THE WELFARE, HOUSING AND HUSBANDRY OF ELEPHANTS IN UK ZOOS

FINAL REPORT

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1. EXECUTIVE SUMMARY OF FINDINGS

- Seventy-seven elephants were housed in UK zoos during this study. Forty-one (53.2%) were Asian and thirty-six (46.8%) African. Their ages ranged from 0.6 to 50 years (Asian) and 0.5 to 40 years (African).

- The elephants were kept in a wide range of husbandry conditions. Even within a zoo, husbandry differed according to an individual's sex, age, species, history, hormonal status, individual temperament, the season and current zoo policy. It was therefore difficult to make generalised findings about overall welfare in relation to housing and husbandry using a conventional statistical approach based on zoo means, but we were able to analyse a range of specific factors affecting or indicating an individual elephant's welfare.

- The total amount of outdoor space available to each individual during the winter ranged between 280 and 22,514m^2, and during the summer between 280 and 36,422 m^2. Most of the outdoor enclosures prevented natural walking patterns that would be adopted by wild elephants. Some of the changes in space allowance when an elephant was moved from the outdoors to the indoors were large. One individual was housed during the day in an enclosure that was 15,527m^2 but during the night was housed singly in an enclosure measuring 17.9m^2. This individual stereotyped for 23.4% of the day – the second highest frequency recorded.

- The elephants spent up to 83% of their time indoors. The total amount of indoor space available to each individual ranged between 17.9 and 560.0m^2 with a mean of 165.9m^2.

- There were concerns about foot health, gait and being overweight (see below). Otherwise, most of the elephants appeared to be in good physical health. The keepers and staff were all highly skilled at detecting health issues such as injuries and disease, and whenever necessary, took appropriate corrective action. The majority of skin lesions were minor (grazes and small cuts, often caused by interactions with other elephants). Keepers were always aware of these minor injuries and if they were more than superficial, they were treated and monitored.

- Stress levels were monitored using faecal cortisol metabolite (FCM) measurements. African elephants had higher FCM than Asians. The range of FCM concentrations in UK zoo elephants was similar to those reported for wild elephants. The highest mean FCM concentrations for zoos were similar to the maximum FCM values recorded from a bull elephant during relocation from the UK to France – a putatively stressful procedure. Elephants kept in larger groups had higher FCM concentrations, but this was probably due to the African elephants (with naturally higher FCM) usually being kept in larger groups than the Asians. African elephants which had experienced a birth in their group had higher FCM than individuals in a group which had not, although this relationship was not significant for the Asian elephants.
- Foot health was a major welfare concern for the elephants; 19.9% had major problems with their forefeet and 8.0% with their hind feet. Sixty-six elephants had their foot health scored on all three visits over 18 months; only 13 of these (19.6%) were scored as having no problems on all three occasions.

- Only 11 of the elephants were scored as having a normal gait; 22% had an imperfect gait, 35% were mildly lame and almost a quarter of the national herd (23%) had an obvious limp or were severely lame. Older elephants had poorer gaits. Elephants with larger amounts of outdoor space during summer had better gaits.

- Only 6 individuals were scored as having normal bodyweight; 75% were categorised as 'overweight' or 'very overweight'.

- Comparing the health and welfare of the UK elephants with those of extensively managed elephants in India, the UK elephants had considerably fewer skin lesions, similar foot health scores, but poorer locomotion scores than the extensively managed elephants of a similar age.

- The time budgets indicated that UK zoo elephants spent approximately 45% of the day-time and 35 % of the night-time, eating. Aggressive interactions were rarely recorded, totalling less than 0.1% of observations.

- Of the 77 elephants, 42 (54%) showed stereotypies during the day-time. More than a quarter (25.9%) of the elephants stereotyped for more than 5% of the day-time. Older elephants stereotyped during the day-time more than younger animals, although 5 young (<15 yrs of age) elephants stereotyped for more than 5% of the day-time. Almost 50% of the Asian elephants in UK zoos performed stereotypies whereas 25% of Africans exhibited these behaviours. In addition, the Asians stereotyped for almost three times as long as the Africans. Elephants provided with less outdoor space during the winter or summer stereotyped more during the day-time.

- 41 elephants which could be reliably identified were filmed at night. More than a third (36.6%) stereotyped for more than 5% of the night-time. One individual stereotyped for 53.2% of the night. Elephants with a small amount of indoor space stereotyped at night significantly more than elephants with a medium amount. Elephants in larger outdoor enclosures stereotyped more when indoors at night.

- Of the 41 elephants that could be reliably identified during both the night-time and day-time, almost half (46.3%) stereotyped for more than 5% of the 24-hr period. One individual stereotyped for 60.8% of 24-hrs. Elephants with a small amount of indoor space stereotyped over 24-hrs significantly more than elephants with a medium amount of indoor space

2. GENERAL INTRODUCTION

(Note: Throughout this document term 'zoo' includes both zoological gardens and wildlife parks)

The life of any zoo-housed animal is markedly different to that of a wild-living conspecific. Many of these differences could be considered positive. For example, zoo animals are protected from predators, receive regular medical checks and are rarely short of food or water. Other aspects are not so positive. Opportunities for exercise may be limited by relatively small enclosures that might also be rather barren, thereby reducing or frustrating the expression of some behaviours such as migration or novel foraging opportunities. Natural patterns of reproduction and/or mate selection are restricted or prevented, and the abundance of food combined with lack of exercise, can lead to obesity. Specific welfare concerns for zoo-housed elephants include their physical health (e.g. foot and joint problems and their tendency to become overweight), behaviour (abnormal behaviours including stereotypies) and problems of high mortality levels and reduced reproductive success.

Elephants are flagship species in zoos throughout the world. They are highly entertaining animals for the public, and attract considerable numbers of visitors and great revenue for zoos. As a consequence, zoos have both ethical and economic interests in ensuring their elephants have a high standard of welfare. However, several reports (e.g. Clubb and Mason, 2002; Anon, undated; RSPCA Campaigns web-page) argue that the welfare of elephants in zoos is not as high as it could be. This is of such great concern that some animal welfare groups have actively campaigned to stop breeding programmes and the placing of any more elephants into zoos. This campaign is obviously resisted by zoos. Unfortunately, the ensuing debate within the UK has been conducted in the absence of objective, independent data on the welfare of the elephants, because no such studies have been conducted. Defra, with joint funding from RSPCA, BIAZA and IFAW, commissioned this research programme to fill this gap.

The aim of this study was, therefore, to provide objective, independent data on the welfare of elephants in UK zoos to assist the stakeholders in this debate. We point out from the very beginning of this report that the purpose was NOT to make recommendations on whether elephants should be kept in zoos. This decision can only be made by the relevant stakeholders.

2.i Objectives

This programme of research had four primary objectives:

(1) Gather expert opinion from an Elephant Welfare Expert Panel to finalise methods of welfare assessment and select variables for data collection during zoo visits;
(2) Collect welfare-relevant data from all participating UK zoos that house elephants by visiting each zoo three times;
(3) Obtain comparative data from wild African elephants and Asian elephants captive in an extensive environment;
(4) Objectively document the current state of welfare of elephants housed in UK zoos and the relationship to their housing and husbandry.

The Introduction, Methods, Results and Discussion pertinent to each of these objectives are included in the chapters that follow.

3. OBJECTIVE 1
Gather expert opinion from an Elephant Welfare Expert Panel to finalise methods of welfare assessment and select variables for data collection during zoo visits

3.i Introduction

One of the most complex problems of any study on animal welfare is that there is rarely agreement as to which are the best indicators of welfare. There is generally considerable debate about which indicators should be measured, even amongst experts when studying well-researched species. Zoo animals are frequently species for which there is relatively little published scientific information, and the animals can be difficult to observe closely or inspect. Therefore, it was decided that, given the multiple sensitivities of those concerned about keeping elephants in zoos, we should consult with many parties as to how they believed elephant welfare should be assessed. The purpose of Objective 1 was to ensure that data collected during visits to the zoos would be relevant, and that all parties concerned would have a fair and equal say in which measures of welfare should be included. This was done using a Quasi-Delphi technique that supplemented existing literature on elephant welfare with expert opinion.

3.ii Methods

Electronic mail messages were sent to 81 people with a range of elephant and animal welfare expertise. Suggestions for experts to contact were taken from representatives of the study funding bodies, literature searches and word of mouth. Each UK zoo or wildlife park housing elephants was asked to suggest one or more relevant experts within their zoo (e.g. a senior elephant keeper). Experts were asked whether they would be prepared to become members of an Elephant Welfare Expert Panel (EWEP) to help finalise methods of welfare assessment and select variables for data collection during zoo visits. Those who responded positively to our invitation were subsequently sent a questionnaire comprising four questions, i.e.

> 1) In your opinion, what are the ten most important indicators of good welfare in zoo/safari park elephants?
>
> 2) In your opinion, what are the ten most important indicators of poor welfare in zoo/safari park elephants?
>
> 3) In your opinion, what are the ten most important factors likely to lead to good welfare in zoo/safari park elephants?
>
> 4) In your opinion, what are the ten most important factors likely to lead to poor welfare in zoo/safari park elephants?

The full questionnaire, together with the covering letter that accompanied it to explain the study, can be found in Appendix 1.

Once membership of the EWEP had been finalised, members were asked for their consent to their names being shared with other EWEP members.

3.iii Results

Fifty experts (62%) replied to our invitation indicating that they would participate, and subsequently returned completed questionnaires. Their areas of expertise included zoo curators and managers, elephant keepers, zoo vets, zoo inspectors, biologists and behaviour and welfare scientists.

In answer to the questions about the most important indicators of welfare, 43 (86%) respondents listed some aspect of behaviour as one of the ten most important indicators, while 42 (84%) mentioned some aspect of physical health. Nineteen (38%) respondents mentioned some aspect of behaviour ahead of health, while 19 (38%) mentioned some aspect of physical health ahead of behaviour.

Responses to the questions about factors likely to lead to good and poor welfare included a variety of factors related to elephants' physical and social environment, housing and husbandry. Wherever possible, this information was incorporated into data gathering materials to be used during the study.

One EWEP member indicated that he preferred to remain anonymous, and the names of the remaining 49 members were subsequently shared within the EWEP by electronic mail.

3.iv Discussion

Response rates to non face-to-face questionnaire surveys are often low. A recent review found an average response rate to postal surveys of 52% (White et al., 2005). Therefore, we were pleased with the 62% response rate to our invitation and questionnaire. The respondents represented a good range of expertise, and their responses were diverse.

The EWEP provided a valuable knowledge base of elephant experts, some of whom we consulted again during the study for advice on specific areas. Their answers to the questions about indicators of good and poor welfare in zoo elephants confirmed that our preliminary intention, to assess welfare using a combination of behaviour, health and physiology, was a sound approach. Responses to the questions about factors likely to lead to good and poor welfare in elephants supplemented our own knowledge, and assisted us in preparing a comprehensive set of questionnaires and data sheets for the zoo visits.

4. OBJECTIVES 2 (Collect welfare-relevant data from all participating UK zoos that house elephants by visiting each zoo three times) AND 4 (Objectively document the current state of welfare of elephants housed in UK zoos and the relationship to their housing and husbandry)

4.i Introduction

Elephants are flagship species in zoos throughout the world. They are highly entertaining animals for the public, and attract considerable numbers of visitors and great revenue for zoos. As a consequence, zoos have both ethical and economic interests in ensuring their elephants have a high standard of welfare. However, several reports (e.g. Clubb and Mason, 2002; Anon, undated; RSPCA Campaigns web-page) argue that the welfare of elephants in zoos is not as high as it could be. This is of such great concern that some animal welfare groups have actively campaigned to stop breeding programmes and the placing of any more elephants into zoos. This campaign is obviously resisted by zoos. Unfortunately, the ensuing debate within the UK has been conducted in the absence of objective, independent data on the welfare of the elephants, because no such studies have been conducted. Defra, with joint funding from BIAZA, IFAW and the RSPCA, commissioned this research programme to fill this gap. The aim of this study was, therefore, to provide objective, independent data on the welfare of elephants in UK zoos to assist the stakeholders in this debate. Such data could only be collected directly, i.e. during the course of a number of visits by the project team to the UK zoos which housed elephants.

We visited most zoos once to introduce ourselves and discuss details of the study, before any data were collected. Using this approach, we gained the co-operation of all 13 UK zoos and wildlife parks that kept elephants.

Co-operation in sensitive areas (e.g. videotaping elephants' night-time behaviour) was secured by assuring the zoos that data would be presented in an anonymous form. Further, we agreed that we would not copy videotapes, and that tapes from each zoo would be the property of that zoo and would be returned to them at the conclusion of the study. Appendix 2 contains the consent statement signed by each zoo Director or authorised other and the study's Principal Investigator (MH).

<u>Husbandry - Introduction</u>

Systems of keeping and managing elephants vary fundamentally between UK zoo. Even within zoos, elephants can be handled and managed by different methods (for example, keepers may share the same unrestricted space with cow elephants but not with bulls). Three basic systems exist for handling elephants: free contact (FC, in which elephants and keepers share the same unrestricted space); protected contact (PC, in which contact occurs via a barrier) and no contact (NC, where physical contact between the elephants and the keepers does not occur). The division between these handling methods is not distinct, however, as some elephants are handled using two methods (for example, experienced keepers may share free contact with an elephant, whereas newer keepers use protected contact). In addition, a variant of protected contact, semi-protected contact, occurs in one UK zoo. In this method, elephants and keepers are separated via a barrier, although this is not a full protected contact wall. Table 4.2 details the handling method(s) used for each UK zoo elephant at the beginning of this study.

A major advantage of free contact handling is that it allows close contact between elephant and keeper, facilitating health inspections, management and veterinary treatment. Free contact generally requires elephants to be highly trained. Elephant keeping is a dangerous profession and keepers are probably more at risk of injury or death when interacting with elephants in a free contact situation (Gore et al., 2006). Protected contact, a relatively new handling system for

elephants, is based on voluntary compliance of elephants with commands, reinforced by rewards. The system is intended to allow the same health and veterinary access to elephants as does free contact, with improved safety for keepers because they do not share the same space with elephants. In practice, however, it may be more difficult to carry out detailed inspections and management such as foot maintenance in protected contact (personal communication with UK zoo elephant keepers). Zero contact handling means that elephants are not routinely handled or trained by their keepers. Control over the elephants' behaviour by keepers is minimised, and risks of keeper injury or death are reduced. However, should health problems occur, investigation and treatment are likely to require sedation or anaesthesia, which carry risks to the elephant.

Behaviour – Introduction

"Behaviour is one of the most easily observed indicators of [animal] welfare: it provides information about animals' needs, preferences and internal states" (Mench and Mason, 1997). Careful observation and interpretation of normal (e.g. eating, drinking, social behaviour, sleeping) and any abnormal behaviour (e.g. excessive aggression, stereotypies) can be used to gain a good overall picture of the welfare of an animal or animals.

Stereotypies are commonly defined as unvarying, repetitive behaviours that have no obvious goal or function (Ödberg, 1978). They are most often observed where animals are confined and there are constraints on their ability to perform certain behavioural patterns (Mason, 1991). The relationship between stereotypic behaviour and animal welfare is complex: more information on this subject is presented in the Discussion.

Health – Introduction

Physical health is one of a range of indicators that can be used to assess animal welfare (Brambell Committee, 1965; Hughes and Curtis, 1997). While good health does not necessarily equal good welfare, ill-health is very often linked with poor welfare. However, an animal's welfare may not be impaired by illness or injury until and unless it experiences a symptom of the condition such as pain (e.g. see Duncan, 1993). For this reason, researchers using health as an indicator of welfare generally do so in combination with other measures (e.g. behaviour and physiology), and must ensure that their findings are carefully interpreted.

Locomotion score – Introduction

Lameness had been highlighted as a problem affecting zoo elephants in Europe (e.g. by Clubb and Mason, 2002). A number of reports describe the causes of lameness and possible risk factors in elephants but the magnitude of the problem has yet to be fully evaluated.

Stashak (2002) defined lameness as any indication of structural or functional disorder affecting one or more limbs or the back [sic]. Kinematic studies have precisely defined variability in normal gait in the elephant (Hutchinson et al., 2006) and proposed that the identification of outliers may be one means by which musculoskeletal abnormalities could be detected at an early stage. Hutchinson et al. (2006) demonstrated that the gait of elephants is fundamentally similar to that of other mammals, with differences limited to a shorter stride length relative to size and lack of limb phases, for example trot or gallop. Gait changes associated with pain and pathology have been characterised in other species by kinematics (Buchner et al., 1996; DeCamp, 1997; Flower et al., 2005) or by behavioural observation (O'Callaghan et al., 2002; Stashak, 2002). Large scale, standardised quantification of lameness prevalence has been made possible in other species following the development of a repeatable numerical rating scales for the behavioural

indicators of locomotor pain, for use under field conditions (Kestin et al., 1992; Welsh et al. 1993; Clarkson et al., 1996; Stashak, 2002).

Faecal cortisol metabolites (FCM) – Introduction

Stressful conditions stimulate the hypothalamic-pituitary-adrenocortical axis to release adrenocorticotrophic hormone which results in the release of glucocorticoids, mainly cortisol or corticosterone (depending on the species) from the adrenal gland. Increased glucocorticoid concentrations have been recorded in a number of species after putatively stressful events, e.g. transport of cats (*Felis catus*; Farca et al., 2006), restraint of cheetahs (*Acinonyx jubatus*; Jurke et al., 1997) and introducing elephants (*Elephas maximus*) into a new herd (Dathe et al., 1992; Schmid et al., 2001).

Cortisol output is often measured using blood or saliva samples, although this can be problematic. First, whilst these methods of sampling may be practical in domesticated animals, they are considerably more hazardous in most zoo animals. Second, the stress associated with handling during collection can elevate recorded cortisol concentrations, thereby invalidating the data. Third, due to the pulsatile release of cortisol, a single sample might not reflect the prevailing cortisol concentrations; accurate assessment can only be made with multiple samples (Brown et al., 1995), but this can be stressful for the animal, again invalidating the data. It is advantageous therefore, to measure cortisol non-invasively using a sample representative of prevailing concentrations. Methods for analyzing cortisol metabolites in urine or faeces have been developed in several species to try to overcome these problems. In elephants, cortisol has been measured in urine (Asian elephants; Brown et al., 1995), faeces (African elephants; Wasser et al., 2000; Stead et al., 2000; Ganswindt et al., 2003) and saliva (African and Asian elephants; Dathe et al., 1992). Of these methods, faecal analysis is optimal because samples can be obtained whilst avoiding direct contact with a potentially dangerous animal. We therefore collected faeces from elephants in each zoo to analyse for faecal cortisol metabolites.

4.ii Methods

Three visits were made to each of the 13 zoos in the UK housing elephants. Visits lasted 1-3 days and were spaced apart by at least 3 months. The initial visit was used to collect baseline data on facilities, management and elephants' life histories, with any changes noted at the second and third visits. During each visit, the welfare of each elephant was assessed using a range of physiological and behavioural indicators, direct examination of the elephants, and reports from zoo staff. Literature searching and questionnaire replies from the EWEP on factors likely to lead to good and poor welfare in zoo elephants were used to devise questionnaires and observation sheets used during the zoo visits, as follows:

i Elephant life history questionnaire (one per elephant);
ii Keeper questionnaire (one per zoo);
iii Standardised health check questionnaire (one per elephant, completed at each visit);
iv House and paddock description sheets (one per area).

One researcher (MH) completed all questionnaires. Appendix 3 contains specimen questionnaires and direct observation sheets used during the zoo visits.

Behaviour – Methods

Behaviour was observed for approximately eight hours per elephant during each visit, using a standardised recording sheet developed for live observations of daytime behaviour. Appendix 4 contains an ethogram of behaviours recorded.

Behavioural observations were distributed throughout the morning and afternoon as much as possible to represent the elephants' 'average' day. Elephants were observed wherever they were at the time – outdoors or indoors. Observations were conducted in 1-hour blocks, during which instantaneous samples were made for each individual at 1, 2 or 3-minute intervals (depending on the number of elephants being simultaneously observed). At each time interval the researcher counted to 10 while watching the elephant's behaviour, then noted the behaviour being performed at the count of 10 seconds. This method enabled identification of stereotypic behaviour, which we defined as an unvarying, repeated behaviour which persisted for at least 10 seconds or (in the case of locomotor stereotypies such as route-tracing) three repetitions. The 1-hour blocks of observations were separated by 10-minute breaks to improve independence of the data and to reduce errors due to observer fatigue.

To supplement daytime behavioural observations, CCTV video equipment was installed at 10 zoos to make videotape recordings of night-time behaviour, and one zoo allowed us to make recordings using their equipment. Zoo staff were asked to make three night-time videotapes per week for three weeks. One observer (Una Quaid) made behavioural observations from the videotapes, starting at the beginning of each tape, usually approximately 17:00-19:00 hours. An instantaneous sample was taken for each individual at 10-minute intervals, using the count-to-ten method described above, until the tape ended, usually when the elephant staff started work in the morning.

Health check – Methods

Standardised health-check questionnaires were devised to be completed by visually inspecting elephants' body areas and simultaneously asking a senior elephant keeper about the health of each body area. Photographs and thermographic images were taken as part of the health-check.

A skin lesion was defined as a visible or palpable, active abnormality. Healed scars and old wounds were not defined as lesions. Major foot problems were defined as: abscess(es); infection; rot; complicated nail cracks; significant overgrowth of the nail(s), cuticle(s) or pad(s); or significant injuries. Minor foot problems were defined as: uncomplicated nail cracks (small cracks which did not extend into the cuticle); minor overgrowth of the nail(s), cuticle(s) or pad(s); or minor injuries. 'Tushes' are small tusks, sometimes present in female Asian elephants. A tusk or tush problem was defined as a recent break that crossed the pulp, required treatment or was otherwise complicated. Minor chips, wear and tear were considered normal for elephants, and not defined as a problem. Several elephants had grooves on their tusks from rubbing on bars or ropes; these grooves were not included as health problems. In some cases it was possible for us to inspect top teeth visually but inspecting bottom teeth, even in elephants trained to open their mouths, proved impossible. Thus the health of teeth was almost exclusively assessed by asking the elephant keeper. Some elephants will open their mouths so that the keepers can look inside. In other cases, indirect evidence such as an ability to eat without difficulty and normal faeces are used to ascertain the normality of teeth.

Faecal cortisol metabolites (FCM) – Methods

At each visit, up to four faecal samples per elephant were collected (ideally, morning and afternoon samples on two days). Where possible, samples were collected from freshly passed, warm boluses. Samples were removed from the faecal bolus in a standardised manner: the bolus was broken open and two small sub-samples (approx 30 cc each) removed from the centre, avoiding any fibrous lumps. Sub-samples were stored in separate containers labelled with the zoo identifier, elephant's name, date and time. Samples were frozen as soon as possible after collection and kept frozen at -30ºC until they arrived at the lab for assaying. They were transported on dry ice to the lab. Although two samples per bolus were collected, only one was sent to the lab, the other being kept in the freezer in case of samples being lost in transit. In the event, this precaution was unnecessary, and extra samples were disposed of at the end of the study.

Of necessity, collection of faecal samples was opportunistic as it relied on a sample from an identifiable individual having been passed recently. This meant we were able to collect multiple samples from some elephants at a single visit but not others. In cases where multiple samples were collected, these were all sent for analysis and included in the data as a mean for that elephant on that visit. An elephant's overall mean FCM was calculated from the three visits.

A detailed description of the methods used to assay the FCM can be found in Ganswindt et al. (2003).

Locomotion score – Methods

Behavioural indicators of lameness include:

1. Limp (observable signs of uneven weight bearing)
2. Tenderness – maximum limb swing slow, gentle/careful foot placements, bilaterally shortened strides (with acceleration, limb swing frequency should increase with stride length – however, stride length may not alter greatly in lame animals)
3. Abnormal foot placement (not heel first)
4. Abnormal foot position in relation to other feet (abduction, adduction, not heel first)
5. Stiffness - reduced joint movements, straight-limb gaits, reduced limb carriage (foot lift)
6. Abnormal limb swing - limb swing medial or lateral of the sagittal plane
7. Postural changes (particularly head carriage i.e. nodding behaviour and spine arching)
8. Inability to accelerate normally and reach top speed for an elephant

A numerical rating scale similar to that used to score lameness in bovines (Whay et al., 1997) has demonstrated features of repeatability and reproducibility for scoring elephant locomotion (Rajapaksha, 2005). An observer (Mr Nick Bell) with several years experience of objective gait score analysis in cattle and other species, used direct observation of the elephants and examined videotapes of the elephants walking and turning to assign locomotion scores according to the scoring system presented in Table 4.1.

Table 4.1 Locomotion score for elephants.

Score	Description	Assessment criteria
0	Sound/Normal	• Walks without any visible gait abnormalities • Locomotion symmetrical (about the sagittal plane i.e. left compared with right); weight evenly balanced • Accelerates and turns normally (adjusted for body mass and age)
1	Imperfect/Abnormal – not lame or tender	• Walks without limp or tenderness but gait not consistent with a sound / normal animal (perhaps due to conformation)
2	Abnormal - perhaps lame or tender	• Signs of lameness observed without certainty or inconsistently
3	Mildly lame	• Some sign of tender footedness or stiffness • Limp only identifiable after careful and repeated assessments (i.e. affected limb or limbs not identified immediately)
4	Lame	• Obvious limp (affected limb unmistakeable) OR • Obvious tenderness or stiffness • Arched back posture may be evident while turning
5	Severely lame	• Mobility obviously compromised • Shows great reluctance walk and to bear weight on the affected limb • Shows exaggerated postural changes e.g. hanging and nodding movements of the head, arched spine

Foot health score - Methods

Based on the researcher's examination of the elephants' feet and/or the keeper's comments, each foot was given a score of 0 (no problem), 1 (minor problem) or 2 (major problem). Major foot problems were defined as: abscess(es); infection; rot; complicated nail cracks; significant overgrowth of the nail(s), cuticle(s) or pad(s); or significant injuries. Minor foot problems were defined as: uncomplicated nail cracks (small cracks which did not extend into the cuticle); minor overgrowth of the nail(s), cuticle(s) or pad(s); or minor injuries. Foot scores were summed for all four feet of each elephant, meaning the maximum score each elephant could be given was 8. This would indicate a severe problem with all four feet.

