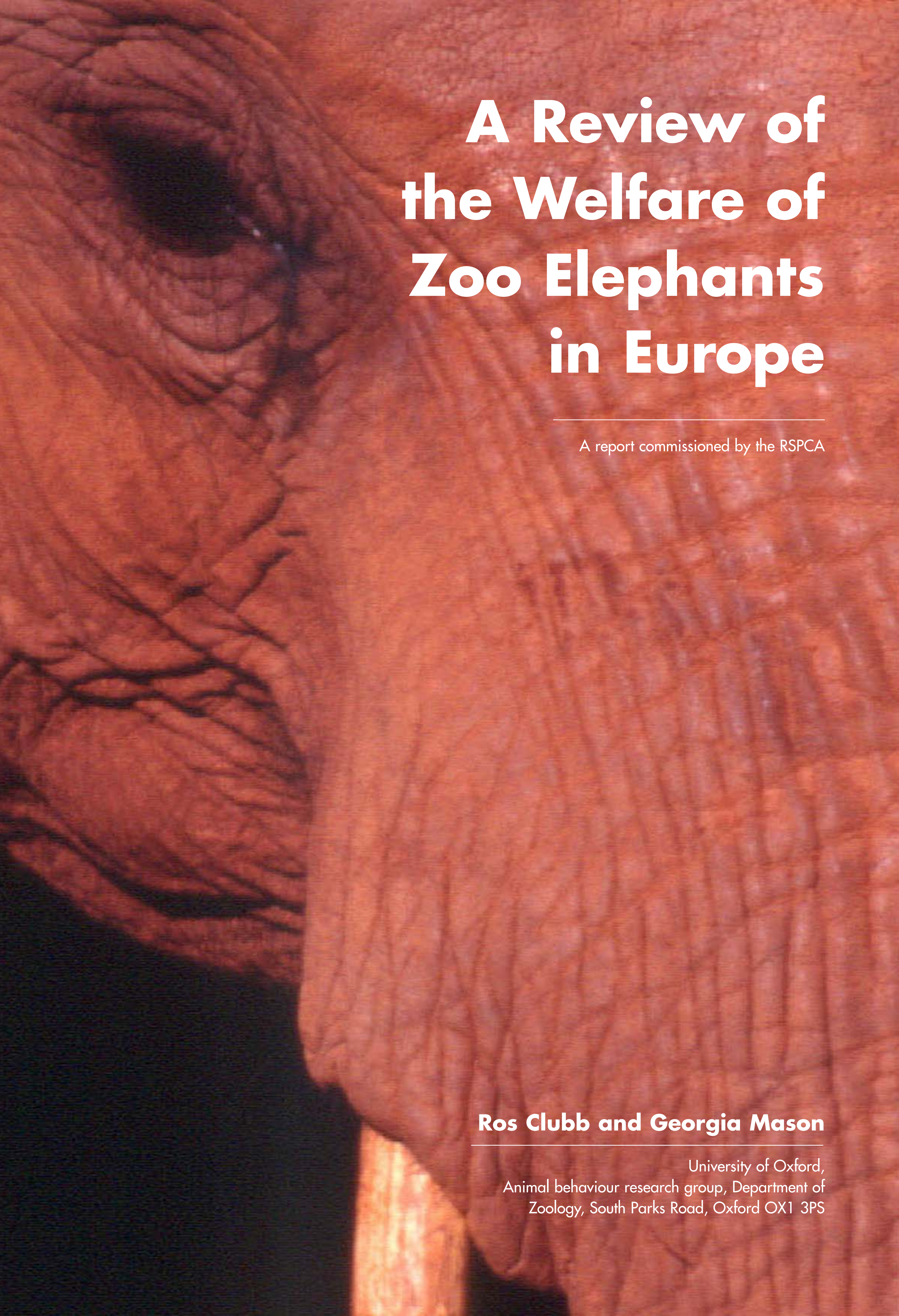

A Review of the Welfare of Zoo Elephants in Europe

A report commissioned by the RSPCA

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Chapter 1

Introduction and methodology

In this chapter, we introduce the issues that prompted the production of this report. We then introduce the concept of animal welfare and briefly summarise the main indicators used to measure the welfare of animals in captivity. The aims of this report are then stated and our general methodology described. We then define some terms used throughout the report, and end by giving an outline of the report's structure.

Aims of this report

Captive elephant management is a highly controversial issue, currently reaching a critical juncture in Europe and the U.S.A.. Elephants are a notoriously difficult species to maintain in zoos (Adams 1981; Schwammer & Karapanou 1997), and this, coupled with several recent high profile cases in the U.K and abroad, have brought to light several areas of concern regarding the welfare of zoo elephants. Issues in the press have largely focused on elephant training. As reviewed in Chapter 6, this traditionally involves the use of physical punishment, and the more extreme methods used have been brought to the fore by several recent legal cases. For example, the use of electric prods during elephant training at Blackpool Zoo was reported by the Performing Animal Welfare Society (PAWS 1999). Harsh methods were also witnessed during training of the famous 'Tuli elephants' in South Africa, prior to their export to zoos and circuses in Germany, Switzerland, China and their use in elephant-back safaris (e.g. Anon. 1998). These and similar cases alleging elephant abuse (discussed in Chapter 6), coupled with the prevalence of elephant handler injury and deaths (see Chapter 10) have led to elephant handling methods being called into question (Priest 1994; Mellen & Ellis 1996). This attention has also highlighted other areas of concern relating to the keeping conditions of zoo elephants, and several animal welfare groups have recently made elephant projects a priority, some campaigning for the banning of zoo elephants altogether (e.g. Captive Animals Protection Society [CAPS], Animal Defenders, People for the Ethical Treatment of Animals [PETA] , Born Free Foundation, Care for the Wild).

All this attention from animal activists, the public and the press has put a great deal of pressure on zoos to alter their practices (Desmond & Laule 1991). Although some zoo authorities have recently issued standards relating to the management and care of zoo elephants (see the following section), these often do not deal directly with the *welfare* of elephants. Instead, the emphasis is on husbandry, and recommendations are largely constrained by what is feasible within the existing zoo setting. The reasoning behind many of the minimum standards set is less than clear. It appears that what is perceived to be best and worse practice at the time is used to modify current practice, rather than addressing issues from first principles. In general, much of the necessary data needed to make really informed decisions to improve zoo elephant welfare are lacking. As put by Deborah Olson, the director of the International Elephant Foundation: "Unfortunately, too often we make statements and policy decisions based on little more than personal opinion – what we think it should be. How big should an elephant stall be? How many elephants should be maintained together? How much exercise should an elephant have? How effective is enrichment and what types of enrichment are effective? When should an elephant be weaned? The list goes on and on. The answers based on scientific study are "We don't know." The answers we give to these questions currently are founded on personal opinions, extrapolated from other animals, and in some cases past experience. Although past experience is certainly a valid consideration, it can be misconstrued or have extenuating circumstances, confounding issues, exceptions, and inconsistencies" (Olson 2002a).

This, coupled with the fact that there is a great deal of disagreement *within* the elephant community about best practice, could at worst lead to spurious recommendations, or at best, leave unresolved issues open to debate. The purpose of this report was, therefore, to collate and review the necessary information so that the following aims, as stated in this report's commissioning remit from the RSPCA, could be met:

- To identify welfare problems associated with keeping elephants in captivity;
- To scientifically identify relationships between such problems and elements of elephant husbandry;
- To make sound, ethically based recommendations for improving welfare of captive elephants.

We additionally highlight the many areas where research is needed, outlining the principle hypotheses and how these might be tested scientifically.

This report will concentrate on elephants held in European zoos, where Europe refers to the geographical, rather than political, region. Information will also be drawn from further afield as a great deal of pertinent research has been done in other countries, particularly North America and Asia. Conversely, much of the information in this report will apply equally to elephants held in zoos in other areas of the world as well as, to a certain extent, elephants held in circuses.

Laws and regulations relevant to zoo elephants

Standards specific to the management of zoo elephants have recently been issued by the American Zoo and Aquarium Association (AZA 2001). In addition, the Zoo Federation of Great Britain and Ireland will soon be releasing their own set of standards, some of which draw strongly from the AZA standards. These standards only cover zoos that are, or wish to become, members of these institutions, and only some are mandatory. Zoos wishing to renew, or apply for, accreditation from these organisations must therefore meet these minimum husbandry requirements. If they do not, accreditation is denied, but AZA-accredited zoos have a five year period within which to comply and this is also likely to be the case for U.K. zoos.

In the U.K., elephants are also covered by more general standards applicable to all zoo animals, namely *The Zoo Licensing Act 1981*, and more recently, *The Secretary of State's Standards of Modern Zoo Practice*. Quotes from the Secretary of State's Standards of Modern Zoo Practice have been used at the beginning of some sections of this report to highlight the standards that should be being met by zoos to qualify for a zoo licence. U.K. zoo elephants are also protected by several animal protection laws: the *Performing Animals (Regulations) Act 1925*; *Protection of*

Animals Act 1911 & *Agriculture (Miscellaneous Provisions) Act 1968*. Several orders that are restricted to livestock (namely "cattle, sheep, goats and other ruminating animals, pigs, rabbits and poultry") are also referred to in this report to highlight existing legislation, relevant to the welfare of zoo elephants, governing the use of electrical goads and other implements in these other species (see Chapter 6). These are: *Statutory Instruments 1995 No. 371: The Welfare of Animals (Slaughter or Killing) Regulations 1995*; *Statutory Instrument 1990 No. 2628: The Welfare of Animals at Markets Order 1990;* and *Statutory Instrument 1997 No. 1480: The Welfare of Animals (Transport) Order 1997*. The relevant sections of each order are highlighted in the appropriate chapters.

