when combined with an understanding of their behavioural ecology. Thus we might reasonably assume a lack of social interaction is likely to be a greater issue for a social primate, such as a Chimpanzee *Pan troglodytes,* than it would be for a solitary predator, such as a Tiger *Panthera tigris,* and we might also be forgiven for assuming that the compression of an elephant's extensive daily foraging routine into 2–3 hours in captivity might pose a greater welfare challenge than altering a snake's feeding ecology in captivity because it takes up a much less significant proportion of its time in the wild. However, caution is of course required, and now is perhaps the time to reiterate, no single variable is satisfactory on its own.

External welfare correlates are a key component of the Five Freedoms which were developed to help simplify welfare concepts in order to facilitate the provisioning of adequate welfare standards, particularly for agricultural animals. These freedoms included the (1) freedom from injury and disease, (2) freedom from hunger, thirst and malnutrition, (3) freedom from thermal or physical distress, (4) freedom to express most 'normal' behaviours and (5) freedom from fear. It is felt that by providing for these freedoms, welfare will be assured, and although developed for agriculture, these are incorporated into the UK zoo licensing legislation (DETR, 2000). Although the five freedoms are not strictly a framework for measuring welfare, they are useful in giving structure and context to captive animal welfare.

CARTESIAN THEORY AND THE PRINCIPLE OF PARSIMONY

This very brief introduction into the measurement of animal welfare highlights its comparative uniqueness amongst other scientific disciplines, in that definitive

proof is unlikely to be attainable in most cases. I will now briefly introduce two more concepts which have had a major bearing on animal welfare science and the interpretation of data.

The first is the 'principle of parsimony' (also known as Occam's razor) whereby one applies the simplest explanation or theory to interpret any specific information or data set. This might at first seem to make the interpretation of welfare data simpler; when an animal appears to be in pain, or appears to be fearful, the most parsimonious explanation is to assume that the animal is in pain or is fearful. However, the principle of parsimony lead to the development of Cartesian theory in the 17th century which would lead to an entirely different interpretation of the same scenario. Rene Descartes argued that animals simply responded to external stimuli in a mechanistic manner and felt that to involve consciousness was not the most parsimonious way in which to interpret animal behaviour. Remember, the welfare of an animal is defined by what an animal feels, not what it does, and so consciousness is in fact a prerequisite of suffering, in other words, the animal has to be aware of its impoverished state for its welfare to be truly compromised. Cartesian theory, in suggesting that animals are not conscious questions their ability to suffer, in other words they may do, but not feel. It has been argued that because humans and animals are related, have brains, nerves, neurotransmitters and generally the prerequisites for pain detection, and tend to behave in the same way in reaction to what we could consider to be painful or stressful stimuli, that they most also feel pain. However, Harrison (1991) argues the avoidance of aversive stimuli and reactions suggestive of aversion can be programmed in robots and seen in amoeba, neither of which have a strong case for the possession of conscious awareness. Furthermore, although such behaviours may well be adaptive, pain itself need not be. Carruthers (1989, 1992) further argues that just as humans can respond to stimuli in an unconscious way, in other words we can act without feeling or thinking, it is argued that an animal need not experience pain to avoid what we would view as painful stimuli, and that just because we feel pain, it does not mean to say that an animal does.

Whether animals are conscious or not, we may never know for sure, but, *an absence of definitive proof of animal consciousness or suffering, cannot be viewed as a proof of absence of animal consciousness or suffering.* Clearly, for zoo elephants (as with any other animal for that matter), we may never be able to definitively prove an individual is suffering as a result of specific variables associated with captivity for the reasons outlined and the small samples sizes available. However, despite the limitations of each individual measure, when we consistently record a number of diverse indicators of impoverished welfare, I believe it is in fact the parsimonious view to give the animal the benefit of the doubt and assume that welfare is likely to be compromised unless there is sufficient evidence to the contrary. Furthermore, even in the absence of data, I do not think it is unreasonable to adopt a precautionary approach and attempt to provide for certain key behaviours in captivity which one can reasonably argue are likely to be important to the animal as has been previously described.

Given the nature of zoo elephants, the limitations of experimental and physiological measures in terms of both implementation and interpretation, we are currently heavily reliant upon behavioural indicators of welfare and establishing and assessing the welfare correlates of the animals' environment, that is the say the extent to which their captive environment comes close to providing the elephant with what we might reasonably assume they 'need' for adequate welfare, and to some degree looking at the physical manifestations of impoverished welfare in the carcasses of dead elephants.