Body condition score – Methods

Photographs of numerous zoo and wild elephants from a range of sources were obtained, preferably taken from the rear of the animal. These photos were examined by an experienced (SH) and inexperienced (CS) researcher. The body condition of each individual was discussed and scored on the basis of spinal protrusion, hip visibility, roundness of the body, and the amount

of tissue covering the thigh areas. A score of 3 was considered normal, a score of 1 was very fat and a score of 5 was very thin. Photos of the UK zoo elephants taken from the rear were then examined and scored independently by the researchers. Scores were compared and disagreements were discussed until a score was agreed. This entire scoring process was then repeated. When the second scores did not agree with the previous (this was never by more than 1.0), the scores were discussed until agreement between the two researchers was reached. The data presented in the results are the final scores given to the elephants. For those elephants for which it was impossible to gain a suitable photograph, the body condition score was taken from direct observations by an experienced researcher (SH). Seven elephants at one zoo were moved overseas prior to collection of the body condition score data.

Statistical analysis – Methods

We note that for some of the analysis, the database was not amenable to the conventional statistical approach. In databases where animals are housed as groups, it is usual to avoid pseudoreplication by using a mean of all the animals in the group, i.e. the zoo would be the statistical unit. However, in this approach it is usual that all the animals in a statistical unit are the same sex, age, have the same history, etc. This was not the case in the present study. For example, a zoo might house an adult male elephant that was wild-caught as a youngster, had spent 15 years in a circus, and is now individually housed with protected contact. This same zoo might have a young female elephant that had been born in that zoo, is housed in a herd of several other females and immature males, and is in free contact handling. Clearly these animals are not similar. In addition, because zoos had different herd compositions (e.g. not all zoos had male elephants or immature elephants) only some zoos could be included in an analysis based on zoo as the statistical unit, thereby severely reducing the size of the database. Another complication is that the herds are not static in their composition. Elephants are moved from one zoo to another where different handling methods might be used, the social organisation of the herd might be disrupted, etc. This also influenced the dataset meaning that the number of elephants or degrees of freedom differ between some analyses. Perhaps most importantly, it should be remembered that we have studied two different species which can differ markedly in their physiology and behaviour. With all these factors in mind, the statistical analysis on many occasions used the individual elephant as the statistical unit. Whilst we accept this might not provide the most robust conventional analysis, we believe it is more meaningful if we are to take into account the great variation between these animals.

We also note that due to repeated analysis on a single dataset, there was an increased probability of a Type I error (i.e. false positive error). This was unavoidable due to the limited dataset. Data used for each analysis were tested for normality and we used parametric or non-parametric statistics as appropriate.

4.iii Results

At the start of the study, seventy-six elephants were present in UK zoos. Forty elephants (52.6%) were Asian, and thirty-six (47.3%) African. Their ages ranged from 0.6 to 50 years (Asian) and 0.5 to 40 years (African) at the start of the study. In cases where elephants were born recently and in captivity, their ages were known exactly; in other instances ages were approximate.

The history of the elephants varied greatly. Twenty-two (55%) Asians and 16 (44.4%) Africans were born in captivity; 14 (35%) Asians and 20 (55.6%) Africans were wild-caught. Four Asian elephants (10%) were of unknown origin. Perhaps because they were younger, all of the African elephants were of known origin. Some elephants had lived in several captive collections, including zoos and circuses, prior to being moved to their current location, and in several cases,

the complete history of older elephants was unknown. The elephants' backgrounds and handling methods at the start of the study are detailed in Table 4.2.

Table 4.2 Background of elephants in UK zoos at the start of the study.

Elephant	Name	Sex	Species	Age (years) *	Where born**	Wild or captive born	Handling method ***	History †	Arrived
1.		F	Asian	50	Sri Lanka or Thailand	Wild	Free + protected contact	Zoo (UK)	1965
2.		F	Asian	40	Unknown	Wild	No contact		1966
3.		F	Asian	39	Unknown	Wild	Free contact	Zoo(Ireland) Circus Zoo (Europe)?	1994
4.		F	Asian	39	Unknown	Wild	Free contact	Zoo(UK)	1995
5.		F	Asian	39	Unknown	Unknown	Free contact	Circus (Europe)	1999
6.		F	Asian	36	India	Wild	Free contact	Zoo (UK)	1976
7.		F	Asian	36	India	Wild	Free contact	Zoo (UK)	1976
8.		F	Asian	36	India	Wild	Free contact	Zoo (UK)	1976
9.		F	Asian	38	Burma	Unknown	Free contact	Zoo (UK)	1994
10.		F	Asian	37	India	Wild	Free contact	Zoo (UK)	1971
11.		F	Asian	37	India	Wild	Free contact	Zoo (UK)	1971
12.		F	Asian	35	Ireland?	Captive	Semi-protected Contact	Zoo (UK)	1977
13.		M	Asian	34	India	Unknown	Protected contact	Zoo (Europe) Zoo (UK) Zoo (UK)	1997
14.		F	Asian	34	India	Wild	Free + protected contact	Zoo (Europe) Zoo (UK) Zoo (UK)	1990
15.		F	Asian	34	Unknown	Unknown	Free contact	Circus (Europe)	1999
16.		F	Asian	26	Burma	Captive	Free contact	Zoo (Europe) Zoo (Europe)	1999
17.		F	Asian	26	Sri Lanka	Wild	Free contact	Orphanage (Asia) Zoo (Asia) Zoo(UK)	2001
18.		F	Asian	24	Burma	Captive	Free contact	Zoo (UK)	1991

					(Logging camp)				
19.		F	Asian	24	Burma	Captive	Free contact	Zoo (Europe) Zoo (Europe)	1999
20.		F	Asian	23	Burma (Logging camp)	Captive	Free contact		1989
21.		F	Asian	23	Burma (Logging camp)	Captive	Free contact		1989
22.		F	Asian	23	Burma (Logging camp)	Captive	Free contact	Zoo(UK)	2001
23.		F	Asian	21	Malaysia	Wild	Free contact	Zoo (Asia) Zoo(UK)	2001
24.		F	Asian	21	Burma	Wild	Free contact	Zoo (Europe)	1991
25.		F	Asian	20	Burma	Wild	Free contact		1991
26.		M	Asian	14	USA (Zoo)	Captive	Protected contact	n/a	1997
27.		F	Asian	14	West Bengal (Sanctuary)	Captive	Free contact		1997
28.		M	Asian	12	West Bengal (Sanctuary)	Captive	Protected contact		1997
29.		F	Asian	12	West Bengal (Sanctuary)	Captive	Free contact		1997
30.		M	Asian	10	Switzerland (Zoo)	Captive	Protected contact	n/a	1997
31.		F	Asian	9	Born here	Captive	Free contact	Born here	n/a
32.		F	Asian	9	West Bengal (Sanctuary)	Captive	Free contact		1998
33.		F	Asian	8	Born here	Captive	No contact	Born here	n/a
34.		F	Asian	7	Born here	Captive	Free contact	Born here	n/a
35.		F	Asian	7	Born here	Captive	Free contact	Born here	n/a
36.		F	Asian	2	Born here	Captive	Free contact	Born here	n/a
37.		F	Asian	2	Born here	Captive	Free contact	Born here	n/a
38.		M	Asian	1.5	Born here	Captive	Free contact	Born here	n/a
39.		M	Asian	1.5	Born here	Captive	Free contact	Born here	n/a
40.		F	Asian	0.6	Born here	Captive	Free contact	Born here	n/a
41.		F	African	40	Unknown	Wild	Protected contact	Zoo (Europe)	1997

42.		F	African	36	Unknown	Captive	Semi-protected Contact	Zoo (UK)	1977
43.		F	African	36	Zimbabwe or South Africa	Wild	No contact		1972
44.		F	African	35	Unknown	Wild	Protected contact	Zoo (Europe) Zoo (Europe)	1997
45.		F	African	34	Unknown	Wild	Protected contact	Zoo (Europe)	1998
46.		M	African	28	Zimbabwe	Wild	No contact		1985
47.		F	African	28	Israel (Zoo)	Captive	No contact	n/a	1994
48.		F	African	28	Zimbabwe or Tanzania	Wild	No contact		1985
49.		F	African	27	Israel (Zoo)	Captive	No contact	n/a	1994
50.		F	African	24	Africa	Wild	Free contact	Zoo (UK)	1983
51.		F	African	24	South Africa	Wild	Protected contact	Zoo (UK)	1983
52.		F	African	22	Zimbabwe	Wild	Free contact ††	Zoo (UK)	1993
53.		M	African	21	Zimbabwe	Wild	Protected contact	Zoo (UK)	1993
54.		F	African	21	Zimbabwe	Wild	Free contact ††	Zoo (UK)	1993
55.		F	African	20	Born here	Captive	No contact	Born here	n/a
56.		F	African	20	Zimbabwe	Wild	Free contact	Circus (UK) Zoo (UK) Zoo (UK)	1998
57.		F	African	20	Zimbabwe	Wild	Free contact	Circus (UK) Zoo (UK) Zoo (UK)	1998
58.		M	African	20	South Africa or Zambia	Wild	Protected contact	Circus (UK)	1990
59.		F	African	18	Israel (Zoo)	Captive	No contact	n/a	1988
60.		F	African	18	Israel (Zoo)	Captive	No contact	n/a	1988
61.		F	African	18	Zimbabwe	Wild	Free contact ††	Zoo (UK)	1993
62.		F	African	18	Zimbabwe	Wild	Free contact ††	Zoo (UK)	1993
63.		F	African	13	South Africa	Wild	Free contact	n/a	1998
64.		M	African	12	South Africa	Wild	Free contact	n/a	1998
65.		M	African	12	South Africa	Wild	Free contact	n/a	1998

66.		F	African	12	South Africa	Wild	Free contact	n/a	1998
67.		M	African	11	Israel (Zoo)	Captive	Free contact ††	n/a	1998
68.		F	African	11	Born here	Captive	No contact	Born here	n/a
69.		F	African	8	Born here	Captive	No contact	Born here	n/a
70.		F	African	7	Born here	Captive	No contact	Born here	n/a
71.		M	African	2.5	Born here	Captive	Protected contact	Born here	n/a
72.		F	African	2	Born here	Captive	Free contact ††	Born here	n/a
73.		F	African	1.7	Born here	Captive	Free contact ††	Born here	n/a
74.		M	African	1	Born here	Captive	Free contact	Born here	n/a
75.		F	African	0.6	Born here	Captive	No contact	Born here	n/a
76.		M	African	0.5	Born here	Captive	No contact	Born here	n/a

* In some cases (where dates of birth are unknown) ages are approximate
** 'Born here' denotes the elephant was born at the zoo in which it was living at the start of the study
*** Some individuals were handled by more than one method, e.g. were in free contact with more experienced keepers while less experienced staff handled them using protected contact
† This column lists each location where the elephant had been kept since birth in chronological order, with UK zoos denoted as 'Zoo (UK)'. In many cases complete historical information was unknown, so only known locations are listed. 'n/a' indicates that the elephant arrived at its present location direct from its birth place
†† One zoo used a system of limited free contact between keepers and elephants, which did not rely on elephants being trained

The group compositions of the elephants are summarised in Table 4.3. There were many fewer males than females, particularly individuals greater than 10 years old (10 males cf. 48 females). This probably reflects the difficulty of housing and controlling males adequately. In this sample, males were on average younger than females.

Table 4.3 The social composition of elephants in UK zoos (accurate at first data-gathering visit). Ages are shown in parentheses.

Zoo	Species	Number of elephants (ages in years)				Total	Actively attempting breeding
		Elephants > 10 years		Elephants <10 years			
		Males	Females	Males	Females		
A	Asian		3 (40,39,39)		1 (8)	4	No
B	Asian		4 (39, 37, 37, 34)			4	No
C	African		3 (40, 34, 34)			3	No
D	Asian	1 (10)	4 (50, 38, 34, 24)	1 (1.5)	2 (9, 2)	8	Yes
E	African	1 (20)	4 (24, 24, 20, 20)	2 (2.5, 1)		7	Yes
F	African	1 (28)	8 (36, 28, 28, 27, 20, 18, 18, 11)	1 (0.5)	3 (8, 7, 0.6)	13	Yes
G	African	2 (21,11)	4 (22, 21, 18, 18)		2 (2, 1.7)	8	Yes
H	Asian + African		2 (36, 35)			2	No
I	Asian	1 (34)	5 (36, 36, 36, 26, 24)		1 (0.6)	7	Yes
J	Asian		2 (22, 20)		3 (9, 7, 7)	5	No
K	African	2 (12,12)	2 (13, 12)			4	Yes
L	Asian	1 (14)	5 (26, 23, 23, 23, 21)	1 (1.5)	1 (2)	8	Yes
M	Asian	1 (12)	2 (14, 12)			3	Yes
TOTAL		10	48	5	13	76	
Mean age		17.4	27.3	1.4	4.9		

During the course of the study, changes occurred in the size and composition of six of the herds, resulting in a national herd size of 69 at the end of the study (9 males and 42 females aged over 10 years and 18 elephants aged under 10 years). These changes are shown in Table 4.4. In addition, at the end of the study, 5 females at 4 zoos were known to be pregnant. An African calf was born in September 2006, an Asian calf in November 2006 and another Asian calf in January 2007, leaving one pregnant African elephant (due approximately August 2007) and one pregnant Asian (due approximately January 2008).

Table 4.4 Changes in herd composition during the course of the study.

Zoo	Species	No. elephants at start of study	No. elephants at end of study	Explanation of change
A	Asian	4	3	1 female aged >10 yrs died between second and third visits
D	Asian	8	9	1 female aged >10 yrs acquired from French zoo between initial and second visits
F	African	13	11	3 females aged >10 yrs transferred to another UK zoo, and 1 calf born, between second and third visits
I	Was Asian, now African	7	3	2 females aged >10 yrs and 1 female aged <10 yrs transferred to European zoo between initial and second visits; 1 male aged >10 yrs and 3 females aged >10 yrs transferred to European zoo, and 3 females aged >10 yrs acquired from another UK zoo, between second and third visits
J	Asian	5	4	One female aged <10 yrs transferred to another UK zoo between second and third visits
L	Asian	8	8	One female aged >10 yrs euthanased between initial and second visits; one female aged <10 yrs acquired from another UK zoo between second and third visits

Environment – Results

Zoo elephants typically inhabit two environments - the indoor house and the outdoor enclosure. Outdoor enclosures were often spacious and varied, although some were relatively small. Indoor housing also differed greatly between zoos, ranging from small and barren individual housing to considerably larger and more enriched group facilities. Of the eight zoos that housed mature males, three had separate bull houses. When indoors, cows at five zoos were individually-housed, but were group-housed at six other zoos. The remaining two zoos housed their cows in a mixture of individual and group-housing.

Some houses included visitor observation areas (7/13 zoos), while the remainder were off-show to the public. Most elephants spent the majority of their 24-hour day confined indoors (Table 4.5). In four zoos, there were some days during the winter when the weather was too inclement for the elephants to be given outdoors access for the entire 24 hrs (estimated range 1-20 days, based on information supplied by elephant keepers). In the remainder of zoos, elephants were let out, or offered voluntary access to outdoor areas, even in the worst winter weather.

Access between houses and outdoor enclosures was variable, with some zoos allowing voluntary access and others not. During the summer, three zoos left their elephants outside for several weeks, while in the others, elephants were always brought indoors at night. Differences in access between indoor and outdoor areas were largely determined by the security of outdoor areas and how they were accessed (directly from the elephant house(s) or via other areas requiring keepers' supervision during transfer) and in some cases, due to local regulations.

Outdoor enclosures varied widely in the amount of space provided, the shape, arrangement and contents. Outdoor floor substrates included grass, mud, clay, sand, concrete, gravel and hardcore. Some zoos gave elephants access to different enclosures at different times of the year, alternated use between areas (e.g. to allow grass to regrow), or simply varied the areas to which the elephants had access to provide variety. Some elephants were taken out of their enclosures during the day for walks, swimming, or to spend time in fields or woods. Some performed displays for the public, either within or outside their house or enclosure. A wide variety of environmental enrichment objects was provided for elephants, both in indoor and outdoor areas. Some of these included water (artificial or natural pools, wallows and waterfalls), rocks and mounds, plants, wood (tree trunks, branches, blocks), chains (alone or with attachments), tyres, and feeding devices (feeding walls, hay nets, puzzle feeders and many unique methods of hiding or making elephants work to obtain food).

Some elephant houses were old, refitted buildings, whereas others had been purpose-built. Arrangements for heating and lighting the houses were variable. Indoor flooring was generally concrete or concrete and tile, although some zoos used rubber or rubberised concrete and sand. Some floors sloped to aid drainage and some were heated. In some zoos, elephants shared indoor air space with other animals. Elephant housing varied within zoos (e.g. bull houses were constructed differently from cow houses). Elephant exhibits were generally rather busy places as elephants are very popular with zoo visitors; however, most zoos reduced their opening hours during winter months and two of the wildlife parks closed to the public during the winter. Elephant keepers at nine zoos cared for elephants exclusively, while at the remaining four they also cared for a range of other species. The number of keepers per elephant was variable.

The small sample size (N=13 different zoos) and wide range of housing conditions meant that it was difficult to draw generalisations between many aspects of the environment and welfare. For example, eleven zoos used concrete or concrete and tile indoor flooring, and only two used some rubber or rubberised concrete. The small number of elephants housed on rubberised floors precluded, for example, testing the effects of floor type on foot health.

Table 4.5 Features of general husbandry of elephants in UK zoos.

Zoo	Features of general husbandry	Approx. no. hours / day spent indoors *
A	Some limited access between house and paddock at night	Summer: 16 or free access Winter: 18 (max. 24)
B	Elephants regularly walked through zoo or to field / woods	Summer: 16 or free access Winter: 17 or free access
C	Elephants outside during day, inside at night	Summer: 16 Winter: 21 (max. 24)
D	New house has several separate areas; elephants able to 'hide' from public indoors. When outdoors, some elephants separated from main group in smaller, less enriched off-show area	Summer: 17 or free access Winter: 19 (max. 24) or free access
E	Regular public feeds (some elephants only); elephants outside during day, inside at night	Summer: 16.5 Winter: 17.5
F	Elephants outside day and night during summer	Summer: 0 Winter: 17
G	Some limited access between house and paddock at night (females and calves only)	Summer: 15 or free access Winter: 17 (max. 24)
H	Free access between house and paddock during daytime; elephants inside at night	Summer: 13 Winter: 15
I	Two separate cow groups; elephants outside day and night during summer	Summer: 0 Winter: 17
J	Extra paddock used in summer which greatly increased amount of available outdoor space	Summer: 16.5 Winter: 18 or free access
K	Alternate use between two outdoor paddocks (different size and shape); elephants outside during day, inside during night	Summer: 16 Winter: 19
L	Separate cow groups; multiple outdoor areas; females and calves regularly walked through the park and to woods	Summer: 0 Winter: 20
M	Different paddocks used at different times of year; females regularly walked through the park, sometimes swim in lake	Summer: 14 Winter: 17

* 'Max. 24' indicates that on some days during an average winter, elephants were not let outdoors at all

Indoor Space Allowance - Results

When indoors, some elephants were individually-housed; others were housed in groups of 2 to 6. The total amount of indoor space available to each individual ranged between 17.9 and 560.0m^2, with a mean of 165.9m^2 (±158.1 SD). Where space was shared between elephants, the amount of indoor space available/elephant was calculated. We made no allowance for different body sizes or age as it could be argued either that larger animals require more space than juveniles because of their size, or that more space is required by juveniles for play. The range of indoor space available to individuals ranged between 14.5 and 240.0m^2/elephant, with a mean of 59.3m^2 (±40.9 SD) (Figure 4.1).

Figure 4.1 Frequency Distribution Of The Indoor Space Available For Elephants In UK Zoos

Outdoor Space Allowance – Results

Outdoor space was usually shared by several elephants. We calculated the total amount of outdoor space available to each elephant, and also the amount of outdoor space available/elephant, again with no allowance for differences in body size or age. In addition, the outdoor space allowance of elephants often changed seasonally; different areas of the enclosure were used in the winter compared to the summer. The summary data for outdoor space allowance are given in Table 4.6.

Table 4.6 Summary data of the outdoor space allowance provided to zoo elephants in the UK.

	Outdoor space allowance		
	Min (m^2)	Max (m^2)	Mean±SD (m^2)
Winter:			
Total available to the individual	280	22,514	8,712.9±7,631.1
Available/elephant	140	15,527	1,868.9±2,160.1
Summer:			
Total available to the individual	280	36,422	11,325.9±10,966.3
Available/elephant	140	15,527	2,257.0±2,299.8

Behaviour – Results

For logistical reasons and due to time constraints it was not possible to observe the behaviour of every elephant for eight hours during every visit, although the majority of recordings were of eight hours duration. In some instances, it was not possible to record behaviour in complete 1-hour blocks, and in these instances 30-minute blocks were used. A total of 1,634.5 elephant hours of behavioural observations were made during the visits (520.5 hours at initial visits, 574 hours at second and 540 hours at third visits).

We were unable to record night-time behaviour at two zoos. At one, the house was too small, with insufficient space between elephant enclosures and house walls to allow equipment to be installed safely. At another, the house construction was too complex to allow effective video-recording. At another zoo, the head elephant keeper refused permission for video-recordings to be made inside the bull house, although he allowed installation of equipment in the cow/calf house. Where elephants were group-housed at night, it was not always possibly to identify individuals reliably. Therefore, it is not possible to give an exact number of observation hours/elephant However, night-time observations were made for 52 elephants, 29 Asian and 23 African. The overall day- and night-time budgets of the elephants averaged over three visits are shown in Figure 4.2

Figure 4.2 Day And Night Time Budgets Of Elephants In UK Zoos

Figure 4.2 shows the day and night time budgets of the elephants. Levels of recorded aggression were very low, totalling 0.1% of day-time behavioural observations.

Elephants were out of sight for a mean of 32% of the night-time. Therefore, results are presented as a proportion of time during which the elephant was visible.

Differences between day-time and night-time behaviour were expected, given that larger proportions of the night would have been occupied by resting and sleeping. There was an increase in both the time spent lying and standing during the night-time; eating was reduced, although this was only by a small amount. Trunk resting was seen more during the night than during the day, probably indicating its purported role as a resting posture. Social behaviour was seen

approximately half as frequently during the night compared to the day, and no aggressive interactions between elephants were noted during night-time observations.

Several individuals exhibited an unusual behaviour of 'walking backwards' for varying amounts of time. One individual occasionally route-traced backwards. Overall, elephants walked backwards for 0.8% of day-time observations (range 0.0 to 2.8%).

Behaviour- stereotypies (general) – Results

The elephants were observed to perform several types of stereotypic behaviour, including swaying/weaving from side to side, rocking backwards and forwards, head bobbing, route-tracing, pacing, and walking forwards then backwards. Sometimes these occurred in combination, e.g. head bobbing while weaving. Swaying/weaving was the most common stereotypy, constituting 67% of the day-time and 77.7% of the night-time stereotypic behaviour. Locomotor stereotypies (route-tracing, pacing and walking forwards then backwards) were the next most common stereotypy, forming 27% of day-time and 11.3% of night-time stereotypic behaviour. All types of stereotypic behaviour were combined for the analysis below.

Behaviour- stereotypies (day-time) – Results

Of the 77 elephants for which we collected behavioural data, 42 (54%) showed stereotypical activity during the day-time. Considering only the 29 elephants that showed stereotypies for greater than 1% of the day-time, the mean time stereotyping was 9.2% (±7.8 SD). One individual stereotyped for over 30% of the day-time. The frequency distribution of the amount of time the elephants stereotyped during the day-time is presented in Figure 4.3 and Table 4.7. There was a highly significant effect of zoo on the mean amount of time that the elephants spent stereotyping during the day ($F_{1,76}$=2.9, P=0.003).

Figure 4.3 Frequency Distribution Of The Amount Of Stereotypical Activity Performed During The Day-Time By Elephants In UK Zoos
(NB: 2 elephants stereotyped for exactly 5% of the day-time, therefore data presented in Figure 4.3 appear to differ slightly from Table 4.7)

Table 4.7 Summary data of stereotypic activity by elephants in UK zoos.