Assessing elephant welfare

Assessing animal suffering

Animal welfare assessment involves making inferences about the mental states of non-human animals. Most people assume that vertebrates can feel pleasure, pain and distress, and indeed animals are now officially considered as sentient beings according to European law (The Amsterdam Treaty, 1999). However, private experiences are inherently inaccessible, so how can we gauge animals' feelings? In the absence of language, we have to rely on some rather indirect means, developed by stress biologists and animal welfare scientists over the last two to four decades. These have been detailed and discussed in many publications, and are merely summarised here; for more details see for example Dawkins (1980), Broom (1986), Broom & Johnson (1993), Mason & Mendl (1993), Toates (1995), Duncan (1997), Hughes (1997), Mench & Mason (1997), Terlouw *et al.* (1997), European Commission (2001), and Mason (in press).

One scientific means of assessing welfare is to investigate what animals are highly motivated to reach or to avoid, and then use this information to judge the relative merits of different practices or housing systems. This approach rests on the assumption that animals will express strong preferences for things which give them good welfare, and strong aversions for things that cause them fear or pain. An alternative means of assessing welfare is to try and judge an animal's current state, using aspects of its behaviour or physiology believed to correlate with subjective feelings. There have been two main methods of selecting such measures. The first is to observe animals experimentally exposed to 'stressors' (stimuli we feel certain must be unpleasant, such as hunger, electric shocks or sensory deprivation), and/or animals known to be injured or ill. Data are collected on changes in these animals' behaviour or physiology, and similar changes can then be used to infer poor welfare in other animals. The second method is to observe the biological changes that occur in humans reporting feelings like fear, anxiety or pain. These data are typically obtained from people who are sick, clinically depressed, bereaved, or faced by stressful events such as important examinations. Any changes we find that correlate with our humans' negative emotions, we again can then seek in non-human animals.

These two methods of seeking correlates for animal feelings have yielded a diverse, yet largely over-lapping, range of measures, as we summarise below. It should be noted, however, that many of these measures suffer from a degree of non-specificity. For example, some (e.g. heart rate) change in response to pleasurable excitement as well to aversive stress. Welfare biologists currently tackle this problem by a) giving most weight to welfare indicators likely to *cause*, as well as to reflect, suffering (e.g. increased susceptibility to disease), and b) measuring many variables at once, to check that they all give a concordant picture. Taking this approach has allowed the scientific evaluation of many practices involving animals. It has also identified the general types of situation likely to cause poor welfare, as we outline at the end of this section.

Behavioural changes

Behavioural signs of poor welfare include loss of appetite, loss of interest in mating, poor parental care (sometimes even infanticide), reduced levels of grooming, reduced interest in exploring the surroundings, increased timidity or aggression, attempts to escape, and the performance of displacement activities (and the sub-class of repetitive stereotypies that derive from them; for more on stereotypic behaviour, see Chapter 10). Animals may also produce social signals of distress or need, such as particular odours or vocalisations. Some behaviours are particularly linked with frustration; these include intention movements (brief repetitions of the start of the motivated behavioural sequence), and 'vacuum' or redirected activities (performances of a motivated behaviour either directed to something quite inappropriate, or 'mimed'). Again, these behaviour patterns may, if repeated often enough, develop into rhythmic, unvarying stereotypies.

Physiological responses

In response to stressors, humans and other animals typically show some very rapid physiological changes, especially the release of adrenaline and an increase in heart rate (i.e. activation of the sympatho-medullary system), and the release of hormones by the adrenal cortex, as stimulated by adrenocorticotrophin (ACTH). Prolonged activation of this last system (the hypothalamic-pituitary-adrenal axis) can sometimes result in chronically raised basal corticosteroid levels in the blood, and also change the sensitivity of this endocrine system. Further physiological changes in response to sustained stress include altered metabolism, particularly a reduced level of protein synthesis (low growth rates, poor coats, slow healing rates, and a poor production of milk can therefore all reflect poor welfare), altered immune function (e.g. immunosuppression), and reduced breeding rates (due to lowered conception rates, and enhanced pre- and post-natal losses). Additional prepathological or pathological states associated with chronic stress include high blood pressure, arteriosclerosis, gastric ulceration, and enhanced susceptibilities to disease.

Causes of poor welfare

The measures above have now been used on a range of species, domesticated and wild, in laboratory, agricultural, zoo, and free-living situations. Together, they reveal two general causes of poor welfare: environments that cause stress, fear or frustration, and bodily changes that cause pain or discomfort. Stress, frustration and depression-like states can be caused by environmental conditions - physical or social - that differ significantly from those that the animal has evolved to cope with in the wild, the extent to which welfare is reduced often depending on the frequency, magnitude and duration of these discrepancies. Health is also clearly a major determinant of welfare: animals with diseases or injury are likely to experience discomfort, distress or even pain, which in turn may also cause stress and/or depression. Therefore we can often use health, and differences between the captive and the wild environment, as both 'warning signs' that welfare might be impaired even if we do not have the behavioural or physiological data needed to confirm this.

Assessing welfare in zoo elephants

For zoo elephants, data on several of the physiological and behavioural variables listed above are available. Behavioural data have been collected on stereotypies and aggression, and poor maternal care and infanticide have been quantified in surveys of reproduction and mortality rates (e.g. studbooks). Morbidity, including the prevalence of various illnesses that might relate to stress, has been investigated, and good quality mortality data are available (e.g. in the studbooks). Various non-invasive means of assessing 'stress hormones' have also been validated. For example, corticosteroids (and/or their metabolites) have now been assessed in elephant urine (Brown *et al.* 1995), saliva (Dathe *et al.* 1992; Exner & Zanella 1999), and faeces (Ganswindt *et al.* 2001). Adrenaline and other catecholamines can also be extracted and assessed from elephant saliva (Exner & Zanella 1999). Reproductive data, for example on inter-birth intervals, are also available from the studbooks. Furthermore, data are also available on factors likely to affect elephant welfare: data on zoo elephant health has been published, and conditions in the wild, with which to compare captive husbandry, are also very well studied.

However, to make useful judgements about the welfare of elephants in zoos, we need to be able to relate health, behaviour and physiology to housing. For this report, we thus needed to compare elephants in zoos with those living in extensive systems (Asian timber camps and sanctuaries: see later in this chapter for definitions) and/or in wild populations, to determine whether welfare is better or worse in zoos. Comparative physiological data were unfortunately simply not available, and morbidity data were very sparse from studies of wild and extensive elephants. However, we could compare the incidence of stillbirths, stereotypies, and inter-birth intervals and other aspects of reproductive functioning. We could also compare mortality rates, some aspects of disease, and infanticide and maternal rejection rates – all measures likely to cause, as well as reflect, welfare problems. Ideally, we also needed comparative data from elephants housed in different types of zoo environment, to identify the causal aspects of husbandry. However, relatively little scientific work has been done to quantify elephant welfare in different zoo housing and management systems. In this report, this left us sometimes having to make inferences from studies of how other species react to similar practices or environments.

Cost-benefit approaches to animal welfare

Animal welfare is often impaired in captivity, yet as a society we often implicitly regard this as a 'price worth paying': the costs in terms of welfare are treated as if outweighed by the benefits of keeping that animal. When using animals for research, however, it is now generally a requirement across Europe for the subjects' welfare to be formally, explicitly weighed against the likely benefits of the science. Thus, the lower the chance of useful or high quality research outcomes, the less acceptable are any welfare costs (see e.g. Driscoll & Bateson 1988 citing Bateson 1986; Wolfensohn & Lloyd 1998) – and indeed an experiment may be prevented on these grounds.

The pros and cons of keeping agricultural animals, pets or zoo animals are never formally weighed up in this way (e.g. Mench & Kreger 1997). However, informally, low perceived benefits have played a key role in the recent debates and legislative changes concerning fur farming, in many countries across Europe. The high welfare costs for the animals involved have also led many zoos to progressively abandon the keeping of cetaceans, and also polar bears (Klinowska & Brown 1986; Ironmonger 1992). In our final conclusions about zoo elephant welfare, we will therefore take the potential benefits of keeping elephants in zoos into account. Such benefits are assessed in Chapter 3.

Methodology

Data collation

Information relevant to this report was collated from a variety of sources, including an extensive literature search; elephant studbooks; animal welfare organisations; and zoo visits and meetings with zoo personnel and researchers. The exact methodology followed is outlined in the following sections.

i) Literature search

Data on elephants in captivity and the wild were collated by searching the literature. A literature search was first conducted using the Web of Science (an Institute of Scientific Information electronic database) on the main variables of interest, using the keyword ‘elephant/s’ along with keywords such as ‘behaviour’, ‘reproduction’, ‘mortality’, etc. Key journals and conference proceedings that held much of relevant data were then also identified (see Table 1 below), and the Web of Science database was used to search the abstracts of every paper published between 1980 and April 2000 in these journals (or the volumes available between these years), while abstracts of papers published between 1960-1980 were hand-searched (because these years are not available in electronic format). The starting year of 1960 was chosen because many selected journals were not in print, or had very few editions available in Oxford, before this time. During these searches, each paper containing relevant information on elephants was marked and then searched by hand. A similar keyword search of the Web of Science database was used to gather information on various other general areas relevant to this review, including training, handling, dominance, sociality, social deprivation, and infanticide.

Additional sources not included in this electronic database were searched by hand. These included various journals, conference proceedings, and newsletters reporting zoo-based research, which were identified through visits to zoo libraries and the bibliographies of other papers (see Table 1 for details). The journals *Elephant* and the *Journal of the EMA* (Elephant Managers Association) were obtained from Dr Rob Atkinson (RSPCA) and directly from the EMA, respectively. Specialist books were also identified through searching the Oxford Libraries with OLIS (The Oxford Libraries Information System) using the keyword ‘elephant/s’.

ii) Studbooks

Studbooks are data-sets compiled by the zoos themselves to optimise the genetic management of their populations. They contain detailed records of individual elephants, including the sex, parentage, location and date of birth, date of death, age, and details of transfers between facilities. Facilities that include their elephants in the studbooks are all members of the European Association of Zoos and Aquaria (EAZA), and as such are eligible to be involved in the European captive-breeding program, co-ordinated by the European Endangered Species Programme (EEP). The studbook data, compiled by the EEP, were used a great deal in this report and are referred to throughout as the ‘EEP studbook data’. We used the 1999 EEP Asian elephant studbook (Dorresteyn & Belterman 1999) and the 2001 EEP African elephant studbook (Terkel 1999), which cover the periods 1896 to 1st January 1999 and 1960 to 9th September 2001, respectively. They contain records for a total of 534 (121 males, 411 females and 2 unknowns) Asian elephants and 242 (60 males, 182 females) African elephants. This includes a living population of 274 (53 males, 221 females) Asians as of 1st January 1999, and 196 (43 males, 153 females) African, as of 9th September 2001.