WHY DO ELEPHANTS POSE A WELFARE CHALLENGE FOR ZOOS?

Captive animal welfare is not by definition inevitably impoverished in comparison to that of wild animals, although there are those who would disagree with this (see Wuchet & Norton, 1995). Animals in the wild typically suffer predation, disease, parasitism, and starvation at levels far higher than those seen in the captivity. In southern India for example, 70% of bull elephants will be killed at the hands of man (Sukamar, 1992). By eliminating these anthropogenic and a plethora of 'natural' stressors whilst simultaneously providing captive animals the opportunity to express their species typical behavioural needs, it is, in my opinion possible that we can actually improve captive welfare over and above wild conspecifics for many species. However, it is not acceptable to view gains in health care, food security or the elimination of predation in captivity as adequate compensation for a reduction in stimulation, behavioural opportunities, etc, because illness, predation or starvation are unlikely to be chronic episodes in the wild, whereas a general maladaptedness of the individual to captivity are likely to present chronic welfare challenges. Ensuring the benefits of captivity can be maximized whilst providing biologically appropriate environments is possibly a greater challenge for elephants than for most species, and I will try and explain why I believe this to be the case.

Elephant society and intelligence Elephants are highly social animals and this presents zoos with two problems. Firstly, the coevolution of elephant intelligence (that is to say their capacity to acquire and apply knowledge towards a specific goal), and their brain to cope with a complex social life is likely to have made them more vulnerable to impoverished welfare in captivity. Secondly, there are considerable logistical problems of maintaining captive elephants in biologically appropriate social groups.

Social animals are typically more intelligent than non-social animals; primate species with larger social networks tend to have a relatively larger neocortex for example (Kudo & Dunbar, 2001). Furthermore, if we consider species typically considered as intelligent (e.g. chimpanzees, dogs, pigs, dolphins or parrots) intelligent solitary species, such as the Orang-utan *Pongo pygmaeus,* are a rarity and probably more social or recently solitary in evolutionary terms than one might first imagine. To function effectively in a society, animals need to have a high level of understanding of conspecifics (empathy), this in turn requires a high level of intelligence and self awareness (consciousness) which in itself is often cited as a prerequisite for suffering. Anecdotally we 'know' elephants are intelligent, they plan, they solve problems, they can learn a bewildering array of trained behaviours and appear to understand more of our language than we do theirs!

The intelligence of elephants may make them more capable of suffering, but their social complexities may make them more likely to suffer in zoos. In general terms, the basic social unit for both African elephants *Loxodonta africana* and Asian elephants *Elephas maximus* is the matriarch; a group of related cows and young led by a more experienced mature cow. These herds vary in number from between six to 40 elephants, but these family groups may also come together in extended family units or clans of up to 100 or in aggregations of up to 1000 (Nowak, 1991). However, nine to 11 is the norm in African elephants (Estes, 1992) and herd sizes recorded for crop-raiding Asian elephants were reported to be around eight (Sukumar, 1992). This organizational structure presents zoos with a number of problems. Firstly, large facilities are required to house the animals required to attempt to replicate even the smaller family units within the confines of a zoo. Secondly, these units should ideally be formed of related animals rather than dis-

parate individuals brought together at the zoo. Lastly, elephants are capable of recognizing the calls of large numbers of conspecifics (McComb *et al.,* 2000) over considerable distances (McComb *et al.,* 2003), something for which elephants are superbly adapted. It seems unlikely that such a 'biological expectancy' could be replicated in any meaningful way in captivity. The extent to which this impacts upon elephant welfare would appear to be particularly difficult to assess, but does not mean that it will be without consequences.

Many of the problems zoos face in elephant management may be linked to the failure of managing elephants in appropriate social groups. Tension and aggression between elephants will almost certainly be reduced in related groups that have grown up together. There is a general consensus, though as yet this still remains unproven, that the problems experienced during parturition and in the early years of life in captive elephants will be reduced if primiparous cows are able to witness parturition in related cows and are able to calve in the presence of experienced, related mothers. These cows may assist in the calving process (Schneck, 1997) and subsequent parental care. Recent estimates of captive calf mortality in the first 5 years have been reported to be as high as 47% in some populations with stillbirths reported as high as 15·3% (Clubb & Mason, 2003). It has been suggested by some that elephants and humans are comparatively unique in having a significant post-reproductive phase in their life, which has been interpreted as an indication of just how crucial a role, leadership, learning and experience play in elephant society (Estes, 1992). Growing up within a more 'natural' group structure will also be important for the appropriate socialization of elephants, critical to them learning the skills required to function effectively within a herd, and to go onto to successfully reproduce. Moreover, social interaction, is perhaps one of the most sustainable forms of enrichment available to animals (Veasey, 2005; Veasey & Hammer, in press) and potentially one of the most rewarding. As a result, for this and many other reasons, the management of elephant societies in captivity must be viewed as a cornerstone of the effective management of these highly social species.