	Day-time	Night-time*	24-hrs*
Nos. elephants never seen stereotyping	35 (45%)	21 (51%)	13 (32%)
Nos. elephants stereotyped <1 % time	13 (17%)	1 (2%)	6 (15%)
Nos. elephants stereotyped 1 to 5 % time	11 (14%)	4 (10%)	3 (7%)
Nos. elephants stereotyped >5% time	18 (23%)	15 (37%)	19 (46%)
Total	77	41	41
	Mean % (±SD) time performing stereotypies:		
African	1.0 (2.2)	4.4 (6.3)	6.4 (7.3)
Asian	5.7 (8.1)	6.6 (12.1)	10.6 (16.0)
Male	3.4 (6.2)	8.8 (17.9)	10.7 (20.1)
Female	3.5 (6.6)	4.8 (6.6)	8.4 (10.9)
All elephants in UK zoos	3.5 (6.5)	5.7 (10.0)	8.9 (13.2)
Minimum	0.0	0.0	0.0
Maximum	31.8	53.2	60.8

* data only from 41 individuals which could be individually identified

There was a significant effect of species (Kruskal-Wallis χ^2=8.637, N=77, 1 df, P<0.01) on the amount of time spent stereotyping during the day-time (Table 4.7). During the day-time, 20 (48.7%) of the Asian elephants performed stereotypies for >1% of the time compared to 9 (25%) Africans. Considering data only from these elephants, the Asians stereotyped for 11.6% (±8.2 SD) of the time compared to 3.8% (±3.0 SD) for the Africans (Kruskal-Wallis χ^2=8.13, N=29, 1 df, P<0.01). There was no significant effect of sex on the amount of time spent stereotyping during the day-time when the data were analysed separately for either the Asian (Kruskal-Wallis χ^2=0.239, N=41, 1 df, NS) or African (Kruskal-Wallis χ^2=0.426, N=36, 1 df, NS) species.

There was a significant, positive correlation between age and the percentage of day-time for which the elephants stereotyped (Kendall's tau b=0.322, N= 77, P<0.001), i.e. older elephants stereotyped during the day-time more than younger animals. Five young (<15 yrs old) elephants stereotyped for more than 5% of the day-time. One of these was an 8-year old female who was born in the zoo where she was observed; she stereotyped for 8.9% of the day-time, and 3.5% of the night-time.

There was a significant effect of birth-place (Kruskal-Wallis χ^2=9.75, N=77, 2 df, P<0.05) and species (Kruskal-Wallis χ^2=8.63, N=77, 1 df, P<0.005) on the amount of day-time stereotyping (Table 4.8). The four elephants with an unknown birth-place stereotyped (numerically) more than those born captive or wild. Of these four elephants, all were Asian, two were obtained from a circus and one was described as having spent its earlier years in a zoo where the conditions were 'cramped'.

Table 4.8 The mean percentage of day-time stereotyping in relation to birth-place.

Origin	Mean % (±SD) of the day-time performing stereotypies			N
	Asian	African	Total	
Unknown	13.8 (±10.1)	No elephants	13.8 (±10.1)	4
Wild	6.8 (±8.0)	1.6 (±2.7)	3.9 (±6.1)	35
Captive	3.4 (±7.0)	0.2 (±0.3)	2.1 (±5.5)	38
TOTAL	5.7 (±8.1)	1.0 (±2.2)		

Elephants that had been in a circus at some time in their life stereotyped during the day-time (N=8; 10.6%±7.8 SD) significantly more than elephants which had not been in a circus (N=69; 2.7%±5.9 SD) (Kruskal-Wallis χ^2=11.3, N=77, 1 df, P<0.001).

There was no effect of housing elephants indoors either individually or in groups on the amount of time stereotyping during the day-time (Kruskal-Wallis χ^2=0.63, N=76, 1 df, NS).

There was an overall significant effect of handling method on the amount of day-time stereotyping (Kruskal-Wallis χ^2=14.5, 3 df, P<0.01), although this differed between the species. Table 4.9 shows that Asian elephants stereotyped the most in 'protected' contact compared to elephants which had 'no contact', or 'free' contact (Kruskal-Wallis χ^2=9.37, 3 df, P<0.05). For African elephants, 'free' contact was associated with the greatest amounts of day-time stereotypying (Kruskal-Wallis χ^2=9.53, 3 df, P<0.05). We emphasize that these differences might be due to a species confound, with different methods preferentially used by the zoos to handle African and Asian elephants due to perceived species-differences in temperament.

Table 4.9 The mean percentage of day-time stereotyping in relation to handling method.

	Mean % (±SD) day-time performing stereotypies			N
	Asian	African	Total	
Protected	12.8 (±7.9)	1.2 (±2.3)	6.7 (±8.1)	15
No contact	5.0 (±5.4)	0.1 (±0.3)	0.8 (±2.3)	15
Free	4.2 (±7.6)	2.8 (±3.5)	3.9 (±6.9)	40
Contact/little training	No elephants	0.2 (±0.4)	0.2 (±0.4)	7
TOTAL	5.7 (±8.1)	1.0 (±2.2)		

When data from all the elephants were considered (including those which did not stereotype), there was no overall correlation between the percentage of day-time stereotyping and the individual's mean FCM (Kendall's tau b=-0.113, N=76, NS). The correlations were also non-significant if considered independently for Asian (P=0.359) and African elephants (P=0.329).

If data from only those elephants which stereotyped for greater than 1% of the day-time were considered, there was no overall correlation between the percentage of day-time stereotyping and the individual's mean FCM (Kendall's tau b=-0.113, N=76, NS). When these data were considered separately for the two species, there was no significant correlation for the Asian (Kendall's tau b=0.095, N= 18, NS) but there was a significant, negative correlation for the African elephants (Kendall's tau b=-0.592, N= 9, $P<0.05$).

If data from only those elephants which stereotyped for greater than 5% of the day-time were considered, there was no overall correlation between mean individual FCM and the percentage of day-time stereotyping (Kendall's tau b=0.015, N= 20, NS). When these data were considered separately for the two species, there was no significant correlation for the Asian elephants (Kendall's tau b=0.167, N= 16, NS) or African (Kendall's tau b=-0.183, N=4, NS).

There was no significant effect of performing stereotypies for more or less than 1% of the day-time on FCM (Kruskal-Wallis χ^2=0.378 N=76, 1 df, NS). Similarly, there was no significant effect of performing stereotypies for more or less than 5% of the day-time on FCM (Kruskal-Wallis χ^2=0.246, N=76, 1 df, NS).

There was a significant (unexpectedly) positive correlation between the time stereotyping during the day-time and the amount of indoor space available/elephant (Kendall's tau b=0.268, N=77, P=0.01) i.e. those elephants with more space/individual indoors stereotyped more during the day (when they would normally be outside). There was no correlation between the time stereotyping during the day-time and the total amount of indoor space available to the elephant (Kendall's tau b=-0.07, N=77, NS).

There was a significant, negative correlation between the amount of time stereotyping during the day-time and total amount of outdoor space available to an individual during summer (Kendall's tau b=-0.339, N=76, P=0.001) and during winter (Kendall's tau b=-0.211, N=76, P=0.01), i.e. those elephants provided with more outdoor space during the summer or winter stereotyped less during the day-time (Table 4.10, Figure 4.4 and 4.5).

There was a significant, negative correlation between the amount of time stereotyping during the day-time and the amount of outdoor space available/elephant during the summer (Kendall's tau b=-0.185, N=76, P=0.03), i.e. those elephants provided with more outdoor space during the summer stereotyped less during the day-time. This relationship was not significant for the amount of space available/elephant during the winter (Kendall's tau b=-0.085, N=76, NS).

Table 4.10 The significance of correlations between outdoor space allowance and time stereotyping during the day-time.

Outdoor space allowance	Correlation with time stereotyping during the day-time	
	Tau b	P
Total winter space available to the individual	-0.211	0.01
Total summer space available to the individual	-0.339	0.001
Winter space available/elephant	-0.085	NS
Summer space available/elephant	-0.185	0.03

Figure 4.4 Time Stereotyping During The Day And The Total Amount Of Space Available Outdoors During Winter

Figure 4.5 Time Stereotyping During The Day-Time And The Total Amount Of Space Available Outdoors During Summer

Behaviour - stereotypies (night) – Results

Of the 52 elephants filmed at night, at least 22 (44%) performed stereotypical behaviour. Forty-one individuals could be reliably identified during the night-time. Of these individuals, 20 (48%) performed stereotypical activity at night ranging between 0 and 53.2% of the night-time, with a mean of 5.7% (±10.0 SD) (Figure 4.6). The following data and discussion refer only to the 41 identifiable elephants.

There was no significant effect of species (Kruskal-Wallis χ^2=0.0001, N=41, 1 df, NS) or sex (Kruskal-Wallis χ^2=0.275, N=41, 1 df, NS) on the amount of time stereotyping during the night-time (see Figure 4.7 and Table 4.7). Numerically, Asians stereotyped more at night than Africans, and males stereotyped more than females. It should be noted that the data from the Asian males, i.e. those which stereotyped most, were from only two individuals. There was no significant correlation between the time stereotyping during the night-time and the individual's mean FCM (Kendall's tau b=0.03, N=41, NS), or age (Kendall's tau b=0.189, N=41, NS).

Figure 4.6 Frequency Distribution Of The Amount Of Stereotypical Activity Performed During The Night-Time By Elephants In UK Zoos

Figure 4.7 Amount Of Night-Time Stereotyping By Elephants In UK Zoos

The indoor space available/elephant was categorised as small (<40 m^2/elephant), medium (between 40 and 80 m^2/elephant) or large (>80 m^2/elephant) to give approximately equal numbers of elephants in each space category. There was a significant effect of indoor space category on the time stereotyping at night (Kruskal-Wallis χ^2=7.74 N=41, 2 df, P<0.05). Elephants with a small amount of indoors space stereotyped during the night-time more than elephants with a medium amount, and elephants with a large amount stereotyped for an intermediate time (Table 4.11).

Table 4.11 Night-time stereotypical activity by elephants in UK zoos in different indoor space categories.

Space allowance	Mean % time stereotyping during the night-time (±SD) *
Small	12.1 (±17.6)
Medium	1.6 (±3.1)
Large	8.1 (±8.8)

* data only from 41 individuals which could be individually identified

There was a highly significant, positive correlation between time stereotyping during the night-time and the amount of outdoor space available/elephant for both the winter (Kendall's tau b=0.582, N=41, P<0.001) and summer seasons (Kendall's tau b=0.449, N=41, P<0.01), i.e. elephants with larger outdoor enclosures stereotyped more when indoors at night (Table 4.12 and Figures 4.8 and 4.9).

Figure 4.8 Time Stereotyping During The Night-Time And The Amount Of Space Available Per Elephant Outdoors During Winter

Figure 4.9 Time Stereotyping During The Night-Time And The Amount Of Space Available Per Elephant Outdoors During Summer

Table 4.12 The significance of correlations between outdoor space allowance and time spent stereotyping at night.

Outdoor space allowance	Correlation with time stereotyping during the night-time	
	Tau-b	P
Total winter space available to the individual	0.07	NS
Total summer space available to the individual	-0.183	NS
Winter space available/elephant	0.582	<0.001
Summer space available/elephant	0.449	<0.01

There was no significant effect of housing the elephants either individually or in groups on the amount of time stereotyping during the night-time (Kruskal-Wallis χ^2=1.3, 2 df, NS).

Behaviour - stereotypies (24-hrs) – Results

Of the 41 elephants identifiable at night, 2 performed stereotypies during the night- but not the day-time, 8 (20%) performed stereotypies during the day- but not the night-time, 18 (44%) performed stereotypies during both the night- and day-time, whereas 13 (31%) did not stereotype during either period. There was a highly significant, positive correlation between the amount of time stereotyping during the night- and day-time, i.e. those individuals which stereotyped more during the night-time also stereotyped more during the day-time (Kendall's tau b=0.536, N=41, P<0.001).

The zoo means for day-time stereotypies (overall 3.7%±13.6 SD) were compared with those for the night-time (overall 5.8±5.4 SD). There was no significant difference between these means (Wilcoxon Sign Test, N=12, Z=-1.15, NS two-tailed). For three of the zoos, the percentage of time

the elephants performed stereotypies more than doubled during the night-time compared to during the day-time. In each case, this was due to large increases for a single animal, which could indicate that the indoor enclosures or night-time husbandry were particularly unsuited for some individual elephants.

For each of the 41 individuals that were identifiable during both the night-time and day-time, the mean amounts of time stereotyping during those time periods were summed. This total denotes the mean time each elephant stereotyped over 24-hr. The mean time performing stereotypies over 24-hrs ranged between 0.0% and 60.7% with an overall mean of 8.9% (±13.1 SD) (Figure 4.10).

Considering the 19 elephants that showed 24-hrs stereotypies for greater than 5% of the time (Table 4.7), the amount of time stereotyping over 24-hrs ranged between 5.9% and 60.8%, with a mean of 18.7% (±14.0 SD).

There was no significant effect of housing the elephants indoors either individually or in groups (Kruskal-Wallis χ^2=1.3, 2 df, NS) and there was no significant effect of species (Kruskal-Wallis χ^2=0.01, 2 df, NS) on the duration of performing stereotypies over 24-hr.

Figure 4.10 Frequency Distribution Of The Amount Of Stereotypical Activity Performed During 24-Hrs By Elephants In UK Zoos

There was a significant effect of indoor space category on the time spent stereotyping over 24-hrs; elephants with a small amount of indoor space stereotyped over 24-hr the most compared to elephants with a medium or large amount of indoor space (Kruskal-Wallis χ^2=7.21, 2 df, P<0.05) (Table 4.13).

Table 4.13 The effects of indoor space allowance on 24-hour stereotypical activity of elephants in UK zoos.

Space allowance	Mean % time stereotyping during 24-hrs (±SD) *
Small	18.3 (±21.2)
Medium	3.1 (±5.2)
Large	11.9 (±12.1)

* data only from 41 individuals which could be individually identified

Health-check – Results

At some zoos (where elephants were trained and health and safety issues allowed), we were able to inspect each part of the elephant's body visually during the health checks. At other zoos, systematic visual inspection was limited or impossible and therefore collection of health data was restricted to asking a senior elephant keeper.

Table 4.14 summarises the health data collected during each visit (NB. not all data are directly comparable due to changes in the social composition). Appendix 5 shows health data summarised by zoo, for each of the three visits.

Table 4.14 Health data of UK zoo elephants at three visits.

No. (% in brackets) elephants displaying health problems of the:	Initial visit (N=76)	Second visit (N=73)	Third visit (N=68)	Overall
Fore feet (major) *	15 (19.7%)	13 (17.8%)	15 (22.1%)	19.9%
Fore feet (minor) **	24 (31.6%)	31 (42.5%)	29 (42.6%)	38.9%
Hind feet (major) *	1 (1.3%)	7 (9.6%)	9 (13.2%)	8.0%
Hind feet (minor) **	27 (35.5%)	29 (39.7%)	29 (42.6%)	39.3%
Eye(s)	2 (2.6%)	2 (2.7%)	2 (2.9%)	2.7%
Ear(s)	0	0	0	0
Tusk(s) / Tush(es) †	0 (0% of 60)	1 (1.9% of 52)	3 (6.1% of 49)	2.7%
Teeth ††	2 (2.6%)	2 (2.7%)	2 (2.9%)	2.7%
Trunk	1 (1.3%)	0	0	0.4%
Tail	1 (1.3%)	1 (1.4%)	1 (1.5%)	1.4%
Faeces / digestion	1 (1.3%)	1 (1.4%)	0	0.9%
Urinary / Sexual organs	6 (7.9%)	6 (8.2%)	6 (8.8%)	8.3%
Systemic disease	0	0	0	0
Skin lesion(s) †††:				
Head / neck	1 (1.3%)	1 (1.4%)	0	0.9%
Face	5 (6.6%)	3 (4.1%)	0	3.6%
Ear(s)	1 (1.3%)	2 (2.7%)	1 (1.5%)	1.8%
Trunk	0	2 (2.7%)	0	0.9%
Chest / abdomen	2 (2.6%)	2 (2.7%)	0	1.8%
Back	4 (5.3%)	3 (4.1%)	0	3.1%
Flank(s)	3 (3.9%)	1 (1.4%)	2 (2.9%)	2.7%
Rump	2 (2.6%)	3 (4.1%)	2 (2.9%)	3.2%
Leg(s)	4 (5.3%)	2 (2.7%)	2 (2.9%)	3.6%
Tail	4 (5.3%)	3 (4.1%)	2 (2.9%)	4.1%
Overweight (in the keeper's opinion)	13 (17.1%)	14 (19.2%)	10 (14.7%)	17.0%
Underweight (in the keeper's opinion)	1 (1.3%)	0	1 (1.5%)	0.9%

* Numbers and percentages refer to number of elephants that displayed one or more problems with one or more of their feet. Major foot problems were defined as: abscess(es); infection; rot; complicated nail cracks; significant overgrowth of the nail(s), cuticle(s) or pad(s); or significant injuries.

** Minor foot problems were defined as: uncomplicated nail cracks (small cracks which did not extend into the cuticle); minor overgrowth of the nail(s), cuticle(s) or pad(s); or minor injuries.

† 'Tushes' are small tusks, sometimes present in female Asian elephants. A tusk/tush problem was defined as a recent break that crossed the pulp, required treatment or was otherwise complicated. Minor chips, wear and tear were considered normal for elephants, and not defined as a problem. Several elephants had grooves on their tusks from rubbing on bars or ropes; these grooves (which were discussed earlier, in the section on behaviour) were not included as health problems. Since not all elephants had tusks/tushes, percentages shown are of those elephants with tusks/tushes.

†† In some cases it was possible to visually inspect top teeth but inspecting bottom teeth, even in elephants trained to open their mouths, proved impossible. Thus the health of teeth was almost exclusively assessed by asking the elephant keeper. Some elephants will open their mouths so that the keepers can look inside. In other cases, indirect evidence, such as the ability to eat without difficulty and normal faeces are used to ascertain the normality of teeth.

††† A skin lesion was defined as a visible or palpable, active abnormality. Healed scars and old wounds were not defined as lesions.

The majority of skin lesions (see Figure 4.11) were minor (grazes and small cuts, often caused by interactions with other elephants). Keepers were always aware of these minor injuries and, where they were more than superficial, they were being treated and monitored. Another source of injuries was accident, e.g. the trunk being trapped in a door or feeder.

Figure 4.11 The Percentages Of Elephants In UK Zoos With Skin Lesions To Areas Of The Body

The health-check questionnaire included questions about and inspection of skin dryness and overgrowth. However, this appeared rather subjective (e.g. the same elephant was scored by one head keeper as having normal skin then, but, after moving to a different zoo, was judged by the new head keeper as having skin that was badly overgrown in several areas). As it is unclear how thickened, dry or overgrown skin relates to welfare, we have not presented the results here.

Foot condition – Results

Table 4.14 shows that foot problems were prevalent. In total 36/76 (initial visit), 44/73 (second visit) and 40/68 elephants (third visit) had a minor problem with one or more feet, and 16/76 (initial visit), 19/73 (second visit) and 20/68 (third visit) had a major problem on one or more feet. We distinguished between 'minor' and 'major' foot problems, although this distinction might not always make a clear division between conditions that are likely to compromise welfare and those that are not. Some of the problems classified above as minor (e.g. simple nail cracks) could be perceived as 'normal'. For example, several elephant keepers described nail cracking as normal in elephants.

It was notable that during the course of this study, the scores for major problems of the hind feet increased from 1.3% (N=1 elephant) at the first visit to 13.2% (N=9 elephants) at the third. This indicates that these substantial problems in the hind feet can develop relatively quickly, although these data suggest they are less prevalent than major problems of the fore feet.

As part of the health checks, photographs and infrared thermographic images were taken of the elephants' feet. The thermographs did not detect any problems that were not already known by keepers, and had been mentioned by them during the interview. This suggests that information gained by keeper interviews about the elephants' health was reliable. It was not possible to take thermal images from non-handled elephants.

Foot health scores – Results

Mean foot health scores ranged between 0.0 and 6.0, with an overall mean of 1.89 (±0.16 SD). This indicates that the 'average' elephant in a UK zoo had at least either one severe foot problem, or two minor problems during the duration of this 18-month study.

Sixty-six of the elephants had their foot health scored on all three zoo visits. Only 13 of these (19.6%) were scored as 0 on all three occasions. Six elephants were scored as 4 or above on all three visits. One animal that scored 6 was euthanased during this project, and another individual was scored as 7 out of a possible maximum of 8 on the final visit. There was no significant effect of sex (Kruskal-Wallis χ^2=0.025, 1 df, NS) or species (Kruskal-Wallis χ^2=0.015, 1 df, NS) on the mean foot health score. However, the foot health scoring system we used might not have distinguished sufficiently between severity and frequency of foot health problems – please see the Discussion.

Figure 4.12 Frequency Distribution Of The Mean Foot Health Score For Elephants In UK Zoos

There was a significant positive correlation between mean foot health score and age (Kendall's tau b=0.182, N=77, P<0.05), i.e. older elephants had more foot problems.

There was no significant correlation between an elephant's mean foot health score and the total amount of indoor space available, total amount of space available outdoors (winter or summer), the amount of indoor space available/individual, locomotion score, the amount of time spent stereotyping during the day-time, night-time, or over 24-hrs, the individual's mean FCM concentration, or body condition score (all Kendall's tau, P>0.1).

There was a significant effect of handling method on mean foot score (Kruskal-Wallis χ^2=13.2, 3 df, P<0.01). Elephants which experienced 'no contact' had the lowest foot scores, i.e. the healthiest feet. It should be noted that for 'no contact' elephants, we obtained the majority of information on foot health by asking the keepers, who themselves were unable to inspect feet closely on a regular basis. It is possible, therefore, that we underestimated the number and/or severity of foot problems because of this limitation, and suggest caution in the interpretation of this result.

Locomotion scores – Results

Figure 4.13 shows that 15.6% of elephants in UK zoos had a normal gait, 22% had an imperfect gait or were perhaps slightly tender, 31% were mildly lame, and 21% had an obvious limp or were severely lame. The mean locomotion score of all UK elephants was 2.4±1.3 (SD). Overall, only two elephants (one African and one Asian) were scored as having the most extreme gait abnormality. One of these animals was euthanased during this project (we believe primarily because of her locomotory problems).

Figure 4.13 Frequency Distribution Of Locomotion Scores Of Elephants In UK Zoos

There was a highly significant, positive correlation between an individual's locomotion score and age (Kendall's tau b=0.348, N=69, P<0.001), i.e. older elephants had poorer gaits.

There was a significant, negative correlation between an elephant's locomotion score and the total amount of outdoor space available in summer (Kendall's tau b=-0.258, N=68, P<0.006) and winter (Kendall's tau b=-0.219, N=68, P=0.02) i.e. elephants with larger amounts of outdoor space during summer and/or winter had better gaits.

The zoo means for the locomotion scores ranged between 2.1 and 3.5, although there was no significant effect of zoo on the locomotion scores (Kruskal-Wallis χ^2=17.3, 11 df, NS). There was no correlation between an individual's locomotion and body condition scores (Kendall's tau b=-0.077, N= 69, P=0.449). Using data from only those animals with a locomotion score greater than 0, there was no significant effect of species, sex, or, handling method on locomotion scores (all Kruskal-Wallis, P>0.05).

There was a significant, positive correlation between the locomotion scores given by the researchers and those given by the keepers as part of the standard health-check questionnaire (r^2=0.17, $F_{1,68}$=13.7, P<0.001), although, the keepers consistently gave lower scores than the researchers. Forty-six of the elephants were scored by their keepers as 0 (normal), whereas the researchers scored these same elephants as 1 or above. Twenty-seven of the elephants were scored by their keepers as 0, whereas the researchers scored these same elephants as 3 or above. This indicates that keepers are significantly underestimating the abnormality of gaits in their elephants.

Ease of lying – Results

Two elephants were thought by the keepers never to lie down. Table 4.15 shows that of those animals which were observed to lie down regularly, over 90% were reported by the keepers as able to do so and return to a standing position 'with ease'. Keepers reported lying down and standing up as 'very difficult' for only two of the animals that lay down regularly, and these were described in this way only on the initial visit; the scores were downgraded on subsequent visits. Overall, 16% (N=12 elephants) were reported to show temporary signs of stiffness.

Table 4.15 summarises locomotion data from the three visits. Appendix 6 shows locomotion data summarised by zoo, for each of the three visits.

Table 4.15 Locomotion data as reported by keepers of UK zoo elephants at three visits

No. (% in brackets) elephants displaying:	Initial visit (N=76)	Second visit (N=73)	Third visit (N=68)	Overall
Gait:				
Walks normally with no signs of difficulty or lameness	65 (85.5%)	65 (89.0%)	60 (88.2%)	87.6%
Walks with mild to moderate signs of difficulty or slight to moderate lameness	6 (7.9%)	5 (6.8%)	5 (7.4%)	7.4%
Walks with considerable difficulty or significant lameness	3 (3.9%)	2 (2.7%)	2 (2.9%)	3.2%
Displays extreme difficulty in walking and/or signs of pain or distress when standing or walking	2 (2.6%)	1 (1.4%)	1 (1.5%)	1.8%
Often sleeps lying down	47 (61.8%)	47 (64.4%)	46 (67.6%)	64.6%
Sometimes sleeps lying down	24 (31.6%)	21 (28.8%)	18 (26.5%)	29.0%
Does not sleep lying down *	5 (6.6%)	5 (6.8%)	4 (5.9%)	6.4%
Lies down only on one side	6 (8.1% of 74)	5 (7.0% of 71)	4 (6.0% of 67)	7.0%
Standing up and lying down appears easy	67 (90.5% of 74)	65 (91.5% of 71)	62 (92.5% of 67)	91.5%
Standing up and lying down appears slightly difficult	5 (6.8% of 74)	6 (8.5% of 71)	5 (7.5% of 67)	7.6%
Standing up and lying down appears very difficult	2 (2.7% of 74)	0 (0% of 71)	0 (0% of 67)	0.9%
Sometimes shows temporary periods of apparent stiffness	12 (15.8%)	12 (16.4%)	11 (16.2%)	16.1%

* Two elephants (initial and second visit) and one elephant (third visit) were thought by their keepers never to lie down. Percentages in the four rows below are of those elephants that did lie down

Body condition scores – Results

The majority of elephants in UK zoos were scored as being overweight (Figure 4.14), with only six individuals scored as 'normal'.