Table 1. Key sources of information on wild and captive elephants

A search of the literature identified several journals and conference proceedings, listed below, which contained the bulk of the information on elephants in the wild and in captivity. All available volumes of these key data sources were searched. This was done by using an electronic reference database (Web of Science) for volumes published after and including 1981, and by hand-searching earlier volumes, and those journals and proceedings not included in the database*.

Journal Title	Years searched
Acta Theriologica	1960 – 2001
African Journal of Ecology	1962 – 2001
American Association of Zoo Veterinarians*	1990 – 1999
Animal Behaviour	1960 – 2001
Animal Welfare	1992 – 2001
Applied Animal Behaviour Science	1975 – 2001
Elephant (Journal of the Elephant Research Foundation)*	1977 – 2000
Ethology	1960 – 2001
International Conference on Environmental Enrichment*	1995 – 1999
International Zoo News*	1998 – 2001
International Zoo Yearbook	1959 – 2001
Journal of Wildlife Management	1960 – 2001
Journal of Zoo and Wildlife Medicine	1969 – 2001
Journal of Zoology	1960 – 2001
Pachyderm	1983 – 2000
Proceedings of the International Society of Applied Ethology*	1995 – 2001
Ratel*	1974 – 2001
Shape of Enrichment*	1992 – 2001
Zeitschrift für Saugetierkunde	1960 – 2001
Zoo Biology	1982 – 2001

iii) Correspondence with organisations and researchers

Various animal welfare and conservation organisations were contacted for information. These include: Animal Defenders; Animal Legal Defense Fund; Captive Animal's Protection Society (CAPS); Care for the Wild; The Federation of Zoological Gardens in Great Britain and Ireland; Humane Society of the United States (HSUS); People for the Ethical Treatment of Animals (PETA); the Performing Animal Welfare Society (PAWS); the Sheldrick Wildlife Trust; African Elephant Specialist Group (AfESG); and Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

In addition, scientists researching specific areas of elephant biology, conservation, captive management, as well as those working on more general areas, such as animal training, were contacted. These are named in the relevant sections. They were chosen for their expertise in specific fields, as identified from papers found during the literature search (see the beginning of this section), or during talks with other experts.

iv) Zoo visits

Several zoos were visited in order to observe at first hand keeping conditions and husbandry, and talk to key elephant handlers, zoo managers and curators. Initially, plans were made to visit all U.K. zoos that held elephants, but given the time constraint on this project these plans were abandoned, and instead, only a few were visited. These were Whipsnade Wild Animal Park, Chester Zoo, and London Zoo. In addition, a visit was paid to the Elephant Sanctuary in Tennessee, U.S.A. (see Chapter 6), a facility with very different keeping conditions compared to zoos, and hence a valuable point of comparison.

v) Elephant handler questionnaire

A questionnaire was designed to gather data on the current U.K. captive elephant population, including housing and husbandry conditions, and information on various welfare indicators. The desired topics covered included:

Basic information on the elephant handlers – age, sex and experience;

General information on the captive environment and husbandry – enclosure size and content, use of chaining, type and frequency of maintenance procedures (e.g. washing and foot care); use of environmental enrichments, social grouping, diet, training methods;

General data on individual elephants – age, sex, height, weight, rearing environment, position in the social group;

Data on welfare indicators that could perhaps be related to captive husbandry – current and previous state of health, degree of abnormal behaviour displayed and reproductive condition and breeding history.

A copy of this questionnaire was sent to the director or head curator of each zoo that held elephants in the U.K., totalling 18 facilities. Unfortunately, at this time the Zoo Federation of Great Britain and Ireland, which had previously supported the preparation of this review, withdrew their support. The result was that no questionnaires were returned from Federation member zoos, (plus none of the four non-member zoos sent back the questionnaire), and so no data were collected. However, a copy of this questionnaire can be found in Appendix I.

vi) Additional sources

Various other sources were used to gather relevant information. The internet was searched for relevant news articles and background information, and many zoo sites were visited for general information on their elephants. Several web sites were particularly useful:

- The Absolut Elefant website run by Dan Koehl, an experienced elephant handler (http://www.elephant.se). This contains a large amount of information on many aspects of zoo elephant management, including a studbook covering zoos world-wide, and links to many relevant web sites;
- The International Species Information System (http://www.isis.org/abstracts). This is an international non-profit membership organisation that serves nearly 550 zoological institutional members from 54 countries world-wide. This database contains information on the number of individuals of all species held in member zoos world-wide;
- The African Elephant Database on the IUCN/SSC African Elephant Specialist Group web site (http://www.iucn.org/themes/ssc/aed/home.htm). This database contains details of hundreds of publications on a wide range of topics relating to the African elephant.

Definitions of terms used in this report

Zoo

As defined under section 21 of the Zoo Licensing Act 1981, a zoo is: "an establishment where wild animals are kept for exhibition to the public otherwise than for purposes of a circus and otherwise than in a pet shop; and this Act applies to any zoo to which members of the public have access, with or without charge for admission on more than seven days in the period of 12 consecutive months." This definition thus includes safari parks that are open to the public, and as such these will be referred to as zoos throughout this report.

Extensive system

This term refers to Asian timber camps (also known as logging or work camps) where elephants are tamed and trained by mahouts (Asian elephant handlers) to work in the logging industry, for instance moving and dragging logs. 'Extensive' contrasts with 'intensive' in that the latter is more physically restrictive, as described in the agricultural literature (e.g. Hemsworth *et al.* 1995b; Le Neindre *et al.* 1996). Following the nomenclature of Kurt (1995), extensive systems refer to those that allow elephants to roam in forests at night, although they are often hobbled to ensure they do not wander too far; graze on natural vegetation, which may be supplemented with additional fodder in some areas; and mix with wild elephants

(Krishnamurthy 1995). In addition, groups are large and mixed (Krishnamurthy 1995; Sukumar *et al.* 1997) and females can be impregnated by wild or captive bulls (Kurt 1995; Sukumar *et al.* 1997), and mahouts do not attempt to manage breeding.

Elephant handler

A person who works directly with elephants, regardless of facility type, who may have trained elephants to respond to commands. This includes people who do not handle elephants directly, but interact with them in some way, for instance by issuing verbal commands to control the elephant's behaviour (e.g. keepers in protected contact systems, see Chapter 4).

Data presentation and analysis

In most cases, there were insufficient data to statistically determine what aspects of the captive environment correlate with welfare indicators, as was the remit of this report (see previous section). Therefore, most data presented here are purely descriptive. The exception was the mortality data, presented in Chapter 7, and reproductive data in Chapter 9, where comparisons were possible between zoo elephants, those held in extensive systems and wild populations; ratio between zoo elephants of different backgrounds. The statistics used are described in this chapter.

Structure of this report

This report is divided into a further ten chapters. The two chapters that follow (Chapters 2 and 3) give a general overview of what is known about elephants in the wild and in captivity, and assess the potential benefits of keeping elephants in zoos. The following three chapters review aspects of the zoo environment that have been shown to, or are likely to, impact the welfare of elephants. These include aspects of general husbandry, such as enclosure size and content, diet, chaining, and the use of environmental enrichments (Chapter 4); the size and structure of social groups (Chapter 5); and the methods used for training and handling zoo elephants (Chapter 6). We then consider four groups of welfare indicators for which data exist for zoo elephants; overall mortality rates (Chapter 7); causes of mortality and morbidity (Chapter 8); reproductive problems (Chapter 9); and lastly, behavioural problems (Chapter 10). Within each of these nine chapters, we review the available data and, where possible, identify relationships between welfare indicators and aspects of husbandry. Where relevant data are not available, we have made inferences from anecdotal observations, and/or research on other species. We also highlight areas that require further research where this is appropriate. The culmination of this review is a series of recommendations based on the evidence in the previous chapters, aimed at improving the welfare of zoo elephants, along with a series of research questions (Chapter 11).

Chapter 2

Elephants in the wild

In this chapter, we first discuss the classification of elephants and the differentiating morphology of each species. We then provide a basic introduction to the ecology and behaviour of wild elephants (to be expanded upon in later chapters), and go on to highlight the current range and conservation status of each species in the wild, and the current legislation protecting elephants in their natural habitats.

Classification, morphology and biogeography

A range of elephant taxonomies is in use today, particularly concerning the classification of subspecies. For the purpose of this report, the taxonomy published in Macdonald's 'The New Encyclopaedia of Mammals' will be used (2001). At some points in this report, data from other sources that have used a different taxonomy will be discussed; in these cases, the method used to deal with such data will be stated in the relevant section.