Whilst significant emphasis is placed upon the matriarchal herd, largely because of the sex bias currently in zoos, we must be mindful that the ratio of bulls in captivity will grow as the number of successful births increases (see also Wiese & Willis, this volume). The subsequent management of a growing bull population will present zoos with a far greater challenge than is presently being experienced in the management of cow herds. Bulls are typically considered as solitary, but in reality this is a convenient over-simplification. In the Asian elephant for example, at least 40% of herds had one adult male within it which may have spent up to 30% of their time there (Nowak, 1991). Bulls typically grow up within a matriarchal herd until such a time that they are either driven out by the females or depart voluntarily around the time of puberty. Young bulls will often remain close by before joining looser groups of males (Schneck, 1997). Males within a region may develop a hierarchy of sorts which is reliant upon regular though potentially infrequent contact. At around the age of 25 years when bulls reach full sexual maturity, their behaviour is highly dependant upon their sexual state. During periods of musth, circulating levels of testosterone may increase by over 100-fold (Jainudeen *et al.,* 1972), and as a result bulls become more aggressive, more wide-ranging, more likely to be found associating with oestrous females and generally spend less time in bachelor groups. Given the volatile nature of bulls, the fact they typically mature earlier in captivity than in the wild and their inherent social complexities, managing large numbers of bulls

in captivity to a high standard will be an immense challenge zoos need to start planning for now, and which I will return to later in this paper.

Ecology Elephants survive across a massive range of habitats from deserts, grassland, swampland, seasonal forests, tropical forest through to montane forests and upland moorland. The African elephant can survive in any African habitat that provides sufficient water (Kingdon, 1979), and will experience seasonal variations that can dramatically alter their surroundings and subsequently their lifestyle. To deal with seasonal, geographical and even social variations, elephants have evolved to be adaptive, flexible and opportunistic and to possess a comparatively diverse and complex behavioural repertoire when compared to most other ungulates. As a result, elephants have the neurological tools and innate behavioural capacity, or what amounts to an 'evolutionary expectancy' to be presented with a potentially changeable and diverse set of environmental parameters. When the environment does not match that 'evolutionary expectancy', suffering maybe more likely, exacerbated by the now surplus neural capacity and potentially 'frustrated' behaviours.

The digestive strategy of the elephant may also precipitate welfare problems in captivity. Unlike cattle, antelope, deer and giraffes, etc, elephants do not ruminate, that is to say, they do not regurgitate and re-masticate partially digested food. Because rumination can be considered as a vital component of ruminant feeding behaviour, it is not unreasonable to assume that it is likely to be rewarding to perform, but even if this is not the case, it is effective in occupying the time of captive ruminants. Captive Giraffe *Giraffa camelopardalis,* for example, ruminate for as much as 40% of observation periods (Veasey *et al.,* 1996b), and Eland *Taurotragus oryx* feed and ruminate in equal amounts (Estes, 1992). As a result, whether rumination is rewarding or not, elephants could have a significant proportion of their time budget unoccupied in captivity compared to ruminating herbivores feeding for comparable amounts of time. Non-ruminants, such as elephants, though less efficient digesters compensate by processing larger quantities of food at a higher rate (Sukumar, 1992; see also Hatt & Clauss, this volume). In the wild, elephants spend 60–80% of their time foraging (Clubb & Mason, 2003), whereas in captivity diet 'quality' in the nutritional sense is likely to be more concentrated and as a result, consumed over a far shorter time frame, more akin to that of a ruminant. This may result in a time vacuum for elephants, whereby large portions of the captive elephant's day are left unfilled with diet acquisition and processing, which can have profound consequences on their welfare.