Figure 4.14 Frequency Distribution Of Body Condition Scores

There was a significant effect of zoo on body condition score, i.e. elephants at some zoos were fatter than elephants at other zoos (Kruskal-Wallis χ^2=21.85, 11 df, P<0.05). There was a significant effect of handling method on body score (Kruskal-Wallis χ^2=8.2, 3 df, P<0.05); elephants with no training were the fattest, whereas animals with free contact were the thinnest. Overall, there was no significant regression of body condition score and mean individual FCM (Kruskal-Wallis χ^2=2.2, 2 df, NS). However, if the six animals with normal bodyweight were excluded from the analysis, there was a significant negative correlation between mean individual FCM and body score (Kendall's tau b=-0.208, N= 62, P<0.05), i.e. fatter animals had higher FCM.

There was no significant effect of species, sex, age, or place of birth on body score (all Kruskal-Wallis, P>0.05). There was no correlation between body score and the total amount of outdoor space available in summer (Kendall's tau b=-0.15, N= 68, NS) or in winter (Kendall's tau b=-0.095, N= 68, NS).

Faecal cortisol metabolites – Results

It was not possible to collect faecal samples from each elephant at every visit. However, when multiple samples were collected from an individual, these values were pooled for all the visits and a mean individual value calculated, i.e. the mean individual FCM value was calculated from several samples collected on three separate visits throughout the 18 months of the study. The total number of samples collected was 150 on Visit 1, 153 on Visit 2, and 116 on Visit 3. The number of samples collected from each elephant over the three visits ranged from 1 to 11, with a mean of 5.4, i.e. on average, approximately two samples/elephant were collected on each visit.

The FCM data were normally distributed (Kolmogorov-Smirnov Z=1.02, N=76, P=0.247). The overall mean concentrations on Visits 1, 2 and 3 were all similar and had small indicators of variance, i.e. 454.4 (±9.1 SEM), 445.9 (±8.8 SEM) and 467.9 (±9.8 SEM) ng/g DFM respectively.

One-way ANOVA showed there was a significant effect of zoo on the mean FCM calculated for each zoo ($F_{12,76}$=10.1, P<0.001), i.e. some zoos had significantly higher mean concentrations than others. The maximum mean value for a zoo was 768.0 (±219 SD) and the minimum mean value was 168.6 (±25.0 SD) ng/g DFM (Figure 4.15).

Figure 4.15 Faecal Cortisol Metabolite Concentrations Of Elephants In UK Zoos

Three-way ANOVA showed that there was a significant effect of species ($F_{1,76}$=10.9, P<0.001) and of handling method ($F_{3,76}$=6.5, P=0.001) on the mean individual FCM, but there was no significant effect of sex ($F_{1,76}$=1.9, P=0.16); all of the interactions were non-significant. African elephants (578.1±189.4SD) had higher FCM than Asians (363.9±129.2) ($F_{1,76}$=28.3, P<0.001) (see also Figure 4.15). Figure 4.16 shows that the handling method of free contact with little training was associated with the highest FCM whereas free contact was associated with the lowest levels. Females had numerically higher FCM, but this was not statistically significant (females 475.6; males 423.5).

Figure 4.16 Faecal Cortisol Metabolite Concentrations Of Elephants In UK Zoos According To Handling Method

For the African elephants, there was a significant, positive correlation between an individual's FCM and the total amount of indoor space available to the individual ($r^{2=}0.91$, $F_{1,35}=8.0$, P=0.008), i.e. a greater amount of total indoor space was associated with increased FCM concentrations; there was no significant correlation for the Asian elephants (P=0.117).

There was no overall significant correlation between an individual's FCM and the amount of indoor space/elephant (P=0.646). Considering data only for the Asian elephants, there was a significant, positive correlation between FCM and indoor space available/elephant, i.e. greater space availability was associated with increased FCM; there was no significant correlation for the African elephants (P=0.499).

There was no correlation between an individual's FCM and the total amount of indoor space available to the individual (P=0.98). When the data for FCM and the total sizes of indoors space availability are plotted (Figures 4.17 and 4.18), data points often appeared clustered for each zoo. This possibly indicates that within-zoo factors overwhelmed any relationship between FCM and sizes of the indoors enclosures.

Figure 4.17 Faecal Cortisol Metabolite Concentration And The Amount Of Indoor Space Available For Asian Elephants

Figure 4.18 Faecal Cortisol Metabolite Concentration And The Amount Of Indoor Space Available For African Elephants

There was a significant, positive correlation between FCM and both the total amount of winter outdoor space, and the total amount of summer outdoor space available to an individual (Table 4.16), i.e. elephants with access to more outdoor space in the winter or summer had higher FCM. However, the relationships between FCM and space availability were not significant when these were considered as space available/elephant.

Table 4.16 The significance of correlations between outdoor space allowance and FCM.

Outdoor space allowance	Correlation with FCM concentration			
	r^2	F	P	slope
Total winter space available to the individual	0.073	$F_{1,75}=5.8$	0.018	positive
Asian only			0.66	
African only			0.769	
Total summer space available to the individual	0.321	$F_{1,75}=34.9$	<0.001	positive
Asian only			0.298	
African only	0.25	$F_{1,35}=12.9$	0.001	positive
Winter space available/elephant			0.084	negative
Asian only			0.134	
African only			0.295	
Summer space available/elephant			0.582	
Asian only	0.083	$F_{1,39}=3.4$	0.071	negative
African only	0.191	$F_{1,35}=8.0$	0.008	positive

Two-way ANOVA showed a significant effect of housing the elephants individually indoors on FCM ($F_{1,75}$=4.2, P=0.048) and a significant effect of species ($F_{1,75}$=37.1, P<0.001), with a non significant interaction (P=0.979). Elephants housed individually had lower FCM concentrations compared to elephants housed in groups (454.7±194.6 and 472.3±192.8 SD ng/gDFM respectively).

There was no overall significant correlation between the mean individual FCM of an elephant and its age (P=0.287). Considering only the Asian elephants, there was a highly significant positive correlation between the mean individual FCM of an elephant and its age (r^2= 0.34, $F_{1,39}$=19.5, P<0.001); there was no significant correlation for the African elephants (P=0.984).

Two-way ANOVA showed a significant effect of the number of elephants in the zoo at the beginning of the study on FCM ($F_{7,75}$=5.5, P<0.001) and a significant effect of the species ($F_{1,75}$=13.0, P=0.001), but with a significant interaction ($F_{4,75}$=4.8, P=0.002). The significant interaction was due to the African elephants being kept in significantly larger groups than the Asians. The mean group size for African elephants was 8.9 compared to 6.4 for Asians ($F_{1,76}$=11.5, P=0.001). When considered separately, there was no significant correlation between FCM and group size for either species.

Two-way ANOVA showed that there was no overall significant effect of where the elephants had been born on FCM ($F_{2,75}$=2.1, P=0.129) (Table 4.17) but there was a highly significant effect of species ($F_{1,75}$=31.4, P=0.001), Africans having higher FCM than Asians. If data for the animals of an unknown origin were omitted from this analysis, there was still no significant difference due to birth place but a significant difference due to species.

Table 4.17 Place of birth and faecal cortisol metabolite concentrations.

Origin	Mean (±SD) faecal cortisol metabolite concentration(ng/gDFM)	N
Wild	520.9 (±193.0)	34
Unknown	458.0 (±154.6)	4
Captive	416.3 (±185.9)	38

Two-way ANOVA showed there was a significant effect of there having been a birth in the group ($F_{1,75}$=4.6, P=0.035) and the species ($F_{1,75}$=11.0 P<0.001) on FCM, with a significant interaction ($F_{1,75}$=10.3, P=0.002). Considering only the Asian elephants, there was no significant effect of whether there had been a birth in the herd (P=0.393), although African elephants which had experienced a birth had higher FCM ($F_{1,35}$=11.2, P=0.002) than individuals which had not (627.8±183.6 and 404.1±70.7 SD ng/gDFM respectively). The 28 individuals comprising the Africans which had experienced a birth in the group came from three separate zoos.

Two-way ANOVA showed there was no significant effect of whether an elephant was in a single sex group on FCM ($F_{1,75}$=2.7, P=0.104) but there was an effect of species ($F_{1,75}$=7.1, P<0.009), and a significant interaction ($F_{1,75}$=5.9, P=0.017). Considering only the Asian elephants, there was no significant effect of whether the group was single sex, although African elephants in a mixed sex group had higher FCM ($F_{1,35}$=4.3, P=0.045) than individuals in a single sex group (600.3±189.2 and 400.4±40.5 SD ng/gDFM respectively). Further analysis revealed that only four females made up the group of Africans from a single sex group with lower FCM. Three of these animals were from one zoo and the fourth was a female African kept with a female Asian, i.e. this is highly likely to be an effect of the zoo rather than being kept as a single sex group.

Changes in group composition had no clear effect on FCM. Between the first and second visits, three zoos changed the group composition by the addition or removal of elephants. For two of these zoos, mean FCM was numerically lower at the second visit compared to the first (Figure 4.19). For the third, there was a slight numerical increase (313 to 340ng/gDFM; statistical significance not

tested). Between the second and third visits, three zoos for which FCM data were available changed the group composition by the addition or removal of an elephant, or a death. One of these changes was associated with a slight numerical decrease in FCM, and one a slight numerical increase (statistical significance not tested). The zoo with the greatest FCM concentrations on all three visits did not change the group composition throughout the study. In one zoo, a change in group composition occurred due to the death of a dominant cow elephant; the zoo mean FCM for the surviving elephants significantly increased from 289.0±53.2 prior to her death to 527.6±194.4 SD ng/gDFM after her death ($F_{1,15}$=13.9, P=0.002). This was the greatest increase in FCM recorded during this study. Interestingly, after this elephant's death, the remaining elephants were reported by the keeper as being calmer and easier to handle.

Figure 4.19 Faecal Cortisol Metabolite Concentrations Of Elephants In UK Zoos During Three Visits

There was no significant correlation between an individual's locomotion score and its mean FCM (P=0.226).

4.iv Discussion

Indoor space allowance – Discussion

Elephants in UK zoos can spend up to 83% of their time indoors, making this a significant welfare consideration. Since captive adult elephants sleep for only 4.0-6.5 hours each night and juveniles a little longer (Tobler, 1992), elephants confined indoors are awake for a considerable proportion of that time and therefore conscious of their surroundings rather than asleep. In the present study, small indoor space allowance (<40m^2/elephant) compared to a medium indoor space allowance (between 40 and 80m^2/elephant) was related to increased stereotypical activity during the night-time and over 24-hrs (Tables 4.11 and 4.13). This relationship between increased space allowance and decreased stereotypies did not extend linearly to large indoor space allowance (>80m^2/elephant), possibly because one of the zoos which included a large number of individuals used in the analysis in this classification underwent major renovation during this study. It is possible that the housing and husbandry changes during the building work elevated stereotypies in the elephants in this zoo.

Individual housing – Discussion

It might be assumed *a priori* that because elephants are gregarious and highly tactile species (Adams and Berg, 1980), housing them individually would be a welfare concern. This is supported by Brockett et al. (1999), who reported that individuals in a group of three female African elephants spent half the night within one body length of another. However, in the present study, there appeared to be few indicators of individual housing compromising welfare. Unexpectedly, FCM was significantly higher in group housed compared to individually housed animals. Numerically, the difference was only 4%, suggesting a statistical difference rather than a biologically meaningful difference.

Individually housed elephants usually retained auditory, olfactory and visual contact with other elephants and often also had physical contact (sometimes considerable) between the barriers of adjacent enclosures. Under these circumstances, it appears that individual housing was not associated with indicators of reduced welfare. Some zoo elephants were housed individually for specific health-and-safety related reasons, e.g. because they were aggressive towards other individuals. This was often the case with mature males. However, in some cases, elephants might have been housed individually due to economic considerations. Given that elephants are social and tactile, we intuitively believe that female elephants at least should not be housed individually.

Outdoor space allowance – Discussion

There is no doubt that many of the outdoor enclosures of the UK zoos prevented natural walking patterns by the elephants. Seasonal ranges in the wild are large, between tens to thousands of square kilometres (e.g. De Villiers and Kok, 1997; Fernando and Lande, 2000; Evans, 2007). On a daily basis, female African elephants tended to walk in loops approximately 1 km long, often walking 250 m in a straight line before turning (Dai et al., 2007). Clearly, it would be difficult to provide such areas in zoos.

The welfare implications of limited enclosure size are possibly worse for mature male elephants. Captivity does not prevent male elephants from entering musth. In wild elephants, musth is an annual period of highly elevated testosterone, accompanied by increased bouts of travel, greater interest in females, and heightened aggressiveness (Schulte et al., 2000). Male elephants experiencing musth in zoos may be unable to increase their activity or satisfy their increased interest in females, possibly resulting in heightened frustration. This situation is made worse because captive elephants begin experiencing musth at an earlier age and for a longer duration than elephants in the wild, sometimes for several months (which would be rare in wild elephants) or even continuously (Taylor and Poole, 1998). On one visit during the present study when a male was in musth, the elephant appeared totally unresponsive to the environment. This was confirmed by the keeper who reported that the elephant was also eating considerably less than he would do normally and was very unwilling to co-operate with the keepers. These responses are similar to those of 'learned helplessness' – a condition considered to signify depression in humans (Seligman, 1975).

The amount of outdoor space allowance varied considerably, often between elephants within the same zoo. The difference between zoos was great – the maximum outdoor space allowance per elephant was over 100 times greater than the minimum. The amount of outdoor space had clear effects on the welfare of the elephants. A smaller amount of space available was associated with increased stereotypical activity during the day (Table 4.10), and also with poorer locomotion. There was also a highly significant, positive correlation between outdoor space allowance/elephant and stereotypic activity during the night-time (Table 4.12). This could indicate that elephants with greater outdoors space allowance during the day were more affected (e.g. more frustrated) when brought indoors, than animals provided with smaller amounts of outdoor space. One caveat is that we were unable to get data on stereotypical activity at night from the zoo with the largest enclosure of all due to the housing and husbandry at the zoo.

Increased outdoor space allowance was unexpectedly associated with increased FCM (Table 4.16). Increased exercise has been associated with increased glucocorticoid release, although this is generally only observed under conditions of high intensity exercise (Lane, 2006), well beyond normal locomotion. It seems highly improbable that the elephants in the zoo with the highest FCM value would have voluntarily exercised to such an extent that their levels were 460% greater than the zoo with the lowest FCM concentrations. Larger outdoor enclosures would tend to have greater complexity than smaller ones. This in turn could mean that elephants in the larger enclosures were experiencing increased general arousal and, therefore, a measurable increase in FCM. When the data were analysed separately for the two species (see Table 4.16), the positive correlation remained significant only for the African elephants.

Some of the changes in space allowance when an elephant was moved from the outdoors to the indoors were very large. One individual was housed during the day in an enclosure that was 15,527m^2 but during the night was individually housed in an enclosure measuring 17.9m^2. This individual stereotyped for 23.4% of the day-time – the second highest intensity recorded here. This indicates that a large outdoor space allowance will not necessarily prevent stereotypies. However,

this individual had previously been housed at a zoo where he was reportedly confined for many hours each day, which may have contributed to the high intensity of stereotypic behaviour.

Behaviour – Discussion

Very little aggression between the elephants was observed during daytime (only 0.1% of observations) and none at all at night. These results could have been affected by the use of instantaneous sampling of behaviour rather than continuous observations. However, watching the elephants outside of scheduled observation periods revealed few other instances of aggression.

Schulte et al. (2000) recorded 118 aggressive interactions amongst three African cows during 43 hours of observations, and Adams and Berg (1980) described several aggressive incidents during observations on captive female African elephants, indicating that reasonably high levels of aggression amongst captive elephants can occur. Clubb and Mason (2002) suggested that aggression between zoo elephants is relatively common, possibly caused by small enclosure sizes and restriction of elephants' movement, or social factors such as keeping groups of unrelated females. We found no evidence to support this suggestion.

Stereotypies – Discussion

Stereotypies are highly repeated, relatively invariant, apparently non-functional behaviours that often develop in animals housed in impoverished environments (e.g. Meehan et al., 2004). Our data show that stereotypies were prevalent amongst the elephants in UK zoos: 38% of the elephants performed stereotypical activity for more than 1% of the day-time, and almost 50% of identifiable elephants performed stereotypies during the night-time. The most extreme example was one individual that stereotyped for over 60% of the 24-hr period. Meller et al. (2007) reported that during the day-time, stereotypical activity in a group of 6 Asian elephants ranged between 0.0 and 55.3%, with a mean of 21.7%. During the night-time, stereotypies ranged between 0.0 and 28.7%, with a mean of 10.3%. Elzanowski and Sergiel (2006) reported that a single Asian elephant spent 52% of the daytime in stereotypic movements, 3.5 times the level reported for females in other zoos' groups (i.e. 14.1%). Gruber et al. (2000) reported that 13 penned circus elephants stereotyped for 19% of their observations. The mean time spent stereotyping by the UK elephants reported here was 3.5% and 5.7% of the day-time and night-time respectively (Table 4.7). These intensities of stereotypy perhaps compare favourably with the reports we cite above. However, with our current understanding of stereotypies, any figures suggested as being an 'acceptable' prevalence or intensity must be considered arbitrary. Stereotypies in elephants have previously been noted to occur in conjunction with specific events such as being given food or water (Friend, 1999), being moved between different sections of the enclosure (Wilson et al., 2004), or even associated with changes in ambient temperature (Rees, 2004). In the present study, it was evident that the intensity and/or occurrence of stereotypy often increased in anticipation of events such as feeding or being let into or out of the house. Brief periods of anticipatory stereotypy are probably not a great welfare concern, especially if behaviour is normal at other times of the day. For example, stereotypies can be observed as repeated circling by pet cats and dogs immediately prior to being fed. However, Table 4.7 indicates that almost one quarter of the UK zoo elephants stereotyped for more than 5% of the day-time, over one third stereotyped for more than 5% of the night-time, and almost half the UK elephants stereotyped for more than 5% of the time per 24-hrs. As discussed above, stereotypical activity of this duration is unlikely to be due to short-term frustration. More likely, this represents animals that are in environments (or have been in environments – see below) that are unsuited for their species-specific needs. We believe the prevalence and intensity of stereotypies amongst elephants in UK zoos has been previously underestimated, perhaps considerably.

There is considerable discussion regarding the importance that should be attributed to stereotypies in terms of assessing animal welfare. It has been argued that stereotypies in animals are similar to

those of autistic or mentally retarded humans, and that the progressive brain dysfunction reflects a general disinhibition of the behavioural control mechanisms of the dorsal basal ganglia (Garner et al., 2003). In effect, stereotypic animals can become progressively less able to break out of repeated behaviour patterns. If so, we might expect that some forms of stereotypy will persist despite changes in the environment, i.e. the stereotypy can become emancipated from its original cause. This could include substantial changes such as being moved from one zoo to another. Furthermore, if an animal develops an overall propensity to stereotype, then when the environment changes, the stereotypy might also change to suit the new environment but the performance *per se* is due to the previous environment. This clearly makes it difficult to state unequivocally whether an observed stereotypy is caused by the animal's current or previous environment. However, several observations indicate that the current prevalence and intensity of stereotypic behaviour by elephants in UK zoos can not be attributed solely to previous experience at another zoo. A paper which investigated stereotypic behaviour in one UK zoo approximately 10 years prior to the current study indicated that three elephants in the zoo did not perform stereotypies at that time. Our data indicate that two of these three elephants (still in the same zoo) now perform stereotypies. Four others in the zoo have increased the intensity of their stereotypies, the greatest increase being from 4.3% to 17.6% of the day-time. Furthermore, one young elephant, born in a UK zoo and still housed there with its mother, exhibited stereotypic behaviour for 8.9% of the day-time. This elephant's mother stereotyped for 15.4% of the day-time; Cooper and Nicol (1994) found that animals may be more likely to develop stereotypies if nearby animals already perform them.

There was a considerable species-difference in the prevalence and intensity of stereotypical activity. Almost 50% of the Asian elephants in UK zoos performed stereotypies whereas 25% of Africans exhibited these behaviours. Furthermore, of those elephants which stereotyped during the day, the Asians stereotyped for almost three times as long as the Africans. It appears that the Asian elephants were more susceptible to factors which induce stereotypies, whether these were historical or due to their current conditions. A difference between Asian and African elephants in the frequency of stereotypic behaviour has been noted previously (e.g. see Clubb and Mason, 2002), although the reasons for the difference are not clear. Stereotypic behaviour in our study was noted to increase with age, so the fact that Asian elephants were on average 4.6 years older could have partly accounted for the difference. Alternatively, differences in stereotypy performance may reflect different responses to captivity between Asian and African elephants.

In captive elephants, some stereotypies might be associated with the causation or prolonging of health problems. Stereotypic rocking or swaying was mentioned by several keepers in UK zoos as a possible causative factor of foot problems in elephants (see also Fowler, 2001). Five elephants in this study had noticeable tusk grooves, associated with repeated rubbing on areas of their environment, e.g. wire-fencing. These did not appear to cause discomfort but might weaken the tusk, increasing the likelihood of it breaking. According to Weissengruber et al. (2005), tusk damage which does not cross the pulp is relatively painless. However, breaks which do cross the pulp can be significant medical problems in elephants, sometimes requiring surgical intervention. This probably indicates reduced welfare where stereotypic behaviour is linked with associated health problems.

Health – Discussion

During health checks where both inspection of the elephant and asking the keeper were possible, we did not detect a problem that the keeper did not also refer to. This suggests that systematic questioning of an experienced elephant keeper about elephant health was a reliable method of gaining information. Nevertheless, where elephants are not handled or handling is limited, it seems inevitable that keepers are less knowledgeable about their elephants' physical health than in zoos where elephants are regularly handled and checked. Therefore health problems could have been under-estimated in these zoos.

Other than foot health (see below), locomotion scores and body condition scores, the elephants appeared to be in good health. The keepers and staff appeared highly skilled at detecting injuries, disease and other health issues, and taking appropriate corrective action.

Foot health and foot health scores – Discussion

"Foot problems constitute the single most important ailment of captive elephants" (Fowler, 2001). It has been estimated that more than 50% of captive elephants in the USA develop some sort of foot-related disease in their lifetime (Fowler, 2001), and our data would suggest that foot problems in UK elephants occur with a similar prevalence. Foot-related conditions and arthritis are leading causes of euthanasia in captive elephants in the USA (Mikota et al., 1994). Locomotory problems were the reason for euthanasia in the case of the one elephant that was euthanased during the course of the study, and the elephant that died spontaneously was also found on post-mortem examination to have serious joint disease.

According to Roocroft and Oosterhuis (2001), cracks in the foot pads of elephants can be normal, although cracks in the nails are not. However, they are common in wild African elephants (Kate Evans and Stephen Harris, unpublished data). Nail cracks in captive elephants are usually the result of repetitive movements that put abnormal pressure on the nail. They can be caused by, for example, poor conformation (any abnormality of leg posture or gait), a dry environment or sleeping on hard surfaces (Roocroft and Oosterhuis, 2001), nail overgrowth or trauma (West, 2001), or by poor diet or poor assimilation of nutrients (Buckley, 2001). Nail cracks are unstable, expand when weight is put on them and, if not properly cared for, can result in chronic problems, especially if they extend upwards to the cuticle. Without treatment, they can lead to abscesses and more serious consequences. However, according to West (2001), nail cracks do not usually develop into more serious problems.

Less than 20% of the elephants examined on all three visits (N=66 elephants) were totally free of foot health problems for the entirety of this relatively brief project (18 months). Several of the elephants were scored as having moderate to severe, or multiple foot problems on all three visits. We also note that due to the husbandry or training methods of the elephants, it was not always possible to examine the feet of each elephant, particularly those in the largest enclosures which were not routinely handled.

Elephants place approximately 60% of their weight on their front feet, so serious foot-related disease is reportedly more common in the front than the hind feet (West, 2001). Our data support this suggestion: while minor foot problems occurred at approximately equal frequency in the front and hind feet, major problems were on average more than twice as common in front feet as hind feet (Table 4.14).

Given the prevalence of foot health problems, it would clearly be advantageous to identify any possible risk factors. However, we were unable to find (many) significant relationships between foot health score and the environment or husbandry. This is possibly because the reasons suggested for these causes (see above) are multifactorial, may interact, and could be highly dependent on the individual elephant's behaviour, e.g. preferred areas to stand and walk. A more long-term study designed specifically to examine these questions might be able to identify factors associated with poor foot health.

We note that there was no significant effect of species on the mean foot health score. There is a widely perceived belief in the zoo community that Asian elephants suffer more foot health problems than Africans; the scoring system used here was unable to confirm this. However, more African than Asian elephants are kept with 'no contact', and, as previously noted, it was difficult to examine

the feet, particularly the soles, of 'no contact' elephants. Additionally, the foot health scoring method used here might not have distinguished sufficiently between severity and frequency of foot problems. Two minor problems might not be equivalent to one major one, and some of the foot abnormalities we classified as minor (e.g. simple nail cracks) were regarded by some keepers as completely normal.

Locomotion scores – Discussion

The frequency distribution of locomotion scores in Figure 4.13 shows that only 15.6% of the elephants showed no evidence of any abnormal gait. Twenty-two percent had an imperfect gait or were perhaps slightly tender, 31% were mildly lame, and 21% (almost a quarter of the national herd) had an obvious limp or were severely lame. We show elsewhere that space allowance was related to improved locomotion score.