Elephants are the only surviving members of the order Proboscidae and belong to the family Elephantidae. There are currently three recognised species: the African savanna, or bush, elephant (*Loxodonta africana*, Blumenbach 1797), the African forest elephant (*Loxodonta cyclotis*, Matschie 1900) and the Asian elephant (*Elephas maximus*, Linnaeus 1758), also known as the Asiatic or Indian elephant (Nowak 1995). African elephants have only recently been recognised as two distinct species. The smaller, darker, forest elephant, which inhabits the tropical rainforests of West and Central Africa (Nowak 1995), was previously thought to be a subspecies of the African elephant (*Loxodonta africana cyclotis*) prior to genetic analysis (Roca *et al.* 2001). Macdonald (2001) also list a smaller subspecies of the forest species, the pygmy elephant (*L. c. pumilio*), found in the dense lowland jungles from Sierra Leone to Zaire (Nowak 1995). Pygmy elephants were originally described by Noack (1906), but many consider them to be small forest elephants or juvenile animals rather than a separate species (e.g. Western 1986, Nowak 1995). The African savanna elephant is larger, and paler, and is found in a wider range of habitats, including deep forest, open savanna, wet marsh, thornbush and semidesert scrub, in Eastern, Central and South Africa (WWF 2000; Nowak 1995; see section '*Conservation status*' for more detail of the current distribution). African elephants in zoos are almost exclusively of the savanna species (see Chapter 3, section '*Numbers held in captivity*') and so for the purpose of this report, discussions of 'African elephants' will be limited to this species. The preferred habitat type of Asian elephants also consists of a mixture of grassland, low woody plants and forest (McKay 1973; Shoshani & Eisenberg 1982; Karoor 1992). Asian elephants can be found on the Indian subcontinent, Indochina, Malaysia, Indonesia and southern China (Macdonald 2001, see section 'Conservation status' for more detail of the current distribution). The number of Asian subspecies varies considerably between different references, but Macdonald (2001) state that four subspecies exist: *E. m. bengalensis*, the Indian elephant found on the Asian mainland; *E. m. sumatrana*, the Sumatran elephant from the island of the same name in Indonesia; *E. m. maximus*, the Ceylon elephant which occurs on the island of Sri Lanka; and *E. m. hirstutus*, the Malaysian elephant found in Malaysia.

The African savanna elephant is the largest species, with males weighing an average of 5000kg (range 4000-6300kg) and standing 3.2m (3-4m) tall at the shoulder, and females averaging 2800kg (2400-3500kg) and 2.5m (2.4-3.4m) tall (Kingdon 1979). Large bulls of the Asian elephant can weigh up to 5400kg and measure 3.2m tall, although there has been a report of a male that measured 3.43m at the shoulder. Females are far smaller and weigh an average of 2720kg (up to 4160kg), and are 2.24m tall (up to 2.54m) (Shoshani & Eisenberg 1982).

Several distinct features distinguish the African and Asian species, apart from size. Africans have far larger ears than Asians, and usually three nails on the hind feet, compared to four in the Asian (Nowak 1995). Both male and female African elephants have large tusks, which are modified incisors that grow throughout the elephant's lifetime (Nowak 1995). Only male Asian elephants grow tusks, and these are either smaller versions of the African elephant's that protrude well beyond the lip, or small 'tushes' which are only just visible (Shoshani & Eisenberg 1982). They also have quite a different profile: the back of African elephants slopes down from the shoulders to the hips, while that of the Asian is domed in appearance (Clutton-Brock 1999). Africans also have two finger-like processes at the tip, one above and below, compared to just one on the upper part of the Asian elephant's trunk (Nowak 1995; Clutton-Brock 1999). These are used skilfully to manipulate and pick up objects, and the African's two processes are said to confer greater manipulative abilities, particularly during feeding, whilst Asian elephants are more adept at using their feet in conjunction with their trunk (Sikes 1971).

Basic ecology and behaviour in the wild

Both the Asian and African elephant thus live in tropical regions of the world (see Chapter 4 for more details of climate). The diet of African savanna elephants is composed primarily of grasses, particularly in the wet season, although they also feed on leaves, bark, twigs, herbs, roots, flowers and fruit (Wing & Buss 1970; Field 1971; Nowak 1995). Asian elephants also feed on a wide variety of grasses, as well as bark, roots, leaves and small stems (McKay 1973; Nowak 1995; Sukumar & Ramesh 1995). A large portion of both species' diet consists of low quality vegetation, and consequently their digestive efficiency is far lower than that of cattle, sheep and horses (Shoshani 1992). Therefore, a considerable portion of their time (60 - 80% of waking hours) must be spent feeding in order to fulfil their nutritional requirements, during which they consume between 150 and 350 kg of wet weight forage (Dougall 1964; McKay 1973; Hanks 1979; Eisenberg 1981; Shoshani & Eisenberg 1982; Macdonald 1984; Karoor 1992; Shoshani 1992). (Chapter 4 gives more detail on elephant nutrition in the wild compared to captivity). Studies of wild Asian elephants have shown two to three main feeding periods over the 24 hour cycle (Eisenberg 1980): the early hours of the morning, mid-day and dusk, although feeding may occur at all times of the day and night (Santiapillai & Suprahman 1986).

With the exception of the effect of human activities, the spatial distribution of elephants in the wild is largely governed by the availability of food and water (Nowak 1995). When these are abundant, herds are relatively dispersed throughout the habitat, but when resources are scarce, such as during the dry season, densities can increase dramatically within certain areas. For example, in the relatively undisturbed Amboseli National Park population in Kenya, elephant density increased from 0.14/km^2 to 10/km^2 within some habitats during the dry season (Western & Lindsay 1984). In order to find these scarce resources, African elephants have been reported to undergo annual migrations over vast areas, sometimes covering several hundred kilometres (Nowak 1995). However, for the most part, elephants remain within an undefended home range (Nowak 1995), which simply defines the area used by the group during their normal activities, excluding infrequent forays (Burt 1943).

Taking the average across a range of studies, the median herd home range size was 113.0km^2 (range 30 – 799.5km^2) for Asian and 1975.7km^2 (range 100 – 5527.0km^2) for African elephants; and for adult bulls, the median range size was 246.3 km^2 for Asian and 175.0 km^2 for African elephants (McKay 1973; Sukumar 1989; Easa 1992; Thouless & Dyer 1992; Whyte 1993; Damiba & Ables 1994; Baskaran *et al.* 1995; African: Jachmann 1995; Asian: Joshua & Johnsingh 1995; Thouless 1996; Douglas-Hamilton 1998; Tchamba 1998; Thouless 1998). However, ranges as small as 10km^2 and 14km^2 for Asian and African elephants, respectively, have been reported by other authors (Kingdon 1979; Shoshani & Eisenberg 1982). On a daily basis, studies by Easa (1992), and Reimers (2001) have shown that Asian family groups travel, on average, 3.2km per day (range 1 - 9km), while Wyat & Eltringham (1974) report 12.0km (3.8 - 7.5km) for African herds. Studies conducted on bulls reveal similar distances for Asian elephants (mean 3.6km), although with a larger range (1 - 14.4km), except when they are in musth and cover an average distance of 8.9km (2.8 - 15km) each day (Sale *et al.* 1992; Reimers *et al.* 2001). Douglas-Hamilton (1998) reports that adult bulls ranges over 9.5km (2.7 - 28.4km), although these were preliminary findings.

Elephants are extremely gregarious, particularly in the African savanna species which have been reported to congregate in their hundreds under certain circumstances (Nowak 1995). Social bonds are especially strong between females, which live in stable groups consisting of related females and their offspring, led by a matriarch (Douglas-Hamilton 1972; Moss & Poole 1983; Sukumar 1989). Adult males are often found alone, but they too form social bonds with other males in bachelor herds when they are not sexually active (McKay 1973; Laws *et al.* 1975; Sukumar 1989; Poole 1994). The behaviour of males changes dramatically when they become sexually active (a state known as musth), which can occur at any time of year. They start to roam extensively in search of receptive females and react very aggressively towards other males they encounter (Jainudeen *et al.* 1972b; Gale 1974; Poole 1981; Barnes 1983; Moss 1988). See Chapter 5 for more details on elephant social organisation, and Chapter 6 for a discussion of their dominance hierarchies.

As already mentioned, breeding takes place all year round (Eisenberg & Lockhart 1972; Shoshani & Eisenberg 1982), although there does appear to be some degree of seasonality in at least some populations. For example, Santiapillai *et al.* (1984) report a higher rate of matings in the dry season, and a greater number of births in the wet season, in a Sri Lankan population. Similarly, a peak in birth occurs just before the rainy season in African elephant populations in Zambia and Uganda (Hanks 1972; Smith & Buss 1973). Females are only in oestrus for a very short period of time, estimated to be between two to six days in the African elephant (Moss 1983), and three to four days in the Asian elephant (Eisenberg *et al.* 1971; Shoshani & Eisenberg 1982), which is one reason why captive breeding is often unsuccessful (see Chapter 9). Gestation is long and lasts 22 months on average, with a range of 17 to 25 months (Shoshani & Eisenberg 1982; Moss 1988; Sukumar 1989; Nowak 1995). Females usually give birth to a single calf, although twins, or even triplets, are born on occasion (Laursen & Bekoff 1978; Shoshani & Eisenberg 1982). The calf is completely dependent on its mother's milk for the first 6 to 24 months (Laursen & Bekoff 1978; Shoshani & Eisenberg 1982; Dublin 1983; Lee & Moss 1986), although they may not be fully weaned until the next calf is born, which can be up to six years later (Shoshani & Eisenberg 1982; Lee 1986; Lee & Moss 1986). Females remain in their natal herd throughout their lifetime, but males leave once they become sexually mature at around 10 to 15 years of age, to establish their own home range, often in association with other bachelor males (Eisenberg *et al.* 1971; Douglas-Hamilton 1972; Sukumar 1989; Poole 1999). Reproduction in elephants is discussed in detail in Chapter 9.

Conservation status and range

Wild populations of both African and Asian elephants are currently in a critical state. It is estimated that more than 100,000 Asian elephants may have been alive at the beginning of the twentieth century, ranging from the Tigris-Euphrates river system in the west, throughout Asia south of the Himalayas, to China in the east (WCMC and WWF-International 2001b). Today, Asian elephants are restricted to small, isolated populations throughout most of their range due to the loss and fragmentation of their habitat, poaching for their ivory and meat, and capture (often illegal) for domestication (Sukumar 1989; Kemf & Santiapillai 2000). Recent estimates from The IUCN/SSC Asian Elephant Specialist Group (AsESG) suggest that there are currently between 34,594 and 50,998 wild Asian elephants in 13 countries (Kemf & Santiapillai 2000; WCMC and WWF-International 2001b). Countries with the largest populations include India, Burma, Sri Lanka and Indonesia, and smaller populations occur in the rest of the Asian subcontinent, Indo-Malaya, Indochina and China. An additional 16,000 are believed to be under the care of humans in Asia, which could thus represent as much as 30% of the entire Asian population (Sukumar 1989).