As far as I am aware, there have been no thorough investigations into the long-term effects of climate and photoperiod upon the welfare of captive elephants but it is likely that these factors will have an impact either directly or indirectly. Although both African and Asian elephants can experience low temperatures in certain parts of their range at certain times of the year, they are unlikely to experience conditions equivalent to those found in many temperate zoos in winter for extended periods of time in the wild. In humans there is evidence linking such temperate climates to an increased incidence of rheumatoid arthritis (Hameed & Gibson, 1997), the same may or may not be true for elephants (see Clubb & Mason, 2003), but nonetheless, arthritis is believed by Fowler (2001) to be one of the main reasons for euthanasing elephants in captivity. If it does not have a direct impact, climate might still compromise the welfare of elephants indirectly by forcing them to be kept inside for prolonged periods of time. This may result in a reduction in activity levels and behavioural opportunities, combined with an increased level

of exposure to unnatural and potentially more challenging substrates and surroundings.

Health care Our understanding of elephant health care and its management is not yet at the level it is for domesticated species or their relatives. As a result, the rate of undetected or unsuccessfully managed disease events is potentially higher than it might be for a zoo bovid for example. Over 60% of adult elephant deaths in captivity can be attributed to disease (Clubb & Mason, 2003) which is not entirely surprising, or indeed worrying because non-accidental death is typically precipitated by, or coincidental with disease in any circumstance. However, when one considers the age of onset of these fatal diseases, there would appear to be some cause for concern. If we accept the data of Clubb & Mason (2003), the life expectancy for captive Asian elephants is 21 years and 18 years for African elephants when death at less than 1 year old is excluded, this compared to a life expectancy of up to 70 years in the wild (but see Wiese & Willis, 2004). However, care must be taken when comparing a maximum longevity with a mean life expectancy. For example, whilst elephants can live to 70 years of age in the wild, in recent years wild populations have been in decline, and so the average elephant is dying prior to reproduction, which with sexual maturity being reached at 14–22 years old (Sukamar, 1992; Nowak, 1997) suggests the average elephant is unlikely to survive much beyond its teens. Data for wild African elephants suggests an average life expectancy (excluding animals which died at under 1 year old) of 21·8 years (Laws *et al.,* 1975), comparable with that seen in zoos. If we analyse Sukamar's (1992) data for wild Asian bulls, we see average age at death is under 23 years. However, these may well be overestimated because early deaths will be underestimated owing to the more rapid deterioration of carcasses and difficulties in locating them. Moreover age classification in adult elephant carcasses is sufficiently difficult that mortality studies include classes as broad as ten and over (Douglas-Hamilton, 1972; cf Clubb & Mason, 2003). Whilst longevity in captivity (and even the wild owing to a high proportion of anthropogenic mortality) is not acceptable, it is in fact potentially comparable. However, typically, most zoo animals live far longer than their wild counterparts and the same should be attainable for elephants, and is possible as can be demonstrated by the increased longevity seen in timber-camp elephants compared with those in zoos (Clubb & Mason, 2003; Sukumar, this volume).

Management in zoos The manner in which we manage elephants in captivity will have a dramatic effect upon their lifestyle. We know elephants live complex social lives in the wild (and I would include bulls in that statement), and we know that they spend a significant proportion of their time foraging and feeding, both areas of high survival value and therefore likely to be of high welfare significance. In captive scenarios, where management results in the restriction of feeding, foraging and social opportunities welfare problems are most likely to occur.

Clearly the training and handling of elephants in captivity can have profound welfare implications, both positive and negative. Training exists across a continuum from comparatively intense hands on or free contact training where the trainer works 'unprotected' with the elephant, typically with the use of an ankus or elephant hook, through to protected contact where a barrier is present between trainer and elephant and zero contact where no training is attempted. Where behaviours are trained, they typically are reinforced via the use of the ankus and or the provision of positive reinforcement; generally food rewards or positive feedback from the keeper. Potential positive aspects of training include the ability to

impose exercise regimes on animals that might otherwise be inactive, the mental stimulation potentially offered by training, the opportunity for elephants to experience more diverse surroundings by moving them outside of their enclosures, the management of chronic health-care issues without the need for chemical immobilization and the opportunity to develop positive relationships with keeping staff, etc.