Body condition scores – Discussion

The distribution of the body condition scores of the UK zoo elephants was relatively narrow (see Figure 4.14). Only one elephant was scored as being greatly overweight, whereas 16 were scored as 1.5, the next leanest score. The vast majority were scored as 2.0, subjectively described as 'slightly to moderately' overweight. What this means in terms of welfare is somewhat open to interpretation. In the present study, we found that for elephants being scored as 'non-normal', fatter elephants had higher FCM concentrations. It has been argued that overweight captive elephants are more susceptible to serious diseases and defects of joints and ligaments, and that heavier females are more likely to experience stillbirths (Taylor and Poole, 1998). However, elephants are unlikely to be aware of the consequences of being overweight. Therefore, they are probably not suffering from being overweight *per se*. It is only when this impinges on other welfare-related biological functions, e.g. circulatory or musculo-skeletal problems, such that the elephant then has difficulty breathing or walking, that the animal is likely to experience suffering. The vast majority of the elephants were judged by their keepers to have little difficulty in getting from a standing to a lying position and the reverse, suggesting that the animals' bodyweight did not hinder movement to any great extent. Overall, it appears that although the UK elephants could be described generally as 'overweight', this is not a critical issue *per se*, unless this leads to secondary health problems. Certainly, the keepers and zoo staff were aware during this study of the elephants being overweight and were attempting to reduce this.

Faecal cortisol metabolites – Discussion

Mean individual FCM values in this study were calculated from multiple samples collected from individual elephants on three separate visits throughout the 18 months of the study. It has been argued that faecal glucocorticoid metabolites can be influenced by the animal's sex, time of day, season, and life history (e.g. Touma and Palme, 2005) making validation problematic. However, Lane (2006) favourably reviews the use of non-invasive measures of corticosteroid activity as an indicator of stress and argues that much of the variance attributable to these variations is negligible or accounted for by multiple sampling, as used in the present study. Brown et al. (2007) showed that the mean serum cortisol concentrations of African elephants was 157% greater than Asian elephants; in the present study we found that mean faecal cortisol metabolite concentrations were 158% greater in the Africans, a remarkably similar finding considering differences between the collection methods and studies. We believe the repeated measuring in the present study has yielded one of the largest, most robust databases of FCM for zoo animals.

The range of mean FCM for elephants in UK zoos was approximately 200 to 800 ng/gDFM (see Figure 4.15). We consider this range to be large. During this study, we were able to record the FCM values of an Asian bull elephant being relocated from the UK to France (Laws et al., 2007);

values of this individual ranged between 200 and 700ng/gDFM. Relocation of animals is widely regarded to be acutely stressful as the animal is typically inundated with novel and potentially threatening situations. The fact that similar maximum values of the relocated elephant were experienced by elephants in zoos as recorded from samples collected over an 18-month period might indicate that some zoo elephants experienced stressful conditions, chronically. As a cautionary note, it is clear from the present report and elsewhere that African elephants generally have higher cortisol levels than Asians. Three of the four zoos with the highest mean FCM values had African elephants, meaning this comparison with FCM values from a relocated Asian elephant should be interpreted with caution.

Comparing the FCM data collected here with those from other studies is likely to be influenced by factors such as sample collection method, storage, diet, species, exercise, sex, and assay techniques. Notwithstanding these concerns, other studies have indicated similar FCM concentrations to the 200 to 800 ng/gDFM range we recorded from elephants in UK zoos (see Figure 4.15). For instance, it has been reported that concentrations in wild (Fig. 2 in Ganswindt et al., 2005) and captive (Fig. 6A in Ganswindt et al., 2003) male African elephants usually ranged between 200 and 1,000 ng/gDFM. If this comparison can be extended, the maximum concentrations that Ganswindt et al. (2003, 2005) presented in their figures were approximately 2,000 ng/gDFM, compared to the maximum value of 1,518 ng/gDFM recorded from a UK zoo elephant in the present study. Ganswindt et al. (2005) reported that two elephants which experienced severe physical trauma (a broken leg and gunshot wounds) had 5- to 10-fold increases in FCM (but did not state the concentrations). During the course of our study, several elephants experienced an almost 3-fold change in FCM. These concentrations suggest that it is likely that elephants in UK zoos experienced similar stress levels to wild elephants, but not the extreme stresses due to physical injury.

The relationships between FCM and environmental factors were generally not clear, indicating that causative factors of increased adrenal activity are probably multifactorial. Stead et al. (2000) reported that elephants in smaller enclosures had higher FCM than elephants in larger enclosures (although we have been unable to obtain a complete copy of this report to verify the finding). Paradoxically, in the present study, the zoo with the greatest mean FCM concentration was a relatively large herd provided with a diverse outdoor environment claimed to be the largest in Europe. This is counter-intuitive to the idea that social animals living in a large group with an expansive, diverse environment will have better welfare than animals in small or impoverished environments. This zoo also practiced a method of handling that was unique amongst UK zoos, i.e. free-contact with little training. Possibly, reduced training leads to reduced habituation to humans, making subsequent free contact more stressful to these elephants. Unfortunately, without replication of the different methods of handling, it is impossible to determine whether this was the case. There were other counter-intuitive findings regarding the relationship between FCM concentrations and welfare. Unexpectedly, the lowest FCM concentration was from the zoo which had the smallest indoors accommodation (although it had an extensive outdoors paddock). In addition, the only zoo to have a mixed-species exhibit of only one African and one Asian elephant, a situation presumed by some to be highly stressful, had mid-range values. We also found no correlation between the intensity of stereotypical behaviour and FCM, in contrast to Wilson et al. (2004) for plasma cortisol in a much smaller group of three elephants. Similarly, the relationships between social factors and FCM were not clear. There were associations between FCM and whether there had been a birth in the herd, the number of elephants in the group, and individual housing. However, these often related to only one species, usually the African elephants.

These counter-intuitive relationships indicate that interpretation of FCM as a welfare indicator for zoo elephants must be made with great caution due to the highly variable nature of the husbandry, handling, history, social composition and individual responses of the elephants.

5. THE OVERALL WELFARE SCORES OF UK ZOO ELEPHANTS

5.i Introduction

An animal's overall welfare will be influenced by the intensity, duration and type of any single factor related to its welfare. Animal welfare is generally considered to be relevant for the individual animal - it is the individual animal that feels pain, experiences frustration or suffers from stress, rather than the group or herd. But how do we take all these factors into account and assess the overall welfare of an individual? Because the history and husbandry of UK zoo elephants is so varied, each individual should be considered unique. This means the replication normally required for conventional statistical analysis is not present and makes analysis highly problematic. In addition, there remains considerable scientific and philosophical debate about what the phrase 'animal welfare' means. We will not re-invent this discussion here, but point out that different researchers often place a different emphasis on aspects of the behavioural and physiological responses taken as indicators of welfare. We decided therefore to attempt an alternative approach by scoring the overall welfare of each individual elephant according to a wide range of welfare-related criteria.

5.ii Methods

We selected a total of 38 variables relevant to the welfare of the elephants (see Appendix 7), extracted necessary information from the database we had collated, and then the three of us independently scored each elephant indicating how much they believed this variable affected the welfare of the elephant. The scores were: 0=no welfare concern, 1=mild welfare concern, 2=medium welfare concern, 3=great welfare concern. Therefore, each elephant was given a total score between 0 and 342 (3 points x 38 questions x 3 researchers). The lower the score, the better the elephant's overall welfare was perceived to be. For many of the variables considered, there were data available from three visits, and we included whether the variable was a long-term or ongoing issue in our assessments.

We note that the welfare variables were not necessarily all relevant to each elephant. For example, having a retained foetus is clearly relevant only to females of breeding age or beyond. If a welfare variable was irrelevant for an individual, it was given a score of zero. This meant that some animals could have been given a higher score than others because more variables were relevant to them, although this only involved a few animals. We also avoided considering variables with dubious welfare relevance. For example, we did not consider skin dryness as one of the variables because there is little consensus on how dry skin is linked to welfare. We also avoided duplicating scores by avoiding including variables that were considered in other scores.

We recognise that comparing the effect of variables as diverse as 'injuries to the feet' and 'does the elephant receive browse every day' might be considered as comparing apples and oranges. However, since each elephant in UK zoos is unique and exposed to a wide range of differing risk factors to welfare, we have attempted to devise a scheme which takes this variability into account.

5.iii Results

The frequency distribution of the individual welfare scores given to the elephants is shown in Figure 5.1. No elephant was scored as 0, and so there was a welfare concern for each individual elephant in the opinion of at least one of us, although for a number of elephants these concerns were minor.

Figure 5.1 Frequency Distribution Of Overall Welfare Scores For Elephants In UK Zoos

Two-way ANOVA showed that there was a significant effect of the size of indoor space allowance on the overall welfare score and whether the animal was housed individually or in a group. Unexpectedly, elephants with a small amount of indoor space had a significantly lower overall welfare score (33.9±16.7SD) than elephants with medium (41.3 ±14.3 SD) or large amounts of space (46.1±11.8SD) ($F_{2,76}$=5.2, P=0.008). More expectedly, elephants that were housed singly had more welfare concerns (mean score=44.1 ±14.1 SD) than elephants that were housed as groups (37.0±15.6 SD) ($F_{1,76}$=6.1, P=0.016).

There was a highly significant positive correlation between an elephant's overall welfare score and its age (r^2= 0.132, $F_{1,76}$=11.4, P=0.001). Two-way ANOVA showed that there was no significant effect on the overall welfare score due to sex (P=0.76) or species (P=0.45).

There was also a significant positive correlation between an elephant's overall welfare score and the duration it performed stereotypies during the day (r^2= 0.103, $F_{1,76}$=8.6, P=0.004) and during the night (r^2= 0.192, $F_{1,40}$=9.2, P=0.004).

There was no significant correlation between an individual's overall welfare score and its mean FCM concentration (P=0.444), the amount of outdoor space available per elephant during the winter (P=0.868) or the summer (P=0.521).

5.iv Discussion

Giving animals an overall welfare score based on a wide range of welfare indicators is an unorthodox approach to assessing animal welfare, but is not unique - see the LayWel report on assessing the overall welfare of laying hens (van de Weerd et al., 2006). Whilst we acknowledge there are weaknesses in this approach, it highlighted some interesting points, and we believe has some merit in assessing a data-set with so much variation. This approach showed clear patterns in overall welfare scores and a variety of husbandry factors, indicting that it is a valid approach, and of benefit in assessing the welfare of zoo animals, many of which cannot be handled in the same way that domesticated animals can be handled. It is a potentially valuable tool that should be explored further.

It is remarkable that no elephant scored zero, i.e. there was a welfare concern for every elephant in the UK in the opinion of at least one of us. We note that although some aspects of health or welfare might be over represented in this approach, e.g. Appendix 7 shows that we considered lesions separately on 12 areas of the body whereas these could have been condensed into one score, this would not have changed the finding that there was a welfare issue for each elephant in the opinion of the researchers.

Perhaps most unexpected were the welfare concerns about the youngest elephants. The greatest concerns for elephants 5 years old or younger were not having access to the outdoors at night, and the long numbers of hours they were indoors; other concerns included young elephants being overweight, having foot problems and general stiffness, and stereotypical activity

The significant correlation between overall welfare score and age indicates that older elephants had worse perceived welfare. It is possible that this simply represents a greater opportunity for welfare issues to arise (e.g. injuries or illness), or that it reflects the history of the elephants, i.e. in the past, older elephants might have been exposed to practices or housing now considered unacceptable.

6. OBJECTIVE 3

6.i Introduction to Objective 3 (a) and (b)

It is often presumed or argued that animals in the wild or living in extensive, semi-natural conditions have better welfare than zoo animals because they are free to move greater distances, select some or all of their own food, show more natural patterns of reproduction and perform a more complete repertoire of natural behaviours. Others argue that because zoo animals are protected from predators, receive regular veterinary attention, good diets, etc, their welfare is better than animals in the wild. Notwithstanding the validity of either of these arguments, it is informative to gather data on wild elephants and elephants in extensive captive conditions to provide base-line data for comparison with elephants in zoos. This is particularly relevant if standardized welfare indicators are used in both the zoos and the more extensive environments to facilitate direct comparisons. Since both Asian and African elephants are kept in the UK zoos, we gathered comparative data from elephants in India and Botswana.

6(a) Obtain comparative data from wild Asian elephants and Asian elephants captive in an extensive environment

6.ii Methods

In April 2006, two of the grant-holders (MH and SH) visited Kaziranga National Park in Assam, north east India. During the visit, we were given access to Assam Forest Department (AFD) working elephants and orphaned calves rescued by and housed at the Centre for Wildlife Rehabilitation and Conservation (CWRC). Unfortunately, due to the long grass and terrain, sightings of wild elephants in the park were infrequent and brief. Therefore, we were unable to make any observations of their health or behaviour. We were unable to gain permission to remove elephant faecal material from India, and so no samples were collected for FCM analysis.

<u>CWRC</u>

The CWRC rescues elephant calves (under one year of age) from all over Assam. The Centre discourages visitors, and asks any visitors not to handle the calves. At the time of our visit ten wild-born calves were housed at CWRC, ranging in approximate age from two months to 5.2 years. Keepers and elephants were in free contact. The daily routine consisted of elephants being fed at 06:00h, followed by walking in the forest, accompanied by their keepers, from approximately 08:00h to 16:00h. After being brought back from the forest, the elephants were given a second meal before being moved to their night-time accommodation.

The two daily concentrate meals consisted of soybean mix and soaked gram, preformulated livestock feed and salt. Elephants also grazed and browsed in the forest during their daily walks, and had access to growing vegetation in their night paddock. They were taken to a stream several times a day to drink. Milk-dependent calves received round-the-clock feeds of infant formula.

Special accommodation was provided for the youngest/newest calves, consisting of a stabilisation room and, as a transition from this room, a night-time area. The stabilisation room measured approximately 9 square metres (3m x 3m), with a concrete floor sloping to a drainage channel, natural ventilation and little or no enrichment. The night-time area measured approximately 120 square metres (15m x 8m) and contained two trees, a water trough and two artificial mounds. At the time of our visit one calf, aged approximately two months, was housed in the stabilisation room.

The night-time paddock was an electric fenced area measuring approximately 1564 square metres (46 m x 34 m) which contained trees, copious vegetation, two shelters, two artificial pools (empty at

the time we visited but filled daily) and artificial mounds for elephants to lie against. The paddock could be divided by an electric fence into separate areas for the smaller and larger elephants.

AFD

Assam Forest Department working elephants are either owned by AFD or privately owned and on loan to the Forest Department. From May to October each year, AFD elephants are used for forest patrol duties only. During the tourist season (November to May) these elephants were also used for rides; typically, rides took place at 05:00h and 06:00h, lasted for one hour and involved the elephant carrying 2-6 people in a saddle on its back plus a mahout sitting on its neck. At the time of our visit the Department was short of elephants so an elephant could be used for rides in the morning, followed by half a day's rest then patrolling in the afternoon. Mahouts estimated that elephants walked up to 3-4 km during each morning tourist ride and forest patrol could involve walking 5-6 km, depending on the terrain. Forest patrol duties could include moving goods from one area to another, so the elephants not only walked long distances but also carried heavy weights. Several of the AFD cows had calves, some of which were fathered by wild bulls. Calves accompanied their mothers during forest patrol and rides.

Mahouts generally worked with only one or two elephants. Mahouts and elephants were in free contact. At the time of our visit there were many people (park visitors, etc.) around, freely touching and interacting with the elephants, including the adult bulls.

Most elephants were hobbled during the mid-day rest period to prevent them wandering too far from their mahouts. At night (i.e. for 10-12 hours) they were hobbled or, more commonly, tethered by a long (approximately 15 metre) chain attached to one leg and secured to a tree. Some elephants had voluntary access to a simple covered night shelter, and were chained to its concrete posts instead of trees. Calves with their mothers were not hobbled or chained.

AFD elephants were given one prepared meal in the evening and had constant access to growing browse. The prepared meal consisted of gram, black salt and masambar. Elephants browsed on vegetation including canes/sugar canes, grasses (e.g. lokocha, nal), leaves (e.g. banyan, tengabar, dimuru, tara), elephant grass, tree bark and fruit. These types of vegetation, plus banana trees, would constitute a typical diet for a wild elephant in Kaziranga. They were given access to water several times a day, and night areas usually had natural sources of water (e.g. ponds) for drinking.

Behavioural observations – Methods

We spent two days observing the behaviour of three cows and three female calves (aged 1.6, 1.6 and 2 years) at AFD. They were at rest during this period (after morning tourist rides), and roaming in the park, within watch of their mahouts but interacting with them very little. The cows were hobbled (i.e. their forefeet were joined by a length of rope), which restricted their movement but did not prevent them walking. Data were collected during 4.5 hours of observation on the first day (three cows and three calves) and 2 hours on the second day (two cows and two calves). Two afternoons were spent observing the behaviour of eight CWRC 'rescue' calves, a mixed-sex group whose ages ranged from 0.8 to 4.5 years, during their afternoon walk/rest period in the forest. This resulted in approximately 3 hours (day 1) and 1 hour (day 2) of observations.

Behavioural observations were conducted in the same way as for UK zoo visits (see Methods in Chapter 4). During each 1-hour block of observations, instantaneous samples were made for each individual at 1-minute intervals. The 'count to 10' method described in Chapter 4 was used, to enable identification of any stereotypic behaviour, part of the definition of which included persistence for at least 10 seconds. The 1-hour blocks of observations were separated by 10-minute

breaks to improve independence of the data and reduce observer fatigue. Appendix 4 contains an ethogram of the behaviours recorded.

Health-check – Methods

Health-checks were adapted from the standardised health-check questionnaire used during the UK zoo visits (see Methods in Chapter 4 and Appendix 3), to include a brief life history for each elephant. As part of the health-checks, photographs were taken, including one from the rear to assess body condition. Videotapes were also made of some elephants walking and turning, to enable locomotion scoring as described in Chapter 4.

The Forest Department officials and mahouts were extremely co-operative in allowing us to examine their elephant's health. We visited the Central, Western and Eastern ranges, and performed health-checks on 31 elephants, including a mixture of bulls (tuskers and tuskless *makhnas*), cows and calves. Video footage was obtained of 20 working elephants walking and turning.

While at CWRC, personnel assisted us perform health-checks on all 10 of their rescue calves. During one of our visits, a privately owned adult bull timber elephant was brought in for medical treatment, and we were able to perform a health-check on him as well as videotaping his locomotion.

Locomotion scoring – Methods

Videotapes were made of 20 of the elephants (aged 15 years or greater) walking and turning. These were analysed by an experienced observer (Nick Bell), using the locomotion scoring system developed for this study, as described in detail in Chapter 4. Briefly, scores under this system range from 0 ('sound / normal') to 5 ('severely lame'), with scores of 1 and 2 indicating abnormality, and 3 and higher indicating definite lameness.

Foot health scoring – Methods

The health of elephants' feet was scored as for the UK zoo elephants (see Chapter 4). Based on the researcher's examination of the elephants' feet and/or the mahout's comments, each foot was given a score of 0 (no problem), 1 (minor problem) or 2 (major problem). Major foot problems were defined as: abscess(es); infection; rot; complicated nail cracks; significant overgrowth of the nail(s), cuticle(s) or pad(s); or significant injuries. Minor foot problems were defined as: uncomplicated nail cracks (small cracks which did not extend into the cuticle); minor overgrowth of the nail(s), cuticle(s), or pad(s); or minor injuries. Foot scores were summed for all four feet, meaning the maximum score each elephant could be given was 8. This would indicate a severe problem with all four feet.

Body condition scoring – Methods

As part of the health-check, a photograph of each elephant was taken from the rear. The body condition of the AFD elephants was assessed in the same way as the UK zoo elephants, described in Chapter 4. Photographs of the Kaziranga elephants were examined and scored independently by two researchers (SH and CS). Scores were compared, and where there was disagreement, this was discussed until a score was agreed. This entire scoring process was then repeated. When the second scores did not agree with the previous (this was never by more than 1.0), the scores were discussed until agreement between the two researchers was reached. The data presented in the results are the final scores given to the elephants

6.iii Results

Table 6.1 summarises the background of elephants observed in Assam.

Table 6.1 Background of elephants at Assam Forest Department and CWRC.

Location *	Name	Sex	Age (years) **	Wild or captive born ***
AFD	1	M	55	Unknown
AFD	2	M	55	Unknown
AFD	3	F	50	Unknown
AFD	4	F	45	Unknown
AFD	5	F	45	Captive
AFD	6	F	45	Wild
AFD	7	F	45	Unknown
AFD	8	F	40	Unknown
AFD	9	M	35	Unknown
AFD	10	M	35	Wild
AFD	11	F	35	Wild
AFD	12	F	35	Unknown
AFD	13	F	32	Unknown
AFD	14	M	28	Captive
AFD	15	F	28	Unknown
AFD	16	F	25	Captive
AFD	17	F	22	Captive
AFD	18	M	21	Unknown
AFD	19	M	18	Captive
AFD	20	M	17	Captive
AFD	21	M	16	Wild
AFD	22	M	16	Unknown
AFD	23	F	16	Captive
AFD	24	F	16	Wild
AFD	25	F	15	Captive
AFD	26	M	6	Captive
AFD	27	M	5	Captive
AFD	28	F	2.5	Captive
AFD	29	F	2	Captive
AFD	30	F	1.6	Captive
AFD	31	F	1.6	Captive
CWRC †	32	M	37	Wild
CWRC	33	M	5.2	Wild
CWRC	34	M	4.5	Wild
CWRC	35	M	2.5	Wild
CWRC	36	M	2.3	Wild
CWRC	37	F	1.5	Wild
CWRC	38	F	1.5	Wild
CWRC	39	F	1.5	Wild
CWRC	40	F	1.2	Wild
CWRC	41	M	0.8	Wild
CWRC	42	F	0.2	Wild

* AFD=Assam Forest Department; CWRC=Centre for Wildlife Rehabilitation and Conservation
** In all cases ages are approximate, and age estimates (often given by mahouts to the nearest five years) are probably less accurate than for UK zoo elephants
*** Captive born calves were born to Forest Department cows, and in some cases fathered by wild bulls
† This adult, privately-owned elephant was brought to CWRC for medical treatment during one of our visits

Behaviour – Results

Figure 6.1 below shows the overall time budget (main behaviours observed) of Asian elephants in extensive captivity. Figure 6.2 shows the time budget of AFD adult cows, AFD calves and CWRC calves.

Figure 6.1 Time Budget Of Asian Elephants (Cows Plus Calves) In Extensive Captivity

Figure 6.2 Time Budgets Of Asian Cow And Calf Elephants In Extensive Captivity

We observed no stereotypic behaviour in any of these extensively housed elephants. However, according to the mahouts, 9/26 (34.6%) of the elephants aged 10 years or older on which we performed health checks displayed some type of stereotypic activity at least occasionally (head bobbing, weaving and/or rocking backwards and forwards), usually at rest or in anticipation of being fed. In addition, two male tuskers had marks or grooves on their tusks, suggestive of repeated rubbing on or playing with their chains.

Health-check – Results

Some of the Assam elephants exhibited health problems not seen in UK zoos, including injuries caused by goring (inflicted during interactions with a wild elephant or rhino), foot thrush, presumably associated with living in warm, wet conditions, and a deliberate injury (a stab wound to the heel, incurred in the course of a dispute between the elephant's owner and another person). Some AFD working elephants wore rope collars around their necks which appeared not to be removed regularly, and we saw at least one open neck wound due to roping. In addition to active lesions, many of the AFD elephants had scars, healed abscesses and other evidence of old wounds. Some of these, particularly around the head, neck and ear areas, appeared to be the result of ankus injuries.

While all elephants had periodic veterinary monitoring (and CWRC calves were seen frequently by a veterinarian), AFD elephants had less frequent veterinary care than elephants in UK zoos. This presumably contributed to the development of some of the health conditions displayed. In some cases mahouts administered 'home' treatments, with variable success (for example, a stab wound in a privately-owned elephant had been treated with turmeric for some time before veterinary assistance was obtained).

The percentage of elephants with skin lesions to various body areas is presented in Figure 4.11. Most of the elephants we health-checked at AFD, with the exception of young calves, showed evidence of some type of physical problem such as skin lesions, active infection or systemic disease. Many had multiple signs of current or previous ill-health.

Table 6.2 summarises health problems exhibited by the elephants examined in Assam, and Table 6.3 summarises locomotion data collected during health-checks.

Table 6.2 Health indicators of Asian elephants in extensive captivity (N=42).