African elephants have also suffered a great reduction and fragmentation of their range over the past century, particularly in West Africa. Populations used to be found throughout Africa, with the exception of desert regions, and although it is difficult measure accurately, it is estimated that between three and five million elephants were alive in Africa in the 1930s and 1940s (WWF 2000).

A dramatic decline in numbers occurred between the 1960s and 1980s across their entire range, due to poaching for their ivory, and also loss of habitat which has led to rising conflict with man (WCMC and WWF-International 2001a). Although they can still be found in 37 countries, around a third of these harbour fewer 10,000 individuals. The IUCN/SSC African Elephant Specialist Group (AfESG) has estimated that Africa now holds a minimum of 301,773 individuals, with an additional "speculative" 68,596 elephants, primarily in Southern Africa as well as smaller populations in Central and Eastern Africa (Barnes *et al.* 1999).

WWF has identified several major threats to the survival of wild elephants (Dublin *et al.* 1997; Kemf & Santiapillai 2000). The biggest threat is habitat loss and fragmentation, due to farming and deforestation/logging. Subsequently, due to the encroachment of humans into elephant habitat, they often come into conflict with man. Elephants, particularly in Asia, are now a significant menace in many rural areas due to their crop raiding activities, and it has been estimated that they kill up to 300 people annually in India (Kemf & Jackson 1995; Dublin *et al.* 1997). Although villagers often attempt to drive the elephants away, this often fails as crops are a highly preferred food, and so the elephants are often killed (Kemf & Jackson 1995). Another major threat to the survival of wild elephants is illegal poaching for their tusks, and meat in some areas of India. Poaching not only decreases numbers, but it also causes a selective reduction in males and hence impairs reproductive success, with knock-on consequences for inbreeding (Kemf & Santiapillai 2000).

The IUCN/SSC Specialist Groups have identified several priorities for elephant conservation, such as enforcing anti-poaching laws, establishing new protected areas, encouraging wildlife as a form of land use, and creating elephant corridors (Santiapillai & Jackson 1990; Thouless 1998). Captive breeding is not listed as a priority, but many zoos that hold elephants participate in managed breeding programmes, such as the European Endangered Species Programme (EEP) or North America's Elephant Species Survival Plan (SSP). The value of captive breeding for elephant conservation has been subject to a great deal of debate. This is reviewed in the following chapter.

Due to the dramatic decline in wild populations, both species are currently classified as endangered in the 2000 IUCN Red Data List (Hilton-Taylor 2000). This means that, according to the AsESG and AfESG, they face a "very high risk of extinction in the wild in the near future". Because of their status in the wild, the Asian elephant was moved to Appendix I of the 1976 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This severely restricts trade in live Asian elephants as well as their parts, such as hides and ivory, except in "exceptional circumstances, e.g. for scientific research", for which export and import permits are required (further stipulations are given in Article III of the Convention, see Box 1):

Box 1. Article III of the Convention on International Trade in Endangered Species of Wild Fauna and Flora: Regulation of Trade in Specimens of Species Included in Appendix I

All trade in specimens of species included in Appendix I shall be in accordance with the provisions of this Article.

The ***export*** of any specimen of a species included in Appendix I shall require the prior grant and presentation of an export permit. An export permit shall only be granted when the following conditions have been met:

(a) a Scientific Authority of the State of export has advised that such export **will not be detrimental to the survival of that species**;

(b) a Management Authority of the State of export is satisfied that the specimen was not obtained in contravention of the laws of that State for the protection of fauna and flora;

(c) a Management Authority of the State of export is satisfied that any living specimen will be so **prepared and shipped as to minimize the risk of injury, damage to health or cruel treatment**; and

(d) a Management Authority of the State of export is satisfied that an import permit has been granted for the specimen.

The ***import*** of any specimen of a species included in Appendix I shall require the prior grant and presentation of an import permit and either an export permit or a re-export certificate. An import permit shall only be granted when the following conditions have been met:

(a) a Scientific Authority of the State of import has advised that the import will be for purposes which are not detrimental to the survival of the species involved;

(b) a Scientific Authority of the State of import is satisfied that the proposed recipient of a living specimen is **suitably equipped to house and care for it**; and

(c) a Management Authority of the State of import is satisfied that the specimen is **not to be used for primarily commercial purposes**.

The ***re-export*** of any specimen of a species included in Appendix I shall require the prior grant and presentation of a re-export certificate. A re-export certificate shall only be granted when the following conditions have been met:

(a) a Management Authority of the State of re-export is satisfied that the specimen was imported into that State in accordance with the provisions of the present Convention;

(b) a Management Authority of the State of re-export is satisfied that any living specimen will be so prepared and shipped as to minimize the risk of injury, damage to health or cruel treatment; and

(c) a Management Authority of the State of re-export is satisfied that an import permit has been granted for any living specimen.

Extracted from CITES (N.B. bold and italics added by the authors)

Thus, zoos can still legally import protected elephants for the purposes of education, conservation and research. African elephants were also afforded Appendix I protection in October 1989 (WCMC and WWF-International 2001a), but there have been a number of changes in the status over the years for populations in specific countries. Currently, most populations of the African elephant are still listed in Appendix I. The exceptions are Botswana, Namibia, Zimbabwe and South Africa, which were downgraded to Appendix II in 1997 because they had large populations of elephants which were increasing and suffered minimal losses from poaching (TRAFFIC 1997). These countries are allowed to trade under specific circumstances and, with respect to live elephants, Botswana, Namibia and Zimbabwe are allowed to export them to “appropriate and acceptable destinations" as determined by the appropriate Scientific Authority of the importing Party. However, the population in Namibia are afforded greater protection in that they are not allowed to be exported for commercial purposes, and South Africa is only allowed to "trade in live animals for re-introduction purposes into protected areas formally proclaimed in terms of legislation of the importing country."

In summary, under CITES zoos can import wild elephants for conservation, education and research purposes, and, in addition, African elephants from Botswana and Zimbabwe can be imported for commercial purposes. See the section entitled '*Source of zoo elephants*' for figures on the number and source of imported wild elephants over the past 30 years.

Summary

- There are three species of elephant, which can be distinguished by various morphological features: the African savanna elephant (*Loxodonta africana*) the African forest elephant (*Loxodonta cyclotis*) and the Asian elephant (*Elephas maximus*). Very few African forest elephants are held in captivity, and therefore for conciseness, the term 'African elephant', or similar, will be used to refer to the savanna species throughout this report.
- Species differences include: body size (Africans are larger); preferred habitat type (Africans are found on open, savanna areas, Asians prefer forested areas); differences in foraging style (Asians make greater use of their feet); maximum home range size (ranges are larger in Africans) and maximum group size (Africans sometimes congregate in their hundreds).
- Elephants spend a great deal of time feeding (60-80% waking hours) on a wide variety of low quality vegetation, including grass, browse, roots, fruit and flowers.
- Some populations travel great distances during migrations in search of food. The range occupied on a regular basis can vary greatly between populations, mainly due to variations in food and water availability. Home ranges of 10 to 800km^2 have been recorded for Asian elephants, and 14 to 5527km^2 in Africans.
- Sociality in males and females is very different. Females form very strong bonds within the herd, which is comprised of related females and their offspring and led by a matriarch (the largest and oldest female). Males often congregate in loose bachelor herds, but during periods of musth (when males are sexually active) males become highly aggressive and remain solitary when they are not associating with females.
- Breeding occurs all year round. A single calf is produced after a 22 month gestation period and calves remain dependent on their mothers milk for 6 to 24 months, although full weaning is usually delayed until three to six years when the next calf arrives. Females remain within the herd all their lives, but males leave once they reach puberty (at 10 to 15 years of age) to establish their own home range.
- Wild elephant numbers have been greatly reduced in recent years, mainly through poaching and habitat loss. Both species are endangered in the wild and trade has been severely restricted by CITES, by classifying Asian elephants, and the majority of African populations, in Appendix I. This means that the export and import of all Asians and most Africans is allowed only for reasons of research, conservation or education, and according to CITES both species must go to facilities that are "suitably equipped to house and care for it" (all Asian and most African elephant populations) or "appropriate and

acceptable destinations" (African elephants from Botswana, Namibia and Zimbabwe) as designated by the appropriate Scientific Authority.

- Priorities in elephant conservation have been identified and include the establishment of more protected areas, enforcing anti-poaching legislation, and various strategies to reduce conflict with humans.

Chapter 3

Elephants in captivity

In this chapter, we review the long relationship elephants have had with humans and assess their current status as zoo animals. Data relating to the number and distribution of elephants held world-wide and, in more detail, across Europe, are presented, as well as data on the origins of the current European zoo population. We then end by exploring whether or not zoo elephants are domesticated animals and discuss their role in conservation.

History of their use by man

Elephants have a long history of being tamed and trained as beasts of burden, for use in warfare, and later, for the purpose of entertainment in circuses and zoos. The first records of tamed elephants date back some 4000 years to the time of the Indus civilisation (Hart 1994; Sukumar *et al.* 1997; Clutton-Brock 1999), where they were revered and honoured as sacred beings and mystical symbols (Gröning & Saller 1998). Their use as a symbol of power during warfare is well documented. For instance, Alexander the Great used elephants during his campaigns against the ancient world in 330BC onwards, and Hannibal famously used tamed African forest elephants to cross the Alps and fight the Romans in 219BC (Watson 1990; Gröning & Saller 1998; Clutton-Brock 1999). The Romans in contrast never adopted elephants for warfare purposes, but they used both species for entertainment in amphitheatre animal fights, where they were pitted against each other, lions and leopards, and armed men. Elephants also became popular in Roman circuses to the point that elephant taming became a profession, with knowledge from Alexandria being used to teach them tricks (Gröning & Saller 1998; Clutton-Brock 1999).