The potential negative welfare aspects of the reliance upon training are however, also numerous. Animals denied choice and control over their surroundings, are likely to suffer a reduction in welfare and thus although the opportunity to explore outside of the elephant's enclosure can be viewed as a welfare asset, the fact it has to be at the behest of the keeping staff and very much on their terms, will diminish the welfare benefit. Training is a skilled and time-consuming process, which although can fill voids potentially left by the lack of behavioural opportunities in captivity, can also result in the albeit temporary, but nonetheless frequent involuntary separation of close-knit social units, with potentially significant welfare consequences (Clubb & Mason, 2003). The apparent reliance on 'punishment' as a training mechanism, is perhaps the most emotive dimension of elephant training. Positive reinforcement, that is to say, the reinforcement of desired behaviours by the provisioning of a reward is problematic for bulk vegetarians such as the elephant which can consume up to 300 kg per day, because each food reward will always be a minute fraction of their daily intake and as a result, of limited significance. Given the nature of elephants and the potential limitations of positive reinforcement, keeper safety in free-contact systems typically relies at least in part on a degree of negative reinforcement whereby undesirable behaviours are punished generally mediated through the use of the ankus. Such an approach to management is comparatively unique amongst zoo animals and appears to originate from traditional management techniques used to manage working elephants in Asia and in circuses. As yet, there appears to be little common ground between the advocates for and against free-contact training, however, both sides must surely agree that the benefits to the elephant of training, through which ever technique, must outweigh the potential costs to the elephant, and if not, there has to be an aspiration to achieve this point. However, what is not acceptable, is to excuse deficiencies in facilities or captive elephant lifestyles by provisioning the elephants with gains delivered through training. Thus chronic confinement to inadequate facilities should not be justified by occasional walks outside of those confines.

Circulatory problems appear to be the most significant cause of death in zoo elephants (Clubb & Mason, 2003) which in humans at least, can be precipitated by chronic stress and obesity and could thus potentially be hastened by inadequate management strategies and facilities. The second biggest cause of morbidity, but perhaps the biggest single health problem in Asian elephants are foot problems (Schmidt, 1986; Fowler, 2001) with as many as half of all captive elephants suffering from foot problems at any one time (Mikota *et al.,* 1994). Factors which are likely to predispose elephants to foot problems are a lack of exercise potentially combined with excess body mass, improper, unhygienic or excessively moist substrates, climate and the performance of stereotypic behaviours (Clubb & Mason, 2003). So many of these factors are intrinsically linked, and precipitated by both management practices and environmental variables that at least for the Asian elephant, the occurrence of foot problems might even be viewed as a crude welfare barometer. Inactivity prevents appropriate wearing down of the footpad and toe nails, and predisposes the animal to obesity that puts additional strain on

inadequately exercised joints and tendons. These problems may be exacerbated by poor substrate choice or maintenance and the performance of stereotypic behaviours that may cause uneven and excess wear. Again, an understanding of species biology is vital. The differences in occurrences and nature of foot problems in captive African and Asian elephants may be attributable to their ecology rather than their management. African elephants range widely over rough terrain and as such would appear to have more robust pads prone to overgrowth in zoos, whereas Asian elephants inhabit arguably less abrasive environments in the wild and regularly forage by raking and kicking at grasses and herbage and so have evolved nails which grow more rapidly and thus require trimming in zoos (Clubb & Mason, 2003). Management should of course reflect these differences. The recent construction of facilities with sand substrates inside appear to show considerable promise in terms of improving foot condition in captive elephants. If designed correctly these are free draining, interactive surfaces which spread the load across the entire foot surface and facilitate lying down in a way concrete substrates do not.

THE FUTURE

I suspect this document will have raised more questions than it has answered regarding elephant welfare in captivity and its management. However, although clearly the management of captive elephant welfare is a significant challenge, I do not believe it to be a theoretically insurmountable one given the will, the financial commitment and an open mind.