	Location			
No. (% in brackets) elephants displaying health problems of the:	CWRC (N=10)	CWRC * (N=1)	AFD (N=31)	Total (N=42)
Fore feet (major) **	0	1	4	5 (11.9%)
Fore feet (minor) ***	0	1	12	13 (31%)
Hind feet (major) **	0	1	11	12 (28.6%)
Hind feet (minor) ***	1	1	12	14 (33.3%)
Eye(s)	0	0	5	5 (11.9%)
Ear(s)	0	0	1	1 (2.4%)
Tusk(s) / Tush(es) †	0	0	1	1 (4.5% of 22 with tusks / tushes)
Teeth ††	0	0	0	0
Trunk	0	0	0	0
Tail	0	0	1	1 (2.4%)
Faeces / digestion	0	0	2	2 (4.8%)
Urinary / Sexual organs	0	0	1	1 (2.4%)
Systemic disease	0	0	0	0
Skin lesion(s) †††:				
Head / neck	0	0	4	4 (9.5%)
Face	0	0	2	2 (4.8%)
Ear(s)	1	0	6	7 (16.7%)
Trunk	0	1	2	3 (7.1%)
Chest / abdomen	0	1	6	7 (16.7%)
Back	0	0	2	2 (4.8%)
Flank(s)	1	0	5	6 (14.3%)
Rump	0	1	5	6 (14.3%)
Leg(s)	0	1	6	7 (16.7%)
Tail	0	0	3	3 (7.1%)
Overweight (in the mahout's opinion)	0	0	0	0
Underweight (in the mahout's opinion)	2	0	2	4 (9.5%)

* This column refers to the privately-owned, adult elephant, seen by the investigators at CWRC

** Numbers and percentages refer to number of elephants that displayed one or more problems with one or more of their feet. Major foot problems were defined as: abscess(es); infection; rot; complicated nail cracks; significant overgrowth of the nail(s), cuticle(s) or pad(s); or significant injuries

*** Minor foot problems were defined as: uncomplicated nail cracks (small cracks which did not extend into the cuticle); minor overgrowth of the nail(s), cuticle(s) or pad(s); or minor injuries

† A tusk problem was defined as a break that crossed the pulp or was otherwise complicated. Minor chips, wear and tear were considered normal for elephants, and not defined as a problem. Since not all elephants had tusks/tushes, percentages shown are of those elephants with tusks or tushes

†† In some cases it was possible to inspect top teeth visually, but inspecting bottom teeth, even in well-trained elephants, proved impossible. Thus the health of teeth was almost exclusively assessed by asking the mahout. Some elephants were trained to open their mouths so that the mahout can look inside. In other cases, indirect evidence such as ability to eat normally and normal faeces, were used to ascertain the normality of teeth

††† A skin lesion was defined as a visible or palpable, active abnormality. Healed scars and old wounds were not defined as lesions

Table 6.3 Locomotion data from Asian elephants in extensive captivity (N=42) as assessed by mahouts.

	Location			
No. (% in brackets) elephants displaying:	CWRC (N=10)	CWRC (N=1)	AFD (N=31)	Total (N=42)
Gait:				
Walks normally with no signs of difficulty or lameness	10	1	30	41 (97.6%)
Walks with mild to moderate signs of difficulty or slight to moderate lameness	0	0	1	1 (2.4%)
Walks with considerable difficulty or significant lameness	0	0	0	0
Displays extreme difficulty in walking and/or signs of pain or distress when standing or walking	0	0	0	0
Often sleeps lying down	10	1	30	41 (97.6%)
Sometimes sleeps lying down	0	0	0	0
Does not sleep lying down *	0	0	1	1 (2.4%)
Lies down only on one side	0	0	1	1 (2.4% of 41)
Standing up and lying down appears easy	10	1	27	38 (92.7% of 41)
Standing up and lying down appears slightly difficult	0	0	3	3 (7.3% of 41)
Standing up and lying down appears very difficult	0	0	0	0
Sometimes shows temporary periods of apparent stiffness	0	0	4	4 (9.5%)

* One elephant was thought by the mahout never to lie down. Percentages in the four rows below are of those elephants that did lie down

Locomotion scores – Results

Table 6.4 shows the locomotion scores for the 20 AFD elephants, as determined by our locomotion scoring system. As with the UK zoo elephants, mahouts were asked about their elephants' locomotion as part of the health-check. Nineteen of the elephants were judged by the mahout to walk normally (score 0), while the remaining elephant, a fifteen-year-old female, was judged to walk 'with mild to moderate signs of difficulty or slight to moderate lameness' (score 1). This individual was scored as 2 using our system indicating abnormality/slight lameness. Figure 6.3 shows the frequency distribution of locomotion scores.

Figure 6.3 Frequency Distribution Of Locomotion Scores Of Asian Elephants In Extensive Captivity

Table 6.4 Locomotion scores of Assam elephants (N=20).

Location	Name	Sex	Age (years)	Locomotion score
AFD	1	M	55	3
AFD	3	F	50	3
AFD	4	F	45	2
AFD	6	F	45	3
AFD	7	F	45	2
AFD	9	M	35	0
AFD	10	M	35	2
AFD	11	F	35	2
AFD	12	F	35	3
AFD	13	F	32	4
AFD	14	M	28	2
AFD	16	F	25	4
AFD	18	M	21	2
AFD	19	M	18	2
AFD	20	M	17	0
AFD	21	M	16	0
AFD	22	M	16	2
AFD	24	F	16	3
AFD	25	F	15	2
CWRC	32	M	37	3

Foot health scores – Results

The range of overall foot health scores for the 31 extensively managed adult elephants whose feet were inspected was between 0 and 8 with a population mean of 2.32 (±2.04 SD).

Body condition scores – Results

As discussed in Chapter 4, body condition was scored on the basis of spinal protrusion, hip visibility, roundness of the body, and the amount of tissue covering the thigh areas. A score of 3 was considered normal, a score of 1 was very fat and a score of 5 was very thin. The mean score for the extensively managed elephants was 3.25 (±0.53 SD)

6(b) Obtain comparative data from wild African elephants

6.iv Methods

As part of her Ph.D., Kate Evans collected data on the behaviour of male wild African elephants in the Okavango Delta, Botswana, for her thesis project, 'A study into the behavioural ecology and movements of adolescent male African elephant (Loxodonta africana) in the Okavango Delta, Botswana'. Kate kindly gave us access to some of her records, comprising behavioural observations made between April 2002 and March 2005.

Behavioural observations were made of 283 male elephants during daytime hours. During 30-minute blocks of observations, instantaneous samples were made for each individual at 5-minute intervals. Additionally, all social behaviours occurring during the 30 minutes were noted.

6.v Results

Figure 6.4 shows the average time budget of wild male African elephants. Social behaviours were recorded relatively infrequently and are included in the 'Other' category of behaviour. No stereotypic behaviour was observed.

Figure 6.4 Time Budget Of Wild Male African Elephants

6.vi Discussion of Objective 3 (a) and (b)

Behaviour – Discussion

Assam Forest Department calves displayed comparatively high levels of social behaviour, showing social interactions during 11.3% of observations. Levels of social behaviour in the AFD cows and CWRC calves were much lower (2.4% and 1.7% of observations respectively). The three AFD calves were younger than several of the CWRC orphans, all female and very similar in age. This may be why the AFD calves spent much of their time playing with each other. They also interacted socially (e.g. rubbing and touching) with their own mothers and the other cows.

As previously noted, wild male African elephants displayed little social behaviour, although exact frequencies are unknown due to methodological differences between the Botswana and Assam studies. 'Other' behaviours, including social behaviour, comprised 4.3% of observations. It might be hypothesised that wild male African elephants displayed a low frequency of social behaviours due to the perception that they are solitary: however, only 26% of Kate's observations were of solitary males. Evans and Harris (2008) reported that dolescent males (10-15 and 16-20 years of age) were the most sociable age group, showing preferences for larger social groupings and being in closer proximity to other elephants; later adolescent males (ages 16-20) showed a tendency for higher social levels. Males of all ages preferred to have males ≥36 years of age as their nearest neighbour. They argued that this proximity to older males provides opportunities for males to learn from more experienced individuals. It has long been recognized that matriarchs are the repositories of social and ecological knowledge within elephant breeding herds: this study showed that mature males are reservoirs for such knowledge within bull society. Clearly, individual housing of male elephants in zoos would prevent this sociality and possibly the learning it provides.

No stereotypic behaviour was observed in extensively housed Asian or wild African elephants. While the Kaziranga study used behavioural methodology designed to detect stereotypic behaviour if it occurred, this was not an objective of the Botswana study. Behavioural observations in Kaziranga were of relatively brief duration and only in the afternoons. Thus, we cannot conclude that our failure to observe any stereotypy was because these elephants never displayed any. Indeed, according to mahouts at AFD, around one-third of elephants aged 10 years and older were known to perform stereotypic behaviours at least occasionally.

Both extensively housed Asian and wild African elephants spent similar amounts of time eating (just over 60% of recorded observations), although this comparison is complicated by the fact that the behavioural category 'walk and eat' was used during observations in Assam (and at UK zoos) but not in Botswana. Although we have not statistically compared the data, it appears that these elephants spent more time eating than elephants housed in UK zoos.

Health – Discussion

Overgrowth of the toenails, foot pads and cuticles was relatively common in the AFD elephants. In some cases, nails were so severely overgrown that they caused the skin between them to split, a

condition that presumably caused pain. In addition to appearing less 'manicured' than the feet of UK zoo elephants, it seemed that the extensively managed Asian elephants received less general management, both of healthy feet and those displaying abnormalities. Failure to monitor and treat simple nail cracks can cause them to develop into more serious problems (Buckley, 2001), and untreated infection or injury may be more likely to develop into a severe condition such as abscess or osteomyelitis.

7. COMPARISON OF THE WELFARE OF UK ZOO ELEPHANTS, EXTENSIVELY MANAGED CAPTIVE ASIAN ELEPHANTS, AND WILD AFRICAN ELEPHANTS

Figure 7.1 shows the day-time behavioural time-budgets for UK zoo elephants, Asian elephants in extensive captivity, and wild African male elephants.

Figure 7.1 Day Time Budget Of Elephants In UK Zoos, Asian Elephants In Extensive Captivity, And Wild African Elephants

Behaviour

Overall, UK zoo elephants appeared to spend less time eating than extensive Asian elephants and wild Africans. However, this comparison is slightly complicated by the use of the behavioural category 'walk and eat' during observations of UK zoo and extensive Asian elephants, but not wild Africans. Eating behaviour was also different for UK zoo elephants in that it often consisted simply of consuming prepared foods, rather than foraging for, selecting and preparing suitable foodstuffs. This could explain the lower proportion of daytime hours that zoo elephants spent eating.

Stereotypic behaviour

In UK zoos, Asian elephants exhibited stereotypic behaviour more frequently and with greater prevalence than African elephants. However, elephants kept in extensive captivity in Assam were not observed performing stereotypies. This may be attributable to their relatively enriched environment, and/or and the fact that they spent the majority of observational time foraging. Notably, even though observations were made during the period leading up to their afternoon feeding, we did not observe anticipatory stereotypies, in contrast to many zoo elephants during equivalent time periods. Elephants in Assam were observed for brief periods of time and only during the afternoons, so it remains possible that stereotypic behaviour was performed at other times of the day. Indeed, the mahouts reported that 34% of the elephants aged 10 years and older performed some type of repetitive behaviour, usually when at rest or in anticipation of being fed. UK zoo keepers reported that 22/30 (73.3%) Asian and 17/28 (60.7%) African zoo elephants aged 10 years and older displayed some form of stereotypy.

Body condition scores

The mean body condition score of the elephants in UK zoos (2.0±0.44 SD) was significantly lower than the extensively managed elephants of Kaziranga (3.3±0.47 SD) (Kruskal-Wallis χ^2=50.9, 1 df, N=94, P<0.001) (see Figure 4.14). However, the extensively managed elephants were all older than 15 years of age, and so we repeated the comparison of the mean body scores omitting zoo elephants of 15 years or younger; there was still a significant difference between the mean scores of the extensively managed elephants (3.3±0.47 SD) and those from the UK zoos (2.0±0.46 SD) (Kruskal-Wallis χ^2=41.9, N=66, 1 df, P<0.001). To eliminate any species-difference confound, we then omitted data from the African zoo elephants; the difference remained statistically significant between the extensively managed elephants (3.3±0.47 SD) and the UK zoo elephants (2.1±0.54 SD) (Kruskal-Wallis χ^2=26.5, N=44, 1 df, P<0.001), i.e. the UK zoo elephants were significantly fatter than extensively managed conspecifics.

Many zoo elephants had limited space and exercise and ready access to abundant amounts of food, much of which (e.g. fruit, bread) is high in calories and requires little handling and processing time. Zoos can experience problems in obtaining sufficient quantities of suitable browse and sometimes use substitutes which may be less suited for management of the elephants' body-weights. As discussed above, being overweight might not impact the welfare of animals directly, but it is likely to predispose the elephants to problems in the long-term. Our scoring system was designed to be sensitive to subtle body conformation differences. Being overweight is a significant (pre-cursor for) welfare concerns for elephants in zoos and this scoring system is a tool that can be used to assess the success of any treatment designed to avoid future welfare problems.

Skin lesions

For all ten areas of the body examined (excluding the feet) the percentage of Kaziranga elephants with skin lesions was higher than that of UK zoo elephants (see Figure 4.11), probably reflecting the more protected environment of zoos, and the time available for zoo keepers to manage and treat any problems. For several areas the differences were very marked (e.g. 16.7% of Kaziranga elephants examined had one or more lesions on their ears, compared to 1.8% of UK zoo elephants).

Foot health scores

Overall, there was a significant difference between the mean foot health score of elephants in UK zoos (0.63±0.54 SD) and extensively managed elephants (1.09±0.95 SD) (Kruskal-Wallis χ^2=0.46, N=119, 1 df, P=0.032). However, if African zoo elephants were excluded from the analysis, the means were not significantly different (Kruskal-Wallis χ^2=0.247, N=83, 1 df, P=0.098). Therefore, while factors such as unnatural substrates, lack of space and exercise, unnatural diet and being overweight are often thought to contribute to foot problems in zoo elephants, we found no difference in foot health scores between UK Asian zoo elephants and those housed in extensive conditions in Kaziranga. This could reflect the hard physical work performed by some working elephants and the relative lack of foot care and veterinary attention. Since the foot health of UK zoo elephants is no better, despite their intensive veterinary care, this confirms the perception that foot problems are a major health and welfare issue in zoo elephants.

Locomotion scores

Overall, there was no significant difference between the mean locomotion scores of the extensively managed elephants (2.2±1.2 SD) and those from the UK zoos (2.5±1.4 SD) (Kruskal-Wallis χ^2=1.313, N=89, 1 df, NS). However, since the extensively managed elephants were all older than 15 years of age, we repeated the comparison of locomotion scores omitting zoo elephants of 15 years or younger. . This showed a significant difference between the mean scores of the extensively managed elephants (2.2±1.2 SD) and those from the UK zoos (3.1±0.9 SD) (Kruskal-Wallis χ^2=8.705, N=61, 1 df, P=0.003). To eliminate any species-difference confound, we then omitted data from the African zoo elephants; the difference remained statistically significant between the extensively managed elephants (2.2±1.2 SD) and the UK zoo elephants (3.2±1.1 SD) (Kruskal-Wallis χ^2=7.889, N=39, 1 df, P=0.005), i.e. the UK zoo elephants had poorer locomotion than the extensively managed elephants (see Figures 4.13 and 6.3).

It was evident that both zoo elephant keepers and mahouts scored the locomotion of their elephants differently to the expert using our scoring system. While there was a significant correlation between our locomotion scores and those of UK elephant keepers, the keepers consistently gave lower scores. Only one of the 20 extensively managed Asian elephants (5%) was judged by mahouts to have anything other than normal locomotion, while the researcher scored 17 (85%) as having some degree of abnormality. Our locomotion scoring system was designed to be sensitive to subtle gait deficits, so it is not surprising that abnormalities were detected in some elephants whose keepers and mahouts judged their locomotion to be normal.

8. GENERAL DISCUSSION AND CONCLUSIONS

Early in this study, it became apparent that almost every zoo was making changes and improvements to the environment and husbandry of the elephants. Many of these were ongoing. Thus, the environment of a UK zoo elephant is not static. Zoos were remodelling and in some cases rebuilding indoor and outdoor facilities, making improvements, increasing space, adding enrichment and altering flooring. The main impetus for these changes is undoubtedly the desire of zoos' management and staff to maintain or improve the welfare of their elephants. Zoos are acutely aware of the issues surrounding the welfare of their elephants, and attempts to enrich and improve their lives are ongoing.

Similarly, all mangers and elephant staff that we spoke to during the course of the study were highly knowledgeable about elephant care and welfare issues. Elephant keepers spend large amounts of time looking after them, observing their behaviour, documenting their management and managing any health issues. UK zoo elephants receive high levels of individual care, comparable to that of companion animals and certainly much greater than many other zoo animals. Even though some elephant keepers also work with other species, there are far more keepers per elephant than would be found on livestock farms, for example.

Another notable trend was the reduction in numbers of elephants resident in UK zoos during the relatively brief period of this study. In the months immediately preceding the start of the study, Dudley Zoo and Longleat Safari Park discontinued keeping elephants. Zoos and safari parks decide not to keep elephants, and individual elephants are moved, sometimes because of concerns over their ability to provide acceptable levels of care. Despite the declining numbers of zoo elephants, concern about welfare among interested parties and the public remains at a high level. This is unlikely to change even though, based on current trends, the number of elephants in UK zoos is likely to continue to decrease.

In this final section, we give an overview of factors widely accepted by scientists as welfare indicators and relate these to UK zoo elephants, their housing and their husbandry.

Social composition:

The social composition of most groups of elephants in UK zoos was atypical of the normal composition of wild elephant herds. Most zoo groups were skewed towards a higher number of younger animals, and in particular, did not have mature bulls. This is markedly different from normal herd structure in which both male and female elephants gain social stability from older elephants, and is a cause for some concern.

Environment:

Indoor housing
Most elephants spent considerable amounts of time confined in indoors enclosures, some of which were small and barren. The minimum indoor space available was 14.5m^2/elephant. Given that wild elephants would naturally range over hundreds or thousands of square kilometres, and are active and move during both the day and at night, the typical indoor environment represents a minute fraction of the amount of space they might normally use. Smaller amounts of indoor space were associated with increased stereotypical activity by the elephants, indicating that zoos should provide as large an amount of indoor space as possible.

Individual housing
None of the measures used here indicated that the welfare of individually housed elephants was worse than that of group-housed elephants housed. This was possibly due to many of the

individually housed elephants being able to maintain visual, auditory, olfactory and sometimes physical contact with others. However, given the high sociality of these species, we do not believe elephants should be kept in individual housing except where necessary for reasons of human and/or elephant health and safety.

Outdoor environment
The minimum outdoor space available was 140m^2 per elephant. In some zoos, the outdoor area available was over a hundred times greater, although, this still represents a small fraction of the amount of space elephants would normally use in the wild. Greater amounts of outdoor space were associated with reduced stereotypical activity and improved gait scores, again indicating zoos should provide as much outdoor space as possible. More outdoor space is clearly linked to improved welfare in UK zoo elephants.

Behaviour:

Aggression
Aggression was rarely observed during this study. This could be interpreted as indicative of good group cohesion, although scan sampling is prone to underestimating rare events such as aggression. Group cohesion in animals is often mediated by far more subtle agonistic behaviours than overt aggression, and this needs careful monitoring in groups which do not reflect wild group composition.

Stereotypies
The high prevalence of stereotypies amongst elephants in UK zoos and the long duration of many of these indicated that the current and/or historical environments of many of the elephants were not suited to their species-specific requirements. Almost half of the UK herd performed stereotypies for more than 5% of the 24-hour period. Some zoos had significantly greater amounts of stereotypy amongst their elephants. This indicates that some factors unique to those zoos might have exacerbated these abnormal behaviours. We found that stereotypical activity was not due solely, and in some cases at all, to historical considerations.

Handling:

There was no clear evidence that handling method had any effect on welfare as indicated by stereotypies or FCM. There was also no clear evidence that handling method influenced other aspects of the elephants' physical health; however, the difficulty of closely examining elephants in some handling systems could have obscured differences.

Health check:

Other than foot health, bodyweight and locomotion scores, the elephants were in good physical health and few problems were recorded. This reflects the very high level of care and attention given to elephants in UK zoos. The majority of UK elephants were scored as overweight. This was a bigger problem in some zoos than others, indicating some zoos are tackling this issue more successfully. The UK zoo elephants spent less time feeding than wild elephants but were also overweight, indicating that diet and/or lack of exercise were probably contributory factors. Many elephants had foot health problems which ranged from minor to severe. It is unclear how these affected their welfare, as they were unrelated to gait scores or FCM. However, major foot problems such as abscesses and osteomyelitis almost certainly cause pain and discomfort, often on a long-term and/or recurring basis. We note that cracked nails are common for elephants in the wild.

Locomotion scores:

Many UK elephants had abnormal or poor gaits, especially when compared with the locomotion scores of working elephants at Kaziranga. UK elephant keepers tended to underestimate the abnormality of their elephant's gaits. It is obviously important to be able to recognise lame elephants, and the ability to detect more subtle gait abnormalities may prevent more severe problems developing in future years.

Faecal cortisol metabolites:

There were significant differences between the zoos and between Asian and African elephants in the FCM concentrations. FCM values collected in this study did not show a clear relationship with the size of indoor or outdoor enclosure. We believe any differences might have been obscured by other factors within the zoo. FCM concentrations are possibly a better reflection of stressors associated with social factors than the physical environment.

Overall welfare score:

Whilst we accept that the approach used for the overall welfare score was unorthodox, we believe it is a valid means of assessing a highly complex issue. The primary finding of the overall welfare score was that there was not a single elephant in the UK that did not have a welfare concern in the opinion of one or more of the researchers. Furthermore, the scores also indicated that the welfare of elephants in UK zoos was worse for older elephants compared to younger.

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APPENDICES

Appendix 1:
Questionnaire and accompanying letter sent to Elephant Welfare Expert Panel members

Centre for Behavioural Biology
Department of Clinical Veterinary Science
University of Bristol
Langford House
Langford
North Somerset
BS40 5DU

Dear

We are working on a study investigating the welfare of zoo elephants in the UK. Our aim is to visit all UK zoo and safari park collections that house elephants, gather information on the elephants, their health, housing and husbandry, and objectively evaluate the welfare of zoo elephants in the UK. This study is funded by the Department for Environment Food and Rural Affairs (Defra), the British and Irish Association of Zoos and Aquariums (BIAZA), the Royal Society for the Prevention of Cruelty to Animals (RSPCA) and the International Fund for Animal Welfare (IFAW). We are currently finalising the data that will be recorded during the visits, and want to ensure that we include all appropriate measures. As a relevant expert we would be grateful if you could assist us by completing the attached, short questionnaire. We are interested in your opinions only, and there are no 'right' or 'wrong' answers.

We would like you to answer four questions. The first two relate to indicators of welfare, which might include behavioural, health or physiological measures, though please do not feel limited to these. The third and fourth questions relate to factors that affect welfare. These might include aspects of the environment, housing or husbandry, though please do not feel limited to these types of factors. For each of the four questions please indicate the ten most important aspects, ranked in order of importance. If in your opinion there are differences due to species (African or Asiatic elephant) please state them. The questions ask about zoo elephants, but please note that the term 'zoo' also includes wildlife and safari parks.

If you do not feel qualified to answer any of the questions please leave them blank. When you have completed the questionnaire please add your name and contact information to the cover sheet, indicate your area(s) of elephant or other expertise and return it to me at moira.harris@bristol.ac.uk as soon as possible, and preferably no later than two weeks from receipt.

Your co-operation is extremely important to the success of this study and we thank you in anticipation of your help. If you have any questions or concerns please do not hesitate to contact Moira Harris whose contact details are below.

Yours sincerely,

Dr Moira Harris, Dr Chris Sherwin and Professor Stephen Harris
University of Bristol

THE WELFARE, HOUSING AND HUSBANDRY OF ELEPHANTS IN UK ZOOS

Name: _____

Areas of elephant or other expertise (please describe briefly):

_____

_____

_____

Postal address:_____

_____

_____

_____

E-mail address:_____

Indicators of welfare

Indicators of welfare might include (though are not restricted to) aspects of behaviour, health or physiology

1. In your opinion, what are the ten most important indicators of good welfare in zoo elephants?

1. ……

2. ……

3. ……

4. ……

5. ……

6. ……

7. ……

8. ……

9. ……

10. ……

2. In your opinion, what are the ten most important indicators of poor welfare in zoo elephants?

1. ……

2. ……

3. ……

4. ……

5. ……

6. ……

7. ……

8. ……

9. ……

10. ……

* Please rank the answers to all questions in order of importance from 1 (most important) to 10 (least important)

Factors that affect welfare

Factors that affect welfare might include (though are not restricted to) aspects of housing and husbandry

3. In your opinion, what are the ten most important factors likely to lead to good welfare in zoo elephants?

1. ……

2. ……

3. ……

4. ……

5. ……

6. ……

7. ……

8. ……

9. ……

10. ……

4. In your opinion, what are the ten most important factors likely to lead to poor welfare in zoo elephants?

1. ……

2. ……

3. ……

4. ……

5. ……

6. ……

7. ……

8. ……

9. ……

10. ……

* Please rank the answers to all questions in order of importance from 1 (most important) to 10 (least important)

Appendix 2:
Consent statement used during the study

THE WELFARE, HOUSING AND HUSBANDRY OF ELEPHANTS IN UK ZOOS

UNIVERSITY OF BRISTOL

This information will be held and processed for the following purpose(s):
Research on the welfare, housing and husbandry of zoo elephants in the UK

The undersigned agree to the University of Bristol recording and processing this information. **I understand that this information will be used only for the purpose(s) set out in the statement above**, and my consent is conditional upon the University complying with its duties and obligations under the Data Protection Act 1998.

The University of Bristol will be responsible for the use of video recordings taken of elephants. These videotapes will be held and analysed until the termination of the project (due: October 2006) for the sole purpose of collecting behavioural data from elephants for the above-named study.

The researchers will not copy the videotapes.

Further, we understand that this agreement concerns quantifiable data extracted from the videotapes (not images), and the videotapes remain the property of the Zoo, and will be returned to the Zoo after use.