In more recent years, Asian elephants have been used extensively in the timber industry in south Asia, which began in the 17th century (Kurt 1995). This remains their most common use today, along with wildlife tourism, religious ceremonies, and zoos (Krishnamurthy & Wemmer 1995). The situation is rather different for African elephants. Historically, they were used almost exclusively for military purposes (Iversen 1995). However, an experiment ordered by the Belgian king Leopold in the late 1800s proved that it was possible to train African elephants and use them for work, just as Asians were. With the help of mahouts from India, a training school was established in the Congo where they were tamed and trained, and successfully used for pulling loads, timber felling and ploughing. In its heyday, the school contained 100 trained elephants, but civil unrest led to the demise of the school, although efforts have been made to revive it to its former glory (Iversen 1995). Nevertheless, African elephants never became an integral part of the culture and working community like the Asian elephants. This is likely due to a lack of demand, but anecdotal evidence also suggests that they may be more difficult to tame than Asians because they are more ‘excitable’ (Adams 1981; de Leon 1981; Watson 1990; Gröning & Saller 1998; Clutton-Brock 1999).

Elephants began appearing in European menageries in the 17th century, for example in the royal animal enclosure in Versailles and later in the Russian Czar’s court (Gröning & Saller 1998). By around 1800, elephants could also be seen in circuses in England, which represented the beginning of the modern circus. However, elephants remained scarce in Europe up until the early 19th century, by which time only around 50 or so elephants had been exhibited (Gröning & Saller 1998). By the middle of the 19th century, trade increased dramatically as elephants began to appear in more and more circuses. Subsequently, it was no longer sufficient to simply exhibit or ride elephants, and so they were trained to perform increasingly complex behaviours. The training methods up until the end of the 19th century were very similar to those used by Asian mahouts, but in 1890 Carl Hagenbeck established a training school alongside his circus, teaching a new method based on his experience with wild animals and Indian mahouts, which largely forms the basis of elephant training today (Gröning & Saller 1998; Koehl 2000). At around the same time that trade in circus elephants increased, the first zoos began to appear, having evolved from the menageries and animal shows of the time (Gröning & Saller 1998). Recently, the zoos have changed their emphasis from that of centres of entertainment to those of conservation, education and research (Magin *et al.* 1994; Mallinson 1995), although their actual value in these areas, regarding all captive species, is currently debated (see Box 2). Today, there are several hundred elephants held in European zoos, and although conditions have changed a great deal over the ensuing years, this long prior relationship that elephants have had with humans has had a major influence on how they are kept in many zoos (see Chapter 6).

Numbers held in captivity

Records of the number of elephants held in captivity are available from several sources. The International Species Information System (ISIS) contains information on the species and sex of elephants held world-wide in zoos that are members of ISIS. More detailed records are available from EEP elephant studbooks, as mentioned in Chapter 1, but these are not maintained in all countries, and not all zoos contribute data. Finally, the Captive Elephant Database contains information on the number of elephants held in zoos all over the world, as well other facilities such as circuses, orphanages and timber camps. Membership is not required for participation, and instead, individuals can post information for their own facility onto the database that can be accessed on the Absolut Elefant website (www.elephant.se/main.htm). Data on the number of elephants held world-wide will thus be taken from this database, because it contains data from the largest number of facilities, and also gives an idea of the distribution of elephants held in a range of facility types.

According to the Captive Elephant Database, there are currently at least 1713 elephants held in captivity world-wide as of 21st Jan 2000 (see Table 2). Most are in zoos (64.6%), but a large number are also held in circuses (30.9%). Only 80 elephants are registered from other types of facility, such as orphanages and camps, but this is certainly an underestimate as thousands of Asian elephants are believed to be under the care of humans in Asia (Sukumar 1989). Table 3 provides more detailed data for elephants held in zoos only. It can be seen that the greatest number are found in Europe (48.0%), followed by North America (33.3%), Asia (13.5%), Africa (3.7%) and finally South & Central America (0.3%). Asian elephants are the more common species in zoos comprising 58.3% of identified elephants. Although figures for the African forest elephant are not available from this database, information from ISIS suggests that this species is very rare in zoos, as only 2 out of 325 African elephants are classed as *Loxodonta africana cyclotis*.

Box 2. The potential benefits of keeping elephants in zoos

The potential benefits of keeping elephants in zoos are as follows, in their likely order of importance.

Enhancing the knowledge of elephant biology through research

It was studies of zoo elephants that first revealed their use of infrasound for communication (Smith & Hutchins 2000), and zoo subjects can indeed be ideal for research. Work on zoo animals has thus advanced our knowledge of elephant communication (e.g. Rasmussen & Schulte 1998; Schulte & Rasmussen 1999; Langbauer 2000), anatomy (e.g. Rasmussen & Munger 1996), and reproductive biology (Smith & Hutchins 2000). Zoo elephant research has also enabled the development of many techniques likely to aid in *ex situ* conservation, such as DNA extraction from faeces and ivory, new methods for monitoring movement patterns, the assessment of reproductive state from faecal hormone metabolites, and new potential methods of contraception (reviewed by Smith & Hutchins 2000). Such research opportunities would seem the greatest benefit of keeping elephants in zoos, although arguably they also could be supplied by logging camp and orphanage animals.

Aiding *ex situ* conservation through public education

The presence of elephants in zoos has been suggested to encourage public interest that can translate into conservation efforts (Olson 1998). Zoos can potentially educate and inspire very effectively (Smith & Hutchins 2000) – although the long-term effects of this are uncertain (Mench & Kreger 1996). The SSC/IUCN African Elephant Specialist Group (AfESG) has also acknowledged the role that zoos can potentially play in elephant conservation through education, training and increasing public support. However, the AfESG do not regard this function as sufficiently important to justify importing African elephants to zoos from Appendix I populations, and has also made the point that displaying living elephants is not necessary for zoos to play this role (Waithaka *et al.* 1998; Hutchins & Smith 1999 343).

Educating the public about other aspects of elephant biology

Public education about general biology can also be a role of zoo elephants. Indeed elephants may provide zoos with a particularly good educational opportunity as in at least some establishments, visitors spend longer in front of larger-bodied species (Balmford 2000). However, visitors are also said to be only interested in elephants when they are bathing, mating, caring for their offspring, or being fed by the public (Kock 1994, cited in Kurt 1995) – all activities which take very little of their time in zoos (see Chapters 4 and 9). It is also uncertain what they might learn from seeing one of the many stereotypic individuals (see Chapter 10). Overall, zoos no doubt have the potential to be excellent educational resources (Smith & Hutchins 2000), but their actual effectiveness in teaching people about elephant biology has yet to be quantified. Furthermore, in some instances focussing on smaller species may be a more cost-effective way of educating the public (Balmford 2000).

Raising funds by attracting visitors

In the world of *ex situ* conservation, elephants are often referred to as ‘flagship species’ due to the large amount of public interest and support they generate (e.g. Sukumar *et al.* 1997), and they may play a similar role in zoos (Dorresteyn & Belterman 1999). The funds resulting from increased visitor numbers may then help zoos support the *ex situ* conservation of elephants (Smith & Hutchins 2000), and/or to conduct the *in situ* conservation and breeding of less charismatic animals. However, the high costs of keeping elephants in zoos make the economics of such an argument rather questionable: replacing them with smaller-bodied species has been suggested as far more cost effective for zoos, and in general more directly useful for *in situ* conservation (Balmford *et al.* 1996; Balmford 2000). Furthermore, there is some evidence that zoos do not suffer financially when they stop housing elephants if the reasons for doing so are explained to the public (e.g. Edinburgh Zoo, UK: Miranda Stevenson, pers. comm.).

Aiding elephant conservation through captive breeding

Maintaining genotypic variation in captive populations requires a large number of successful breeders. However, too few animals reproduce for genetic variability to be preserved in zoo elephants (see Chapter 9, also Balmford *et al.* 1996; Wiese 2000). Furthermore, Leader-Williams (1990) has calculated that keeping African elephants in zoos is 50 times more expensive than protecting equivalent numbers in the wild. For these and other reasons, it is therefore widely agreed that captive breeding does not have a direct conservation role for elephants (Balmford *et al.* 1996; Waithaka *et al.* 1998; Smith & Hutchins 2000; WCMC and WWF-International 2001a).

Another notable feature is that females are by far the most common sex in zoos, the ratio being 1 male to 4.3 females in Asians and 1 male to 4.7 females in Africans. In contrast, wild populations have a roughly 1:1 sex ratio (e.g. Douglas-Hamilton 1972; McKay 1973; see Chapter 5).

Table 2. The number of elephants held in various types of facility world-wide

Numbers in parentheses represent the number of institutions holding elephants. 'Zoos' include some safari parks, and the category 'Other' refers to working camps and private owners. Figures with a '+' indicate that there were also additional elephants of unidentified species, and hence these represent minimum figures. Data are reproduced from the Captive Elephant Database (Koehl 2001).

Continent	Zoos		Circus		Other		Total	
	Asian	African	Asian	African	Asian	African	Asian	African
Europe	330 (109)	230 (64)	184 (57)	105 (40)	0	0	514 (166)	335 (104)
North & Central America	210 (67)	179 (71)	184 (99)	61 (34)	14 (7)	25 (11)	408 (173)	265 (116)
Asia	79+ (24)	24+ (7)	11 (2)	0	8 (2)	0	98+ (28)	24+ (7)
Africa	5+ (2)	15 (3)	3 (1)	0	0	21 (3)	8+ (3)	36+ (6)
Australia	10 (4)	4 (2)	9 (3)	1 (1)	0	0	19 (7)	5 (3)
South America	0+	1+ (1)	0	0	0	0	0	1 (1)
World-wide	634 (206)	453 (148)	391 (162)	167 (75)	22 (9)	46 (14)	1047+ (377)	666+ (237)

Table 3. The number of elephants held in zoos world-wide

These data include some safari parks. Numbers in parentheses represent the number of males and females, and the number of different facilities following the format males.females: facilities. Unknown species are unsexed. Total figures for males and females have a '+' after them if some unidentified elephants are included, indicating that these are minimum figures. Data are reproduced from the Captive Elephant Database (Koehl 2001).