Perhaps the first step forward (for those who have not already undertaken this) is to completely re-evaluate institutional elephant management strategies putting the welfare of the elephants at the absolute core whilst avoiding being unnecessarily restricted in our deliberations by what we already do and why we do it. Elephant welfare is consistently an important consideration in the mindset of elephant management teams, but I suspect it is not always 'the' most important factor, or if it is, it is often the most important factor within the constraints of institutional considerations or limitations and often based on how it has always been done. It is unacceptable for institutions to try and do the best they can in perpetuity if this infrastructure falls below what is required to ensure adequate welfare standards are maintained. Deciding what is required and what is adequate, is of course a major challenge in itself, however, in the absence of data, institutions or regional associations need to establish sensible, but in reality, what will be challenging minimum standards to which institutions must reach within a reasonable time frame, or decide not to keep elephants if they cannot attain those standards. In the UK, the BIAZA guidelines have taken an important first step towards that end (Stevenson & Walter, 2006), and a number of zoos have responded by taking the brave decision of 'going out' of elephants, or perhaps the even braver decision of striving to meet or surpass those standards. However, setting meaningful evidence-based standards is a difficult task because elephant welfare is so evidently multifactorial and highly complex. Thus minimum indoor facility sizes need to reflect climate and time animals will be kept indoors, and although size is an easy variable to measure, enclosure complexity and design are also critical. So, although we have to accept that deciding what elephants need or where we set the standards will be challenging or inevitably controversial, I would offer the following suggestions in anticipation of further advances in our understanding of captive elephant management, and thus more stringent evidence-based guidelines.

Everyone involved in the management of elephants has to be open-minded to novel approaches to management. Too many of our current management

strategies are relics of circus-management practices, particularly with regards to the management of Asian elephant and their feet. We train elephants for many reasons, but in reality, the only acceptable justification for free-contact management in particular, as a result of its inherent human health and safety risks and potential elephant welfare costs, has to be to optimize the welfare of the elephants within an institution. Thus the *potential* welfare costs of training can only be justified, in my opinion, if there is a clear net welfare benefit to that training. Human health and safety should not be a justification for free-contact management because this should be managed through facility design as it is with all other dangerous animals within zoos. All other justifications which relate to the elephant rather than humans worthy of consideration can surely be overcome by research leading to improvements in husbandry and design. Given the health problems in captive elephants and most notably foot problems in Asian elephants, free-contact management strategies can of course be extremely useful in the treatment of these and a multitude of other problems. However, it has to be the aspiration, whether it is achievable or not, to work towards reaching a point where free-contact management and training as we now know it is effectively obsolete because the environment we are capable of providing our elephants is such that regular intervention is not required. Likewise, the environments we provide elephants should be sufficiently socially and physically complex and enriching that we do not need to walk them around the zoo or further a field (always on our terms) to ensure their welfare is optimized. In order to work towards this point we really have to address the inadequacies of the elephant's environment in captivity from a social and physical perspective.

To achieve this elephants will have to be maintained in biologically appropriate units. For females this will mean related, compatible herds covering a number of generations. In the long term, zoos will need to 'grow' these herds through breeding but for the immediate future these will probably need to be established by co-operatively experimenting with combinations of cows already in zoos to ensure, if at all possible, compatible herds can be developed. Too many zoos appear to accept the fate of lone elephants or pairs of elephants within their 'herd' that are not compatible with the remaining animals. Such an approach would not be possible and certainly not desirable in many (if any) other social species in zoos, so why elephants? Zoos need to consider the herd as the focus, rather than becoming overly fixated or too attached to particular animals to the detriment of judicious regional management. Likewise, reproductive planning on an institutional basis must coincide with strong, long-term regional collection planning and studbook management to support the aspiration to 'grow' and manage biologically appropriate herds. Thus moving single young cows to other institutions should not occur (unless incompatibilities develop, which should not be the case within a related herd), but rather trios or more of compatible, related elephants should be moved on to form the nucleus of new herds. Once zoos reach carrying capacity, assuming there is not a demand for captive-bred elephants in range states (and culling is still considered unacceptable for elephants), reproduction will probably need to be managed in such a way that each herd is self-sustaining with birth rates being equivalent to mortality rates whilst maintaining a stable age pyramid. Thus, matriarchal herds would be comparatively stable with the movement of bulls between zoos maintaining the genetic integrity of the population. The low rate of reproduction required will be a cause of concern in relation to reproductive senescence, social enrichment and learning, etc, but in the absence of culling,

and an outlet for captive bred elephants, I see little alternative.

Clearly, for the foreseeable future, reproduction in captivity is likely to yield at least as many bull calves as cows, which is more than zoos need or can currently handle. As a result, zoos either need to develop an ethically acceptable manner in which the proportion of bull calves born can be reduced or culled, or develop a long-term strategy for the management of a large and growing population of bulls within zoos. It is conceivable, though currently unlikely that zoos could play a role in repopulating bulls in Asia where they have historically been reduced by sex-biased poaching for tuskers resulting in a heavily skewed sex ratio. However, for a multitude of reasons, this is unlikely to occur in the short to medium term and would require well-adjusted, socialized bulls that had grown up in appropriate social scenarios, not to mention considerable levels of funding from zoos.