Signature (Zoo Director or Authorised Other) **…….**

Signature (Principal Investigator) **…….**

Zoo …….. **Date .....……**

Appendix 3:

Questionnaires and direct observation sheets used to record information during zoo visits:

i Elephant history
ii Keeper questionnaire
iii Standardised health check
iv House and paddock sheets

University of BRISTOL

Elephant General and Life History Questionnaire

Researcher:…….. Date:…….……

Zoo Code…….……...

Elephant's name:……..

Name of respondent…….

Respondent is: curator / keeper / other (specify) ……..

Notes on completion of this questionnaire

This Questionnaire is intended to characterise the **general history, life-history**, **health-history and behavioural history** of each elephant currently resident in this zoo's collection. It is to be completed at the initial zoo visit only. Please complete all sections as accurately and completely as possible. Feel free to add notes!

1. GENERAL INFORMATION

Studbook number ……

Species (African or Asiatic) ……

Distinguishing features (how will we recognise this elephant):

……..

Sex Male / Female

Age …… years / months

Date of birth (if known) ……

Place of birth (if known) ……

Was this elephant captive born / wild born

If captive born, was it mother reared / hand reared / NA (wild born) / don't know

As far as you know, is this elephant related to any other individual(s) in the collection?

Yes / No

If YES give details (name of other individual/s and type of relationship)

…….

…….

…….

2. LIFE-HISTORY

If this elephant was NOT born at this zoo, when did it arrive?

At age …….. months / years OR

In …….. (year) OR

N/A (born at this zoo)

Did it live anywhere other than its birth place before arriving at this zoo? Yes / No

If Yes, give full details of all previous residences including type of institution (zoo / circus / logging camp etc) and duration of residence

……

……

……

…….

3. HEALTH-HISTORY

Did this elephant arrive at this zoo with any ongoing **health problems**? **Yes / No**

If YES give details including type of problem(s) and brief history

…….

…….

…….

…….

Did this elephant arrive at this zoo with any ongoing **foot problems or lameness?**

Yes / No

If YES give details including type of problem(s) and brief history

…….

…….

…….

Has this elephant developed any **health problems** since arrival at this zoo? Yes / No

If YES give details including type of problem(s) and brief history

…….

…….

…….

Has this elephant developed any **foot problems or lameness** since arrival at this zoo?

Yes / No

If YES give details including type of problem(s) and brief history

…….

…….

…….

How often does this elephant have **blood samples** taken?

Every …… weeks / months / infrequently

Have any **abnormalities** been detected from recent blood tests? Yes / No

If 'Yes' please describe nature of abnormality(ies) and date(s) ……..

……..

……...

Do you perform **TB trunk washes** on this elephant? Yes / No

Do you perform any **other diagnostic tests** on this elephant? Yes / No

If 'Yes', what test(s)? …….

Have any **abnormalities** been detected from diagnostic tests? Yes / No

If 'Yes' please describe nature of abnormality(ies) and date(s) ……..

……..

……...

List below the vaccinations **that this elephant has received, when last vaccinated and how frequently vaccinated:**

Disease	How frequently vaccinated	When last vaccinated	Notes

4.BEHAVIOURAL HISTORY

Did this elephant arrive at this zoo with any ongoing **behavioural problems** (e.g. stereotypy, anxiety, excessive aggression)? Yes / No

If YES give details including type of problem(s) and brief history

…….

…….

…….

…….

Has this elephant developed any **behavioural problems** since arrival at this zoo (e.g. stereotypy, anxiety, excessive aggression)? Yes / No

If YES give details including type of problem(s) and brief history

…….

…….

…….

…….

…….

…….

Please score this elephant's stereotypic behaviour according to the following scale:
0=never exhibits stereotypic behaviour;

1=rarely exhibits stereotypic behaviour;

2=sometimes exhibits stereotypic behaviour;

3=often exhibits stereotypic behaviour

Is there anything else **you can tell us that would help us to understand this elephant better?**
Yes / No

If YES give details below

…….

…….

…….

…….

…….

…….

University of BRISTOL

Keeper Questionnaire

Researcher:…….. Date:…….……

Zoo Code……..……...

Name of respondent(s)…….

Respondent occupation(s) (e.g. curator, keeper) …….

Notes on completion of this Questionnaire:

This Questionnaire is intended to be a 'snap-shot' of elephant management at this Zoo and at this particular moment in time. Its aim is to assess the current management of the elephants. If anything has changed in the last year, please note the change and when it took place. Feel free to add notes!

General

1. How long has a Zoo been in operation on this site? …….. years

2. How long has this zoo been keeping elephants? ……. years

3. How many elephants do you currently have? …….. African cows
   …….. African bulls
   ……. African juveniles (< 2 yrs)
   ……. African sub-adults (2-8 yr)

   ……. Asiatic cows
   ……. Asiatic bulls
   ……. Asiatic juveniles (< 2 yrs)
   ……. Asiatic sub-adults (2-8 yr)
4. How many elephant houses do you have? ……

5. How many outdoor enclosures do you have? …….

6. In your opinion, do your elephants form a cohesive social group? Yes / No
   If 'Yes', but not all elephants are part of the group, give details:
   ……..
   ……..
   ……..
7. Is the social structure of your herd currently stable? Yes / No
   If 'No', describe the nature of the instability (e.g. dominance changed due to pregnancy) ……...
   ……..
   ……..
8. Can you describe the dominance hierarchy of your elephants, ie which animals are dominant and which subordinate to which other group members? Yes / No
   If 'Yes', describe below in as much detail as possible:
   ……..
   ……..
   ……..
   ……..

9. If there are / have been births in the collection: How are cows managed during births (e.g. separated from herd / put on chains / no special management)?
   ……..
   ……..
   ……
   ……

Daily Routine

10. How many hours per day are elephants generally kept indoors? ……. hours
(If the answer to question 8 varies between individuals or between seasons please give details here) …….
……..
……..
……..

11. Are any of the elephants kept separated or housed singly at night? Yes / No
   If 'Yes', give details, including the reason for the single housing ……..……
   ……
   ……
   ……

12. Describe the foot care provided to elephants (what happens and how often)
……
……
……

(If the answer to question 15 varies between individuals please give details here)
……..
……..
……..

13. Describe the body care (e.g. washing / scrubbing) that is provided to elephants (what happens and how often) …….

……..

……..

(If the answer to question 16 varies between individuals please give details here)

……..

……..

……..

14. Describe any other routine daily care that is provided to elephants ……
    ….

    ……..

    ……..

(If the answer to question 17 varies between individuals or care is other than daily please give details here) ……..…….

……..

……..

……..

15. Are any of the elephants **restrained** (e.g. put on chains or into a restrictive corral) as part of the normal daily routine? Yes / No
    If 'Yes', give details below including type of restraint (chain/corral), number of hours per day typically restrained and which elephants are restrained if not all

    ……..

    ……

    ……..

16. Do you have an **elephant restraint chute?** Yes / No

Visitor Contact

17. How many hours per day do elephants have visual contact with zoo visitors?
    …….. hours

18. Is this contact same air space / through window

    If 'same air space', how close are visitors allowed to get to the elephants?

    Approximately …….. cm / m (delete as appropriate)

19. Do any of your elephants have direct (touching) contact with zoo visitors? Yes / No

    If 'Yes', provide details including frequency of contact: ……..……..

    ……

    ……..

    ……..

20. Do you allow members of the public to feed your elephants? Yes / No

    If 'Yes', provide details including which elephants: ……...

    ……..……

    ……..

    ……

21. What measures do you take to prevent people feeding your elephants other than at public feeds? ……..

22. Are any of your elephant given opportunities for exercise, e.g. walks around the zoo? Yes / No

    If 'Yes' give details including name(s) of elephants: ……..

    ……..

    ……..

    ……..

23. Approximately how far do elephants walk as part of their everyday routines (e.g. between and house and paddock; walks around zoo)? …… m / km / miles

24. Do any of your elephants participate in shows or displays? Yes / No

    If 'Yes' give details including name(s) of elephants: ……..

    ……..

    ……..

    ……..

Keepers

25. Can we go through each of the keepers and take some information about them?

Name	Position (e.g. senior keeper; keeper)	Age (years)	Sex (M / F)	No. years working with elephants at this zoo	No. years working with elephants total	Works with other species?* (Y / N)

* In this keeper's current position at this zoo, does he/she also work with other species (=Y), or only with elephants (= N)?
If 'Y', indicate no. hours per day spent with elephants

26. Does one specific keeper generally look after one specific elephant? Yes / No

If 'Yes', please list the keeper / elephant pairings:

……..

……..

……..

If 'No', describe how elephant care is allocated:

……..

……..

……..

27. Can you briefly describe how your new elephant keepers are trained?

……..

……..

……..

……..

28. Can you briefly describe what ongoing training established keepers receive?

……..

……..

……..

……..

29. Can you describe the ways that keepers monitor modern zookeeping methods worldwide, to keep up with best practice?

……..

……..

……..

……..

30. Can you describe the ways that keepers share information with other Zoos and Safari Parks in Britain, for example on keeping methods?

……..……

……..

……..

……..

31. In your opinion, do you receive adequate funding to maintain your elephants?

Yes / No

If 'No', please give details ……..

……

……..

……..

32. In your opinion, are there currently enough elephant keepers? Yes / No

If 'No', please give details ……..

……

……..

……..

33. In your opinion, are your current elephant facilites adequate? Yes / No

If 'No', please explain why not ……...

……..

……..

……..

Handling

34. List the elephants that have **free contact** with keepers …….

……..

……..

……..

35. List the elephants that have **protected contact** with keepers…….

……..

……..

……..

36. List the elephants that have **zero contact** with keepers …….

……..

……..

……..

37. Has any of your elephants **changed from one handling method to another?**

Yes / No

If 'Yes', please explain the reason(s) why: …….

……..

……..

……..

38. Do you consider any of your elephants **difficult to handle?** Yes / No

If 'Yes' please give details below including the name of the elephant(s)

……..

……..

…….

Feeding

39. Can you tell me what you feed your elephants and how much?
(include concentrates, hay, browse, fruit, vegetables, bread and anything else fed)

Type of food	Amount given per day (indicate measure, e.g. kg or number of fruits / vegetables)

40. How many meals do elephants receive each day? …….

41. At what times are meals served? ……..

42. Do your elephants receive any dietary supplements? Yes / No
If 'Yes', please list them, including type of supplement (name) and how frequently given: ……...
……..

43. Does elephants' diet vary by season? Yes / No

If 'Yes', please say what changes: ……..

…….

44. Are any of your elephants currently on a weight-reducing or other special diet? Yes / No

If 'Yes', list which elephant(s) and what type of diet: ……

……..

45. Are your elephants monitored by a nutritionist? Yes / No

46. Why do you feed your elephants what you do (i.e. what rationale is there for the elephants' current diet)? ……

…….

……..

……..

University of BRISTOL

Health-Check Questionnaire For Elephants

Researcher:…….. Date:…….……

Zoo Code:…….……...

Elephant Keeper's Name:…….

Elephant's name:……..

Ambient temperature: …… C Weather: ……

Notes on completion of this Questionnaire:

This Questionnaire is intended to be a 'snap-shot' of the elephant's health. Its aim is to assess the current health status of the elephant. Therefore, a 'lesion' means any visible or palpable abnormality at the time of inspection. For any lesion noted, please record whether exudate is or is not present. Historical records of health will be collected from the medical records to assess lesions, exudate, etc. which have occurred previously but are now not observable.

Each area of interest should be visually inspected, and the keeper asked about its health. If only visual inspection, or only keeper information, is available, please make a note of this. If no information is available please note this.

For any lesion or problem area take a digital photograph and (if appropriate) a thermographic image.

1. SKIN LESIONS

Please note the number and length (cm) of any lesions, and whether any exudate is present.

Inspect	Keeper			Inspect	Keeper
☐	☐	Head……..	Back……	☐	☐
☐	☐	Face……	Abdomen…….	☐	☐
☐	☐	Chest……	Rump……..	☐	☐
☐	☐	Left flank…….	Right flank……..	☐	☐
☐	☐	Left ear…….	Right ear……..	☐	☐
☐	☐	Trunk……	Tail……..	☐	☐
		Legs (not feet)			
☐	☐	Left fore……..	Right fore……	☐	☐
☐	☐	Left rear……..	Right rear…….	☐	☐

2. SKIN DRYNESS

Please score the skin for being dry/scaly/thickened on the following areas

0=normal, 1=slightly dry, 2=very dry, 3=extremely dry

Inspect	Keeper			Inspect	Keeper
☐	☐	Head……Back……..…		☐	☐
☐	☐	Face……	Abdomen……..	☐	☐
☐	☐	Chest……	Rump……	☐	☐
☐	☐	Left flank……	Right flank……	☐	☐
☐	☐	Left ear……	Right ear……	☐	☐
☐	☐	Trunk……	Tail……	☐	☐
		Legs (not feet)			
☐	☐	Left fore……	Right fore…….....	☐	☐
☐	☐	Left rear……	Right rear…….....	☐	☐

3. EYES

Please score the amount of any abnormal fluid the eyes are exuding

0=none, 1=small amount, 2=large amount, 3=very large amount

	Score	Inspect	Keeper
Left Eye		☐	☐
Right Eye		☐	☐

Please describe any fluid exuding from the eye (thickness, colour, etc) -- whether abnormal or not.

……..

4. TUSKS

Does this elephant have tusks? Yes / No

(If no go to 'Teeth')

	Inspect	Keeper
Left Tusk	☐	☐
Right Tusk	☐	☐

		Left Tusk	Right Tusk
Is the tusk broken?		Yes / No	Yes / No
Does the break cross the pulp?		Yes / No / NA	Yes / No / NA
Does the break extend into the root?		Yes / No / NA	Yes / No / NA
Is there any discharge around the base of the tusk?		Yes / No	Yes / No
Is the tusk receiving treatment of any kind? (If 'Yes' add details below)		Yes / No	Yes / No
Does this treatment appear to be working?		Yes / No / NA	Yes / No / NA
Has corrective surgery been planned?		Yes / No / NA	Yes / No / NA

Details of any current or planned tusk treatment: _____

_____

5. TEETH

	Inspect	Keeper
Left Upper	☐	☐
Right Upper	☐	☐
Left Lower	☐	☐
Right Lower	☐	☐

Please score the health of the elephant's molars

0=healthy, 1=slightly, 2=very, 3=severely

	Left Upper	Right Upper	Left Lower	Right Lower
Mis-alignment or deviation from cranio-caudal axis				
Abscessed				
Cracked				
Decayed				
Broken				
Discharge around molars				

6. TRUNK

	Inspect	Keeper
Trunk	☐	☐

Please score the amount of any abnormal fluid the trunk is exuding.

0=None, 1=small amount, 2=large amount, 3=very large amount

Please describe any fluid (thickness, colour, etc) whether abnormal or not.

Please score the functionality of the trunk.
0=100% functional, 1=66% functional, 2=33% functional, 3=0% functional

If other than 0, please describe the nature of the abnormal function, e.g. cannot move trunk to one side

7. LOCOMOTION

	Inspect	Keeper
Locomotion	☐	☐

Please score locomotion according to the following scale

0=walks normally with no signs of difficulty or lameness;

1=walks with mild to moderate signs of difficulty or slight to moderate lameness;

2=walks with considerable difficulty or significant lameness;

3=displays extreme difficulty in walking and/or signs of pain or distress when standing or walking

Does this elephant sleep lying down? Yes often / Yes occasionally / Never

Does this elephant only lie down on one side? Yes / No

If 'Yes', which side? Left / Right

Does standing up and lying down appear easy / slightly difficult / very difficult

Does this elephant ever show temporary periods of apparent stiffness (e.g. when starting to walk about in the mornings)? Yes / No

If 'Yes', please give details:

_____
_____
_____
_____

8. FEET

	Inspect from above	Inspect from underneath	Keeper
Left fore	☐	☐	☐
Right fore	☐	☐	☐
Left hind	☐	☐	☐
Right hind	☐	☐	☐

Please state the number and length of lesions (cm)

Condition	Left fore	Right fore	Left hind	Right hind
Nail cracks > 2cm (mark on diagrams)				
Nail crack extending into cuticle (mark on diagrams)				
Discharge around the toes				
Overgrown nail cuticle				
Recent lesions on sole				
Recent cracks on sole				
Overgrown sole				
Sole bruising				

Do any of the toes have multiple nail cracks? Yes / No

If 'Yes', please state the foot, toe, number and length of cracks:

_____

_____

****

NOW TAKE A DIGITAL PHOTOGRAPH OF EACH FOOT: TOP AND UNDER SIDE AND A THERMOGRAPHIC IMAGE OF EACH FOOT

****

9. FAECES

	Inspect	Keeper
Faeces	☐	☐

Please score the faecal fluidity

0=normal, 1=slightly fluid, 2=very fluid, 3=extremely fluid

Please score the faecal dryness

0=normal, 1=slightly dry, 2=very dry, 3=extremely dry

In general, how many times per day does this elephant defecate? …….. times

Please score the number of parasites that are evident in the faeces
0=none, 1=few, 2=many, 3=very many

10. TAIL

	Inspect	Keeper
Tail	☐	☐

Please score the functionality of the tail
0=100% functional, 1=66% functional, 2=33% functional, 3=0% functional

If other than 0, please describe the nature of the abnormal function, e.g.

cannot move tail to one side

11. BODY CONFORMATION

	Inspect	Keeper
Body conformation	☐	☐

How much does the elephant weigh? …….. kg / lb
Is this weight known to be accurate / approximate

What is the elephant's height to the shoulder? …… m / ft

Is this height known to be accurate / approximate

Is the elephant at her / his target weight? Yes / No

Please score the elephant for being overweight.

0=normal, 1=slightly, 2=very, 3=extremely

Please score the elephant for being underweight.

0=normal, 1=slightly, 2=very, 3=extremely

Please score the elephant for spine protrusion.
0=normal, 1=slight protrusion, 2=medium protrusion, 3=extreme protrusion

Please score the elephant for roundness when viewed from behind
0=normal, 1=slightly round, 2=very round, 3=extremely round

****
NOW TAKE A DIGITAL PHOTOGRAPH OF THE ELEPHANT FROM BEHIND
****

12. SEXUAL ORGANS

	Inspect	Keeper
Sexual organs	☐	☐

Please score the amount of any abnormal fluid from the vagina/vestibule or penis/prepuce

0=None, 1=small amount, 2=large amount, 3=very large amount

Please describe any fluid exuding from the sexual organs (thickness, colour, etc) – whether abnormal or not.

13. REPRODUCTIVE STATUS

	Keeper
Reproductive status	☐

FEMALE ELEPHANTS ONLY:

Is the elephant cycling? Yes / No / Don't know

Is the elephant currently in oestrus? Yes / No

If 'Yes' Is this the first / subsequent oestrus?
How is oestrus determined?
Hormone assay / behaviour / other (specify): _____

Is the elephant currently pregnant? Yes / No

If 'Yes': Is this the first / subsequent pregnancy?
Approximately how far into pregnancy? ._____ weeks / months
How is pregnancy determined?
Hormone assay / behaviour / other (specify): _____

Has the elephant recently given birth? Yes / No

If 'Yes': How long ago? _____ weeks / months

Does the elephant currently have a retained foetus? Yes / No

If 'Yes': For how long has it been retained? _____ weeks / months

Is the elephant lactating? Yes / No

If 'Yes': How long has she been lactating? _____ weeks / months

MALE ELEPHANTS ONLY:

Is the elephant currently in musth? Yes / No

If 'Yes': How long has he been in musth? _____ weeks / months

Is this his first musth? Yes / No

Is it a full musth / mini musth? (circle one)

14. ANY OTHER Please note any other observations that might relate to the health of this elephant, e.g. coughing, sneezing, fly-strike, any lesions or injuries not already mentioned.

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Houses and Outdoor Enclosures

Researcher: …….. Date: ……..……

Zoo Code: ……..

Notes on completion of this Section:

This Section is intended to characterise the elephants' physical environment. The environment will comprise several areas (one or more houses with / without attached hard standing; one or more outdoor enclosures). Houses and outdoor enclosures might vary between elephants in a collection (e.g. separate accommodation for cows and bulls). Please complete all sections as fully and accurately. Feel free to add notes!

This Section is in two parts, both of which should be completed on the first visit:

i House Sheets and House Plans (complete one for each House)

ii Outdoor Enclosure Sheets and Outdoor Enclosure Plans (complete one for each Outdoor Enclosure)

House Sheet **House Name: …….**

How many **animals** use this house? …… cows
…… bulls
…… juveniles (< 2 yrs)
…… sub-adults (2-8 yr)

How **old** is this house? …… years / months

What **temperature** is the house maintained at? …… C / no set temperature

If the set temperature is varied according to **time of day** and / or **season** give details below:
…….
…….

Does the house have **skylights or windows** for natural light? Yes / No

How is the **dawn / dusk** achieved? none / all lights dimmed /
lights sequentially switched on or off

What is the current **lighting pattern** (e.g. 12 h light: 12 h dark; natural)? …….

What is the current **light source?** (circle all that apply) fluorescent / incandescent / natural

Is there any **coloured lighting**? Yes / No If 'Yes' what colour? ……

What is the **floor** of this house made of? ……..……

Is any of the floor **heated**? Yes / No

If 'Yes', which parts? ……

Is the **floor** flat / sloped?

If sloped, what is the approximate **angle of the slope** …… degrees

How does the floor **drain**? ……

How often is the **floor cleaned**? …… times per day / week?

How is the **floor cleaned**? (e.g. power wash, detergent – specify what type)?

……..

How many permanent **enclosures** are there in this house? ……..

Does the house incorporate a **pool**? Yes / No

If Yes, draw a plan of the pool below, to include shape and dimensions (including depth):

Is there water in the pool? Yes / No

Does the pool appear to be currently in use? Yes / No

If No, why not? ……..

Are there facilities in this house to **separate one or more elephants** (e.g. cow and calf) if required? Yes / No

Are there any **electrical fences** within reach of the elephants? Yes / No

Is there anything potentially **dangerous** to the elephants in this house, e.g. anything electrical within reach, anything sharp, broken etc.) Yes / No

If 'Yes', describe …….

How do elephants achieve **access** to outdoors? door / corridor / other ……...

Do **zoo visitors** have access to this house? Yes / No

If Yes, during what hours? …….

If Yes, what separates visitors from elephants: window / space / barrier

House Plan **House Name: …….**

Draw a **plan** of this house below, to include **elephant areas, public areas, keeper areas, attached hard standing**. Give **overall dimensions** (L, W, height) of house and include **dimensions of all indoor enclosures** (indicate whether permanent or temporary). Indicate position of **pools, showers/waterfalls**, **feeders** (include type and height), **drinkers** (include type and height), **enrichments** (include type), **scratching posts, windows, doors, skylights**

Outdoor Enclosure Sheet **Enclosure Name: ……**

How many **animals** use this enclosure? …… cows
…… bulls
…… juveniles (< 2 yrs)
…… sub-adults (2-8 yr)

How **old** is this enclosure? …… years / months

What is the **ground material** (e.g. grass, soil, concrete, gravel)? ……..

Describe the **condition(s) of the ground material** (e.g. muddy, well-grassed, even, uneven)
……..

What is the **soil type** (e.g. sandy, clay)? ……..

Is this **enclosure** generally flat / gently sloping or slightly hilly / steeply sloping or very hilly

Describe the nature, height and number of any **ground protrusions** the elephants might tread on, trip or stumble over ……
……
……

Does the enclosure incorporate a **pool**? Yes / No

If Yes, draw a plan of the pool below, to include shape and dimensions (including depth):

Is there water in the pool? Yes / No

Does the pool appear to be currently in use? Yes / No

Are there any elephant-dug **wallows or dust baths?** Yes / No

If Yes, indicate number and dimensions, whether wet or dry and whether wallows appear to be currently in use ……..……..

……..

……..

……..

Are there any **electrical fences** within reach of the elephants? Yes / No

Is there a **moat** around this enclosure? Yes / No

If Yes, is there an electric fence / other barrier between elephant and moat?

Is there anything else potentially **dangerous** to the elephants in this enclosure, e.g. anything electrical within reach, anything sharp, broken etc.) Yes / No

If Yes, describe …….

Outdoor Enclosure Plan **Enclosure Name: …….**

Draw a **plan** of this enclosure below, to include **elephant areas, public areas, keeper areas**. Include **shape** and **dimensions.** Indicate position of **pools, showers / waterfalls, elephant-dug dust baths / wallows, feeders** (include type and height) and **drinkers** (include type and height), **enrichments** (include type) and **scratching posts**

Appendix 4:
Partial ethogram of zoo elephant behaviours

Category	Code	Description
Aggression	C	Charge
	G	Gore with tusks
	K	Kick other elephant
	T	Threat
	Th	Trunk hit during aggressive encounter
General	H	Headshake
	Bs	Full bodyshake
	Hr	Rest head on environment
	L	Lie on side
	Ls	Lie sternally
	Rf	Rest foot on enclosure content
	S	Stand (all feet on ground)
	S3	Stand with one leg bent and foot off ground (weight on three feet only)
	Sh	Shuffle on chains (not stereotyped)
	Si	Sit on backend
	TD	Trumpet display
	Tm	Trunk in own mouth
	Tr	Rest trunk on environmental substrate
	Ts	Trunk sway
	Tt	Trunk on tusk
	W	Walk
	WB	Walk backwards
Interaction / Investigation / Manipulation of Environment	I	Interaction with environment
	Ie	Interaction with environmental enrichment device
	In	Investigation of environment with trunk
	Man	Manipulation of object with trunk after picking up
Maintenance	Ab	Blow air out of trunk onto body
	D	Drink
	Db	Dust bathe
	De	Defecate
	E	Eat
	Ba	Stand in water to depth of belly or deeper
	N	Nurse / suckle (cow)
	P	Paw enclosure substrate while standing
	Sc	Scratch
	Sp	Spray water outward, not on oneself
	Sw	Shower
	Swa	Stand in water (all four feet)
	Su	Suckle / suck (calf)
	To	Use a tool (branch, stick etc.) to brush or scratch body
	U	Urinate

Out of sight	OofS	Out of sight of observer
Other	A	Blow air out of trunk in bursts, no vocalisation
	B	Bar bite
	Fb	Faeces bathe
	IntK	Interact with keeper
Play	O	Object throw, not stereotyped
	Pl	Play
Sexual	F	Flehmen
	M	Masturbation
	Mo	Mount
Social	Pu	Push
	R	Rub/touch another elephant
	Ti	Trunk intertwine with another elephant
	Tmo	Trunk in mouth of another elephant
	He	Rest head on another elephant's head
	Hb	Headbutt
	Tp	Place trunk on another elephant's body
Stereotypy*	Hbb	Head bob
	Pa	Pace back and forth over a short distance
	Ro	Rock backwards and forwards
	Rt	Route trace
	Shs	Shuffle
	Sws	Sway
	Tur	Tusk rub
	We	Weave (side to side)
	Wbf	Walk forwards then backwards
Unusual eating	Co	Coprophagy
Vocalisation	Vg	Growl
	Vt	Trumpet
	Vr	Vocalisation raspberry sound

* Definition of stereotypic behaviour included persistence for 10 seconds or three repetitions. See full description in Chapter 4.