Continent	Asian	African	Unknown species	Total
Europe	330 (62.268: 109)	230 (47.183: 64)	0	560 (109.451: 263)
North America	210 (30.180: 67)	179 (18.161: 71)	0	389 (48.341: 107)
Asia	79 (24.55: 24)	24+ (9.15: 7)	55 (:24)	158+ (33+.70+: 49)
Africa	5+ (1.4: 2)	15 (4.11: 3)	23 (:1)	43+ (5+.15+: 4)
Australia	10 (3.7: 4)	4 (1.3: 2)	0	14 (4.10: 5)
South & Central America	0+	1+ (1.0: 1)	2 (:1)	3+ (1+.0+: 2)
World-wide	634+ (120.514: 206)	453+ (80.373: 148)	80 (:26)	1167+ (200+.887+: 430)

Most European zoo elephants listed in the Captive Elephant Database also appear in the EEP studbooks. These contain information on 274 (53 males, 221 females) Asian and 196 (43 males, 153 females) African elephants that were living by the 1st September 1999 or 2001, respectively, within 113 facilities (Dorresteyn & Belterman 1999; Terkel 1999). A slightly higher number is reported in the Captive Elephant Database, probably due to a small number of zoos that do not participate in the studbook. Overall, this suggests that the Captive Elephant Database is accurate, at least for the European population.

A closer look at the European data reveals that German zoos collectively contain the greatest number of elephants, for both species, followed by U.K. zoos (see Figure 1). The third largest collections are found in The Netherlands for the Asian elephant and Spain for the African, and France ranks fourth for both species. The remaining 20 countries hold 5% or less of the total European population.

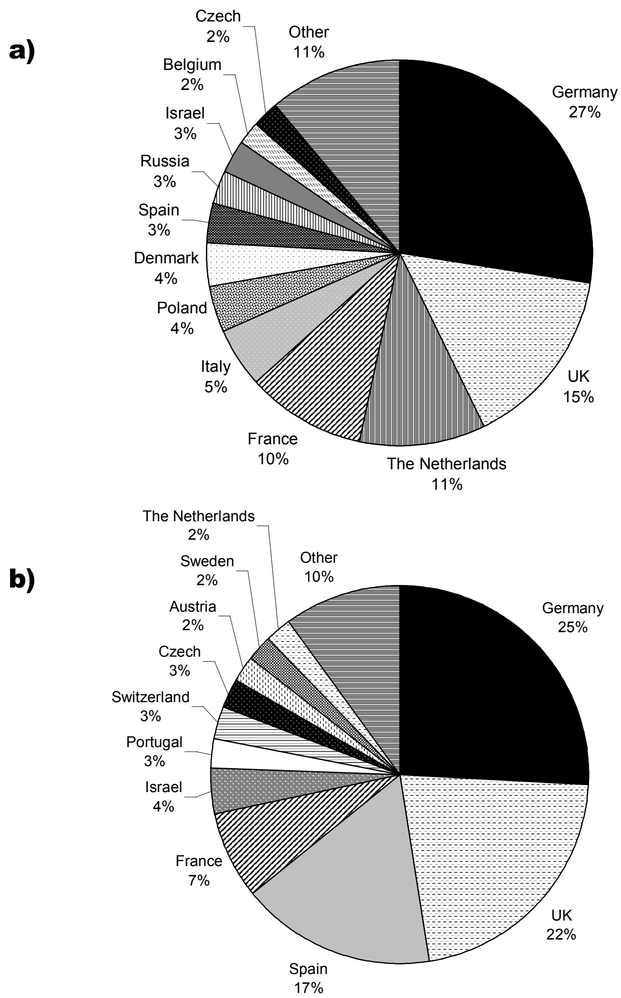


Figure 1. Distribution of a) Asian and b) African elephants held in European zoos

The pie charts above show the distribution of zoo elephants held in Europe. Figures show the percentage of the total European population for each species. Countries in the 'Other' category hold less than 2% of the population (fewer than seven Asian or fewer than five African elephants). Data are reproduced from the Captive Elephant Database (Koehl 2001).

Source of zoo elephants

The origin of the elephants currently held in European zoos will be explored in this section. This is considered to be important not simply for background information, but also due to the implications this could have for the role that zoo elephants play in the conservation of the species (see Box 2). Data from the EEP studbooks are presented first of all, to quantify the origin of elephants currently held in European zoos, including changes over the years. Secondly, data from the CITES Trade Database show the number of wild African and Asian elephants that have been imported into Europe according to the country of export and import.

Studbook data on the origin of elephants

The EEP studbooks contain information on the origin of most elephants that have been held in a European zoo at some point in their life. Elephants were classified as either wild caught or captive born according to whether the studbooks stated 'birth' or 'capture' for each individual. Elephants that had been born in a zoo outside Europe were classed as captive born. Some Asian elephants were recorded as having been born, rather than captured, in an Asian country and so it was assumed these were imported from timber camps, as only a country, rather than a zoo, was listed.

Data on the origin of elephants currently living in European zoos were taken from the EEP studbooks. As can be seen from Figure 2, most elephants were caught from the wild (59.7% Asians, 83.3% Africans), and only 19.4% of Asians and 14.7% of Africans were born in captivity. Some of the 66 Asian elephants (21.0%) assumed to be imported from timber camps may also have been born in captivity, but records are not available from the studbooks, and so these were grouped into a separate category.

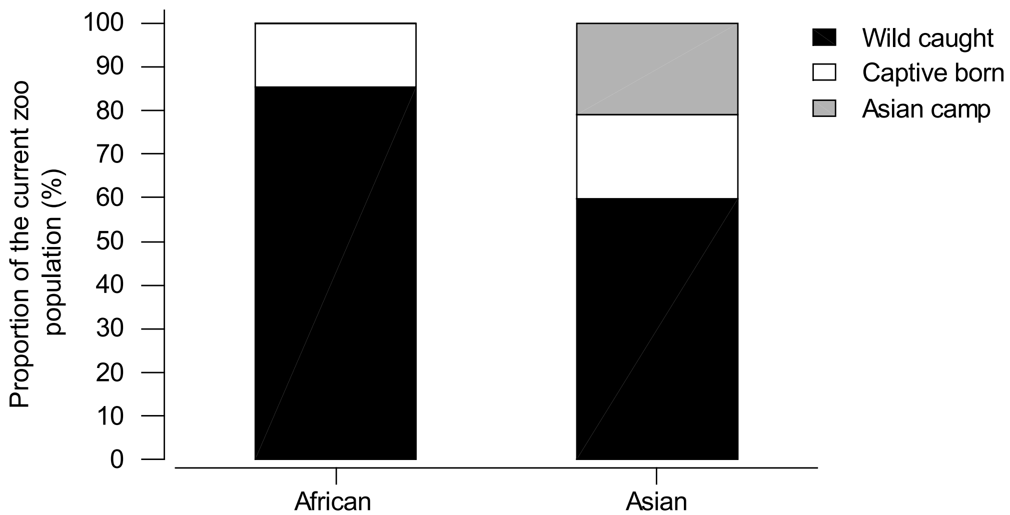


Figure 2. Origin of the current population of elephants held in European zoos
Elephants were classified according to whether they were wild caught, captive born, or had likely been imported from an Asian timber camp. Elephants of unknown origin were not included. Data were taken from the 1999 EEP Asian and 2001 EEP African elephant studbooks.

In order to determine whether there had been a significant change in the origin of zoo elephants over the years, the data were broken down into five ten-year-long categories according to when each individual arrived at a European zoo. Data from the years preceding 1950 were not included as only a very small number of elephants were involved (fewer than 10 for Asians and zero for Africans).

Although a statistical test was not appropriate due to the small sample size, it can be seen from Figure 3a that the number of wild-caught Asian elephants has decreased over the past fifty years from a peak of 77 in the 1960s to just nine individuals (9.1%) between 1990 to 1999. Some of this deficit has been met by the importation of timber elephants from Asian countries, but the majority of new elephants in the last decade have been captive-born as a result of an increase in birth rates (Figure 3a). These figures do not take into consideration the survival rate of calves (see Chapter 7). The main reason for this marked decrease in wild elephants is likely due to the severe restrictions placed on trading imposed by CITES after Asian elephants were placed in Appendix I in 1973 (see Chapter 2) coupled with the increase in captive breeding success.

Figure 3b shows that the number of African elephants arriving into European zoos increased from 1950 to 1989, almost exclusively through the importation of wild elephants. The large number of African elephants supplied to zoos during the 1970s and 1980s was a result of the widespread culling operations that took place at this time (Olson & Wiese 2000). Although this route remains open to zoos, nowadays they are less inclined to exploit culling operations possibly due to the recent negative publicity surrounding the importation of young orphaned elephants from South Africa; see Chapter 7 for further details on the 'Tuli elephant case'). However, in the last decade the number of wild imports has almost halved from 77 elephants in the 1980s to 43 (see Figure 3b), and the number of captive births has increased from just 6 to 23.

Overall, zoos today are relying less on wild populations to sustain their numbers, especially for Asian elephants. Zoos are, however, still relying to some extent on imports from Asian timber camps, some of which may have been captured from the wild (Kemf & Santiapillai 2000). Captive breeding has also dramatically increased in the last decade, but zoos are still a far cry from maintaining a self-sustaining breeding population (Olson & Wiese 2000; Wiese 2000). The problems associated with captive breeding are discussed further in Chapter 9.