At this time, it is difficult to hypothesize what the answer might be for bull elephants and their management in captivity, but I suspect facilities with large, complex spaces in warmer climates may provide the best chance to experiment with bachelor herds. Ideally the bulls would be provided with the space and environmental complexity (topography, vegetation, visual barriers, etc, and physical separation when required) to avoid each other when needed, but also the opportunity to choose contact when desired. Ideally, they should be in a region less reliant upon indoor facilities because these animals will almost inevitably have to be managed in a comparatively hands off manner owing to the space required and the fact that they are bulls. These herds could not only then attempt to address the surplus bull issue, but also provide zoos with the genetic resources they can utilize when needed for breeding. Thus bulls from these hypothetical herds could be selected to visit cow herds on a breeding loan or to remain on a more permanent basis. Such an approach, is more natural in the sense of bulls visiting stable cow-based herds, and likely to be more successful than moving individual cows from a herd situation to be mated by a bull elsewhere. Thus any collection which wants to breed elephants should plan for 'difficult', 'hands-off" bulls rather than relying on cows being moved on for breeding or on artificial insemination. I also think it appropriate, that zoos which attempt to hold bachelor herds, and in doing so, help to solve a potentially very difficult and growing issue for zoos, be collectively compensated by those institutions focusing primarily on cow herds. Initial trials in Spain with young Asian bulls, appear promising but only time will tell whether or not these will work in the longer term as the bulls mature.

The management of elephant diets in captivity is also ripe for improvement, and not just from a nutritional perspective. In order to manage elephant welfare in captivity, zoos should strive to replicate elephant feeding ecology in the wild. To do this zoos need to dissipate feeds both spatially and temporally from 'events' to a continuous, omnipresent opportunities and should include feeds outside of zoo working and opening hours. Thus elephant feeding should take up the majority of the animals' time in captivity without predisposing them to obesity. Thus 'low-quality' bulk feeds spread through out the day should be provided, preferably where the elephant is required to manipulate, process or work for the food. This has additional benefits other than keeping the elephant active. By reducing the significance of individual feeds, aggression commonly reported in captive herds at feeding time may also be dissipated, and could facilitate a more cohesive herd structure within captivity. Increasing the time occupied by this inherently rewarding behaviour, also reduces the opportunity for elephants to develop other 'vices' such as destroying infrastructure and stereotyping. Access to a natural grazing sub-

strate is the most obvious solution to this, but something that can only be realistically achieved for the ultimately desirable larger herds in extensive areas. It would certainly be advantageous, if not necessarily attainable for all elephant holding facilities to provide their herds (which should be of a biologically relevant size) with sustainable areas for grazing because the space provided will also allow for behavioural opportunities over and above that relating to feeding.

In order to ensure elephants are active on natural substrates even in more temperate regions, it may be worthwhile experimenting with techniques used in the care of reptiles where hot spots are rotated within an enclosure to encourage activity. Multiple shelters, sufficient to protect from wind and rain located in outdoor facilities with heat provided on a rotating basis might encourage increased levels of activity on more natural substrates over and above the levels typically seen in temperate zoos during winter, particularly when combined with the provisioning of feeding devices or opportunities. Thus elephants would be empowered to make choices to seek food, contact, shelter, exercise, etc, even in winter. Clearly designing and building such a system capable of withstanding the interest of such powerful and intelligent animals is a challenge, but one which may be well worth pursuing.

With regards to the other aspects of the physical environment, other than the obvious suggestion of providing enough space that elephants can graze for most of their time, zoos really need to start addressing the basics. Facilities must not predispose animals to injury or disease which it could be argued, they appear to do at present to greater or lesser degrees. If one uses a precautionary approach for behavioural needs and elephant welfare, that is to say an approach that does not rely upon proof of suffering but rather focuses on factors likely to be of welfare significance to the elephant as described, the way forward seems (to me at least) surprisingly clear and entirely obvious. In my opinion, if zoos can provide elephants with environments that are sufficiently large and complex to be capable of sustaining the grazing pressure of functioning, biologically appropriate social units which feed for the majority of any given day, for the majority of the year, without predisposing the animals to any health defects then I believe we could feel far more confident about the welfare of elephants in our care. The issue of affordability and practicality is one that must be addressed on an institutional basis, but I do believe, it is within our power to manage elephant welfare to a high standard in captivity.

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