Appendix 5:
Health data for UK zoo elephants summarised by collection, at the three visits.

In the tables below, collections where full systematic visual inspection of elephants (including the soles of the feet) plus systematic questioning of an experienced elephant keeper was possible are indicated in bold. Collections where complete systematic inspection was not possible (and therefore health data were collected partly or exclusively through questioning an elephant keeper) are indicated in non-bold font.

i. Health indicators of UK zoo elephants at the initial visit (N=76)

	Collection						
No. (% in brackets) elephants displaying health problems of the:	A (N=4)	**B (N=4)**	C (N=3)	D (N=8)	**E (N=7)**	F (N=13)	G (N=8)
Fore feet (major) *	1	**3**	1	1	**0**	1	0
Fore feet (minor) **	2	**1**	3	4	**5**	0	1
Hind feet (major) *	0	**0**	0	0	**0**	0	0
Hind feet (minor) **	1	**2**	3	3	**5**	1	2
Eye(s)	0	**1**	0	0	**0**	0	0
Ear(s)	0	**0**	0	0	**0**	0	0
Tusk(s) / Tush(es) †	0	**0**	0	0	**0**	0	0
Teeth ††	0	**0**	1	1	**0**	0	0
Trunk	0	**0**	0	0	**0**	0	0
Tail	0	**0**	0	1	**0**	0	0
Faeces / digestion	0	**0**	0	0	**0**	0	0
Urinary / Sexual organs	0	**2**	0	0	**1**	0	0
Systemic disease	0	**0**	0	0	**0**	0	0
Skin lesion(s) †††:					**0**		
Head / neck	0	**1**	0	0	**0**	0	0
Face	0	**1**	0	1	**0**	0	0
Ear(s)	1	**0**	0	0	**0**	0	0
Trunk	0	**0**	0	0	**0**	0	0
Chest / abdomen	0	**0**	0	0	**0**	0	0
Back	0	**0**	0	0	**0**	0	0
Flank(s)	0	**0**	0	0	**0**	0	0
Rump	0	**0**	0	0	**0**	0	0
Leg(s)	0	**1**	0	0	**1**	0	0
Tail	0	**2**	0	1	**0**	0	0
Overweight (in the keeper's opinion)	1	**1**	3	1	**1**	0	1
Underweight (in the keeper's opinion)	0	**0**	0	1	**0**	0	0

i (continued)

	Collection						
No. (% in brackets) elephants displaying health problems of the:	**H (N=2)**	I (N=7)	**J (N=5)**	**K (N=4)**	**L (N=8)**	**M (N=3)**	Total (N=76)
Fore feet (major) *	**1**	0	**1**	**1**	**4**	**1**	15 (19.7%)
Fore feet (minor) **	**0**	2	**0**	**4**	**1**	**1**	24 (31.6%)
Hind feet (major) *	**0**	0	**0**	**1**	**0**	**0**	1 (1.3%)
Hind feet (minor) **	**1**	0	**1**	**4**	**1**	**3**	27 (35.5%)
Eye(s)	**1**	0	**0**	**0**	**0**	**0**	2 (2.6%)
Ear(s)	**0**	0	**0**	**0**	**0**	**0**	0
Tusk(s) / Tush(es) †	**0**	0	**0**	**0**	**0**	**0**	0 (0% of 60)
Teeth ††	**0**	0	**0**	**0**	**0**	**0**	2 (2.6%)
Trunk	**0**	0	**0**	**1**	**0**	**0**	1 (1.3%)
Tail	**0**	0	**0**	**0**	**0**	**0**	1 (1.3%)
Faeces / digestion	**1**	0	**0**	**0**	**0**	**0**	1 (1.3%)
Urinary / Sexual organs	**0**	0	**2**	**1**	**0**	**0**	6 (7.9%)
Systemic disease	**0**	0	**0**	**0**	**0**	**0**	0
Skin lesion(s) †††:							
Head / neck	**0**	0	**0**	**0**	**0**	**0**	1 (1.3%)
Face	**0**	1	**0**	**0**	**1**	**1**	5 (6.6%)
Ear(s)	**0**	0	**0**	**0**	**0**	**0**	1 (1.3%)
Trunk	**0**	0	**0**	**0**	**0**	**0**	0
Chest / abdomen	**0**	0	**0**	**1**	**0**	**1**	2 (2.6%)
Back	**0**	2	**0**	**1**	**0**	**1**	4 (5.3%)
Flank(s)	**1**	0	**0**	**0**	**1**	**1**	3 (3.9%)
Rump	**0**	0	**0**	**0**	**1**	**1**	2 (2.6%)
Leg(s)	**0**	0	**0**	**0**	**1**	**1**	4 (5.3%)
Tail	**0**	0	**0**	**0**	**1**	**0**	4 (5.3%)
Overweight (in the keeper's opinion)	**0**	2	**2**	**0**	**1**	**0**	13 (17.1%)
Underweight (in the keeper's opinion)	**0**	0	**0**	**0**	**0**	**0**	1 (1.3%)

* Numbers and percentages refer to number of elephants that displayed one or more problems with one or more of their feet. Major foot problems were defined as abscess(es), infection, rot, complicated nail cracks, significant overgrowth of the nail(s), cuticle(s) or pad(s) or significant injuries

** Minor foot problems were defined as uncomplicated nail cracks (small cracks which did not extend into the cuticle), minor overgrowth of the nail(s), cuticle(s) or pad(s) or minor injuries

† A tusk problem was defined as a recent break that crossed the pulp, required treatment or was otherwise complicated. Minor chips, wear and tear were considered normal for elephants, and not defined as a problem. Several elephants had grooves on their tusks from rubbing on bars or ropes; these grooves (which were discussed earlier, in the section on behaviour) are not included as health problems. Since not all elephants had tusks/tushes, percentages shown are of those elephants with tusks or tushes

†† In some cases it was possible to visually inspect top teeth, but inspecting bottom teeth, even in well-trained elephants, proved impossible. Thus the health of teeth was almost exclusively assessed by asking the elephant keeper. Some elephants are trained to open their mouths so that the keepers

can look inside. In other cases, indirect evidence such as ability to eat normally and normal faeces are used to ascertain the normality of teeth

††† A skin lesion was defined as a visible or palpable, active abnormality. Healed scars and old wounds were not defined as lesions

ii Health indicators of UK zoo elephants at the second visit (N=73)

	Collection						
No. (% in brackets) elephants displaying health problems of the:	A (N=4)	**B (N=4)**	C (N=3)	D (N=9)	**E (N=7)**	F (N=13)	G (N=8)
Fore feet (major)	3	**3**	1	1	**0**	0	0
Fore feet (minor)	2	**4**	0	5	**2**	0	4
Hind feet (major)	0	**0**	0	1	**0**	0	1
Hind feet (minor)	0	**3**	3	2	**5**	1	6
Eye(s)	0	**1**	0	0	**0**	0	0
Ear(s)	0	**0**	0	0	**0**	0	0
Tusk(s) / Tush(es)	0	**0**	0	0	**0**	0	0
Teeth	0	**0**	1	1	**0**	0	0
Trunk	0	**0**	0	0	**0**	0	0
Tail	0	**0**	0	1	**0**	0	0
Faeces / digestion	0	**0**	0	0	**0**	0	0
Urinary / Sexual organs	0	**2**	0	0	**1**	0	0
Systemic disease	0	**0**	0	0	**0**	0	0
Skin lesion(s):						0	
Head / neck	1	**0**	0	0	**0**	0	0
Face	1	**0**	0	0	**0**	0	1
Ear(s)	1	**0**	0	0	**0**		1
Trunk	1	**0**	1	0	**0**	0	0
Chest / abdomen	0	**0**	0	0	**0**	0	0
Back	0	**0**	0	0	**0**	0	0
Flank(s)	0	**0**	0	0	**0**	0	0
Rump	1	**0**	0	0	**0**	0	0
Leg(s)	1	**1**	0	0	**0**	0	0
Tail	0	**2**	0	1	**0**	0	0
Overweight (in the keeper's opinion)	2	**1**	3	1	**1**	0	1
Underweight (in the keeper's opinion)	0	**0**	0	0	**0**	0	0

ii (continued)

	Collection						
No. (% in brackets) elephants displaying health problems of the:	**H (N=2)**	I (N=4)	**J (N=5)**	**K (N=4)**	**L (N=7)**	**M (N=3)**	Total (N=73)
Fore feet (major)	**1**	0	**1**	**0**	**2**	**1**	13 (17.8%)
Fore feet (minor)	**2**	2	**0**	**3**	**5**	**2**	31 (42.5%)
Hind feet (major)	**2**	0	**2**	**0**	**0**	**1**	7 (9.6%)
Hind feet (minor)	**2**	0	**0**	**4**	**0**	**3**	29 (39.7%)
Eye(s)	**1**	0	**0**	**0**	**0**	**0**	2 (2.7%)
Ear(s)	**0**	0	**0**	**0**	**0**	**0**	0
Tusk(s) / Tush(es)	**0**	0	**1**	**0**	**0**	**0**	1 (1.9% of 52)
Teeth	**0**	0	**0**	**0**	**0**	**0**	2 (2.7%)
Trunk	**0**	0	**0**	**0**	**0**	**0**	0
Tail	**0**	0	**0**	**0**	**0**	**0**	1 (1.4%)
Faeces / digestion	**1**	0	**0**	**0**	**0**	**0**	1 (1.4%)
Urinary / Sexual organs	**0**	0	**2**	**1**	**0**	**0**	6 (8.2%)
Systemic disease	**0**	0	**0**	**0**	**0**	**0**	0
Skin lesion(s):							
Head / neck	**0**	0	**0**	**0**	**0**	**0**	1 (1.4%)
Face	**0**	1	**0**	**0**	**0**	**0**	3 (4.1%)
Ear(s)	**0**	0	**0**	**0**	**0**	**0**	2 (2.7%)
Trunk	**0**	0	**0**	**0**	**0**	**0**	2 (2.7%)
Chest / abdomen	**0**	0	**0**	**1**	**1**	**0**	2 (2.7%)
Back	**0**	2	**0**	**1**	**0**	**0**	3 (4.1%)
Flank(s)	**0**	0	**0**	**0**	**0**	**1**	1 (1.4%)
Rump	**0**	1	**0**	**0**	**0**	**1**	3 (4.1%)
Leg(s)	**0**	0	**0**	**0**	**0**	**0**	2 (2.7%)
Tail	**0**	0	**0**	**0**	**0**	**0**	3 (4.1%)
Overweight (in the keeper's opinion)	**0**	1	**3**	**0**	**1**	**0**	14 (19.2%)
Underweight (in the keeper's opinion)	**0**	0	**0**	**0**	**0**	**0**	0

iii Health indicators of UK zoo elephants at the third visit (N=68*)

	Collection						
No. (% in brackets) elephants displaying health problems of the:	A (N=3)	**B (N=4)**	C (N=3)	D (N=9)	**E (N=7)**	F (N=10)*	G (N=8)
Fore feet (major)	1	**3**	1	2	**0**	1	0
Fore feet (minor)	2	**2**	1	5	**0**	1	5
Hind feet (major)	0	**1**	1	1	**0**	1	3
Hind feet (minor)	0	**2**	3	2	**4**	0	5
Eye(s)	0	**1**	0	0	**0**	0	0
Ear(s)	0	**0**	0	0	**0**	0	0
Tusk(s) / Tush(es)	0	**0**	0	0	**1**	0	0
Teeth	0	**0**	1	1	**0**	0	0
Trunk	0	**0**	0	0	**0**	0	0
Tail	0	**0**	0	1	**0**	0	0
Faeces / digestion	0	**0**	0	0	**0**	0	0
Urinary / Sexual organs	0	**2**	0	0	**1**	0	0
Systemic disease	0	**0**	0	0	**0**	0	0
Skin lesion(s):							
Head / neck	0	**0**	0	0	**0**	0	0
Face	0	**0**	0	0	**0**	0	0
Ear(s)	0	**0**	0	0	**0**	0	1
Trunk	0	**0**	0	0	**0**	0	0
Chest / abdomen	0	**0**	0	0	**0**	0	0
Back	0	**0**	0	0	**0**	0	0
Flank(s)	0	**0**	0	0	**0**	0	1
Rump	0	**0**	0	0	**0**	1	0
Leg(s)	0	**0**	0	0	**0**	0	0
Tail	0	**0**	0	1	**0**	0	0
Overweight (in the keeper's opinion)	0	**1**	3	1	**1**	0	0
Underweight (in the keeper's opinion)	0	**0**	0	0	**0**	0	0

iii (continued)

	Collection						
No. (% in brackets) elephants displaying health problems of the:	**H (N=2)**	I (N=3)	**J (N=4)**	**K (N=4)**	**L (N=8)**	**M (N=3)**	Total (N=68)*
Fore feet (major)	**2**	0	**1**	**0**	**4**	**0**	15 (22.1%)
Fore feet (minor)	**2**	2	**1**	**4**	**3**	**1**	29 (42.6%)
Hind feet (major)	**2**	0	**0**	**0**	**0**	**0**	9 (13.2%)
Hind feet (minor)	**2**	3	**1**	**4**	**0**	**3**	29 (42.6%)
Eye(s)	**1**	0	**0**	**0**	**0**	**0**	2 (2.9%)
Ear(s)	**0**	0	**0**	**0**	**0**	**0**	0
Tusk(s) / Tush(es)	**0**	0	**1**	**0**	**1**	**0**	3 (6.1% of 49)
Teeth	**0**	0	**0**	**0**	**0**	**0**	2 (2.9%)
Trunk	**0**	0	**0**	**0**	**0**	**0**	0
Tail	**0**	0	**0**	**0**	**0**	**0**	1 (1.5%)
Faeces / digestion	**0**	0	**0**	**0**	**0**	**0**	0
Urinary / Sexual organs	**0**	0	**2**	**1**	**0**	**0**	6 (8.8%)
Systemic disease	**0**	0	**0**	**0**	**0**	**0**	0
Skin lesion(s):							
Head / neck	**0**	0	**0**	**0**	**0**	**0**	0
Face	**0**	0	**0**	**0**	**0**	**0**	0
Ear(s)	**0**	0	**0**	**0**	**0**	**0**	1 (1.5%)
Trunk	**0**	0	**0**	**0**	**0**	**0**	0
Chest / abdomen	**0**	0	**0**	**0**	**0**	**0**	0
Back	**0**	0	**0**	**0**	**0**	**0**	0
Flank(s)	**0**	0	**0**	**0**	**0**	**1**	2 (2.9%)
Rump	**0**	0	**0**	**1**	**0**	**0**	2 (2.9%)
Leg(s)	**0**	1	**0**	**0**	**1**	**0**	2 (2.9%)
Tail	**0**	0	**0**	**0**	**1**	**0**	2 (2.9%)
Overweight (in the keeper's opinion)	**0**	0	**3**	**0**	**1**	**0**	10 (14.7%)
Underweight (in the keeper's opinion)	**0**	0	**0**	**0**	**1**	**0**	1 (1.5%)

* At this collection, eleven elephants were present at the third visit; however, health data were collected from only ten, excluding a newly-born calf. Thus, the total number of elephants is 68

Appendix 6:
Locomotion data for UK zoo elephants summarised by collection, at the three visits.

i Locomotion data as reported by keepers of UK zoo elephants at the initial visit (N=76)

	Collection						
No. (% in brackets) elephants displaying:	A (N=4)	B (N=4)	C (N=3)	D (N=8)	E (N=7)	F (N=13)	G (N=8)
Gait:							
Walks normally with no signs of difficulty or lameness	2	4	3	7	4	13	7
Walks with mild to moderate signs of difficulty or slight to moderate lameness	2	0	0	0	2	0	1
Walks with considerable difficulty or significant lameness	0	0	0	0	1	0	0
Displays extreme difficulty in walking and/or signs of pain or distress when standing or walking	0	0	0	1	0	0	0
Often sleeps lying down	1	3	3	8	4	10	2
Sometimes sleeps lying down	2	0	0	0	3	3	4
Does not sleep lying down *	1	1	0	0	0	0	2
Lies down only on one side	2	1	0	1	1	0	0
Standing up and lying down appears easy	3	4	3	6	5	13	6
Standing up and lying down appears slightly difficult	1	0	0	2	1	0	0
Standing up and lying down appears very difficult	0	0	0	0	1	0	0
Sometimes shows temporary periods of apparent stiffness	0	1	1	2	1	0	2

i (continued)

	Collection						
No. (% in brackets) elephants displaying:	H (N=2)	I (N=7)	J (N=5)	K (N=4)	L (N=8)	M (N=3)	Total (N=76)
Gait:							
Walks normally with no signs of difficulty or lameness	2	7	3	4	6	3	65 (85.5%)
Walks with mild to moderate signs of difficulty or slight to moderate lameness	0	0	0	0	1	0	6 (7.9%)
Walks with considerable difficulty or significant lameness	0	0	2	0	0	0	3 (3.9%)
Displays extreme difficulty in walking and/or signs of pain or distress when standing or walking	0	0	0	0	1	0	2 (2.6%)
Often sleeps lying down	0	2	2	2	7	3	47 (61.8%)
Sometimes sleeps lying down	2	5	3	2	0	0	24 (31.6%)
Does not sleep lying down *	0	0	0	0	1	0	5 (6.6%)
Lies down only on one side	0	0	0	0	1	0	6 (8.1% of 74)
Standing up and lying down appears easy	2	7	4	4	7	3	67 (90.5% of 74)
Standing up and lying down appears slightly difficult	0	0	1	0	0	0	5 (6.8% of 74)
Standing up and lying down appears very difficult	0	0	0	0	1	0	2 (2.7% of 74)
Sometimes shows temporary periods of apparent stiffness	1	1	2	1	0	0	12 (15.8%)

* Two elephants (initial and second visit) and one elephant (third visit) were thought by their keepers never to lie down. Percentages in the four rows below are of those elephants that did lie down

ii Locomotion data as reported by keepers of UK zoo elephants at the second visit (N=73)

	Collection						
No. (% in brackets) elephants displaying:	A (N=4)	B (N=4)	C (N=3)	D (N=9)	E (N=7)	F (N=13)	G (N=8)
Gait:							
Walks normally with no signs of difficulty or lameness	2	4	3	8	6	13	7
Walks with mild to moderate signs of difficulty or slight to moderate lameness	2	0	0	0	1	0	1
Walks with considerable difficulty or significant lameness	0	0	0	0	0	0	0
Displays extreme difficulty in walking and/or signs of pain or distress when standing or walking	0	0	0	1	0	0	0
Often sleeps lying down	1	3	3	9	4	10	2
Sometimes sleeps lying down	2	0	0	0	3	2	4
Does not sleep lying down	1	1	0	0	0	1	2
Lies down only on one side	2	1	0	1	1	0	0
Standing up and lying down appears easy	3	4	3	7	5	13	6
Standing up and lying down appears slightly difficult	1	0	0	2	2	0	0
Standing up and lying down appears very difficult	0	0	0	0	0	0	0
Sometimes shows temporary periods of apparent stiffness	0	1	1	2	1	0	2

ii (continued)

	Collection						
No. (% in brackets) elephants displaying:	H (N=2)	I (N=4)	J (N=5)	K (N=4)	L (N=7)	M (N=3)	Total (N=73)
Gait:							
Walks normally with no signs of difficulty or lameness	2	4	3	4	6	3	65 (89%)
Walks with mild to moderate signs of difficulty or slight to moderate lameness	0	0	0	0	1	0	5 (6.8%)
Walks with considerable difficulty or significant lameness	0	0	2	0	0	0	2 (2.7%)
Displays extreme difficulty in walking and/or signs of pain or distress when standing or walking	0	0	0	0	0	0	1 (1.4%)
Often sleeps lying down	0	1	2	2	7	3	47 (64.4%)
Sometimes sleeps lying down	2	3	3	2	0	0	21 (28.8%)
Does not sleep lying down	0	0	0	0	0	0	5 (6.8%)
Lies down only on one side	0	0	0	0	0	0	5 (7% of 71)
Standing up and lying down appears easy	2	4	4	4	7	3	65 (91.5% of 71)
Standing up and lying down appears slightly difficult	0	0	1	0	0	0	6 (8.5% of 71)
Standing up and lying down appears very difficult	0	0	0	0	0	0	0 (0% of 71)
Sometimes shows temporary periods of apparent stiffness	1	1	2	1	0	0	12 (16.4%)

iii Locomotion data as reported by keepers of UK zoo elephants at the third visit (N=68*)

	Collection						
No. (% in brackets) elephants displaying:	A (N=3)	B (N=4)	C (N=3)	D (N=9)	E (N=7)	F (N=10)*	G (N=8)
Gait:							
Walks normally with no signs of difficulty or lameness	2	4	3	8	6	10	6
Walks with mild to moderate signs of difficulty or slight to moderate lameness	1	0	0	0	1	0	2
Walks with considerable difficulty or significant lameness	0	0	0	0	0	0	0
Displays extreme difficulty in walking and/or signs of pain or distress when standing or walking	0	0	0	1	0	0	0
Often sleeps lying down	1	3	3	9	4	8	2
Sometimes sleeps lying down	1	0	0	0	3	1	5
Does not sleep lying down	1	1	0	0	0	1	1
Lies down only on one side	1	1	0	1	1	0	0
Standing up and lying down appears easy	2	4	3	7	6	10	7
Standing up and lying down appears slightly difficult	1	0	0	2	1	0	0
Standing up and lying down appears very difficult	0	0	0	0	0	0	0
Sometimes shows temporary periods of apparent stiffness	0	1	1	2	1	0	2

iii (continued)

	Collection						
No. (% in brackets) elephants displaying:	H (N=2)	I (N=3)	J (N=4)	K (N=4)	L (N=8)	M (N=3)	Total (N=68)*
Gait:							
Walks normally with no signs of difficulty or lameness	2	3	2	4	7	3	60 (88.2%)
Walks with mild to moderate signs of difficulty or slight to moderate lameness	0	0	0	0	1	0	5 (7.4%)
Walks with considerable difficulty or significant lameness	0	0	2	0	0	0	2 (2.9%)
Displays extreme difficulty in walking and/or signs of pain or distress when standing or walking	0	0	0	0	0	0	1 (1.5%)
Often sleeps lying down	0	2	1	2	8	3	46 (67.6%)
Sometimes sleeps lying down	2	1	3	2	0	0	18 (26.5%)
Does not sleep lying down	0	0	0	0	0	0	4 (5.9%)
Lies down only on one side	0	0	0	0	0	0	4 (6% of 67)
Standing up and lying down appears easy	2	3	3	4	8	3	62 (% of 67)
Standing up and lying down appears slightly difficult	0	0	1	0	0	0	5 (7.5% of 67)
Standing up and lying down appears very difficult	0	0	0	0	0	0	0 (0% of 67)
Sometimes shows temporary periods of apparent stiffness	1	0	2	1	0	0	11 (16.2%)

* At this collection, eleven elephants were present at the third visit; however, health data were collected from only ten, excluding a newly-born calf. Thus, the total number of elephants is 68

Appendix 7:
The welfare indicators scored from 0 to 3 by the researchers to generate an overall welfare score for each UK zoo elephant

Mean faecal cortisol concentrations
Body condition score
Duration of day-time stereotypical behaviour
Duration of night-time stereotypical behaviour
Exhibit size
Number of elephants in the herd
Locomotion score
Lesions to the head
Lesions to the face
Lesions to the chest
Lesions to the flanks
Lesions to the ears
Lesions to the trunk
Lesions to the legs
Lesions to the back
Lesions to the abdomen
Lesions to the rump
Lesions to the tail
Lesions to 'other'
Health of the eyes
Health of the tusks
Health of the teeth
Health of the trunk
Is the elephant stiff or does it have difficulty standing?
Health of the feet
Dryness/wetness of the faeces
Health of the tail
Health of the sexual reproductive organs
Reproductive status
Does the elephant have a retained foetus?
Can the elephant escape public scrutiny indoors?
Can the elephant escape public scrutiny outdoors?
How many hours/day is the elephant indoors?
Is the elephant shut outdoors or free access during the day?
Is the elephant shut indoors or free access during the night?
Is the elephant individually housed at night?
Is the elephant given browse every day?
Other