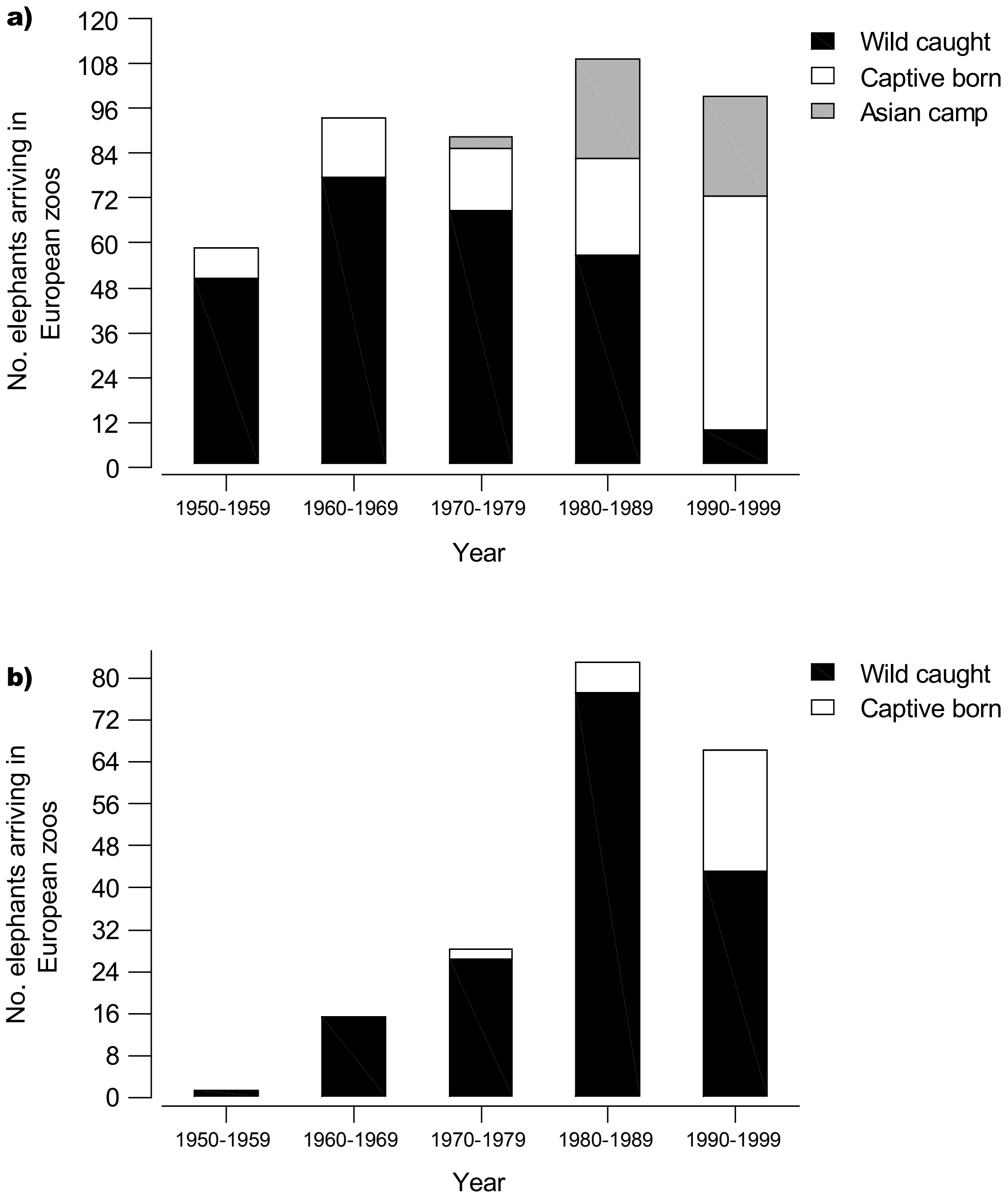


Figure 3. Origin of a) Asian and b) African elephants arriving in European zoos over the years

The source of zoo elephants (wild caught, captive born, or imported from Asian timber camps) were taken from the EEP studbooks. The number of individuals from each source are shown by the year they were transferred, or born, into a European zoo.

CITES data on the origin of wild elephants destined for zoos

As discussed in the first section, wild elephants are protected by law and all trade is strictly governed by CITES. This means that a permit must be obtained before elephants can be exported to a different country, and this holds for re-exportation as well as initial exports from the country of origin (see Box 1). In order to quantify how many elephants had been caught from the wild and exported during this time, records of all imports and exports of Asian and African elephants, accurate from 1975 to 1999, were obtained from the CITES Trade Database Manager (World Trade Conservation Monitoring Centre, Cambridge, U.K.).

The information provided in this database was not entirely complete, and some discrepancies in the data were found. Therefore, for the purpose of this investigation, the following methodology was followed. Firstly, it was assumed that elephants had been captured from the wild if they were reported as having been exported from a country within their natural range (e.g. India) and were not listed as having been captive bred, and only these data were used in the calculations that follow. Secondly, the number of elephants exported sometimes differed from the number recorded as having been imported. In this case, the number of elephants exported and the number imported were both calculated. Thirdly, categories for the purpose of exportation were as follows: 'Breeding', 'Education', 'Botanic Garden', 'Hunting Trophy', 'Re-introduction', 'Personal', 'Circus', 'Scientific', 'Commercial', 'Exhibition' and 'Zoo'. Consultation with the CITES Trade Database Manager revealed that not all exports to zoos are listed in the last category, and instead, some are listed under 'Breeding', 'Education', 'Scientific' and 'Commercial'. Therefore, all exports listed for these five purposes were used in the calculations that follow. Details on the purpose of exportation, as well as the number of elephants involved, were missing for 8 Asian and 18 African exportation events from their country of origin, and so these could not be included in calculations. Therefore, the data presented in the following paragraphs represent the minimum number of elephants exported.

According to the CITES Trade database, 67 Asian and 459 African elephants were exported to European zoos from their country of origin between 1975 and 1999. These include elephants exported for the purpose of breeding (1 Asian, 4 Africans), education (4 Asian, 6 African), science (2 Asian, 0 Africans) and commerce (27 Asians, 200 Africans), as well as those explicitly destined for zoos (33 Asians, 249 Africans). However, records show that only 382 African elephants were actually imported, but figures for imports and exports of Asian elephants show no such discrepancy. The reason for this discrepancy is likely due to reporting error, as pointed out in the CITES Trade Database notes.

The vast majority of Asian elephants were imported from Burma and India (see Table 4). Unlike India, capture from the wild is still legal, and common, in Burma (Kemf & Santiapillai 2000) and thus it is likely that some of the elephants imported from this country have been wild caught. Most African elephants originated in Zimbabwe and Zambia (see Table 4). Given that Zimbabwe populations of wild elephants are only afforded Appendix II protection this makes it far easier to obtain an export permit from CITES.

Table 4. Country of origin for elephants exported to European zoos, from CITES data

Data on the number of Asian and African elephants imported from their countries of origin between 1975 and 1999 taken from the CITES Trade database.

Species	Country of origin	No. exported	No. imported
Asian	Burma	37	Same as no. exported
	India	21	
	Indonesia	2	
	Sri Lanka	2	
	Malaysia	2	
	Thailand	1	
	Vietnam	2	
	TOTAL	67	
African	Zimbabwe	249	190
	Zambia	161	143
	Namibia	47	47
	Tanzania	2	2
	TOTAL	459	382

The most significant countries in the importation of zoo elephants from the wild were the Netherlands, for Asian elephants, closely followed by Germany, which were also responsible for the majority of African imports (see Table 5). Belgium, the U.K. and Portugal have also been responsible for a significant number of African imports, while other European countries have mostly imported fewer than ten individuals.

Therefore, although there has been a significant decrease in the number of wild elephants being imported, many of those that are currently held in European zoos are wild caught. Most African elephants have been imported from populations that are not endangered (i.e. CITES Appendix II), but the exact origin of Asian elephants is less clear. This is because the major country of export, Burma, still allows capture from the wild and thus an unknown number of these are likely to have been taken directly from the wild. The majority of elephants have been imported by only a handful of European countries, but many of these will be re-exported to other zoos in Europe and elsewhere.

Table 5. Destination country for elephants imported to European zoos, from CITES data

Data on the number of Asian and African elephants imported from their countries of origin between 1975 and 1999 were taken from the CITES Trade database. Details of the methodology used to arrive at these figures can be found in the text.

Species	Importer	No. exported	No. imported (if different)
Asian	The Netherlands	28	same as no. exported
	Germany	27	
	Denmark, Portugal, U.K., Yugoslavia	2 per country	
	France, Sweden, Switzerland, Turkey	1 per country	
	TOTAL	67	
African	Germany	270	213
	Belgium	75	65
	U.K.	30	32
	Portugal	23	23
	France	13	11
	Italy	13	9
	Spain	13	7
	The Netherlands	8	8
	Switzerland	6	6
	Sweden	4	4
	Denmark	2	2
	Czechoslovakia	2	2
	TOTAL	459	382

Are zoo elephants domesticated?

The fact that elephants, mainly the Asian species, have been tamed and trained to respond to commands for thousands of years (see section '*History of their use by man*') has led some authors to conclude that elephants under the care of humans e.g. timber elephants are domesticated (e.g. Jainudeen *et al.* 1971; Iversen 1995; Clutton-Brock 1999), or semi-domesticated (e.g. Weilenmann & Isenbrugel 1992). Price (1984) has defined domestication as "that process by which a population of animals becomes adapted to man and to the captive environment by genetic changes occurring over generations and environmentally induced developmental events occurring during each generation." Therefore, the question is whether zoo elephants have undergone these changes across generations and within their own lifetimes. Elephants originating from each of the three

sources, highlighted in the previous section, will be considered: wild caught, captive born and those imported from Asian timber camps.
Results from the previous section showed that the majority of elephants held in European zoos came directly from the wild. It is obvious that those imported directly from the wild will not have undergone any degree of genetic or developmental domestication. They are, however, likely to have undergone some degree of taming, prior to their importation and/or within the zoos. This process, defined by Wood-Gush (1983) as "the elimination of the tendency to flee in the presence of man," takes place within an animal's own lifetime and can occur through habituation and positive conditioning towards humans (Wood-Gush 1983; Price 1984). Thus, domestic animals have learnt that the presence of, and/or contact with, humans either has no effect (i.e. habituation) or results in a pleasant experience, such as food (positive conditioning), and thus display a diminished escape response. These aspects of learning are discussed further in Chapter 6.

It is also unlikely that the Asian elephants imported from timber camps have undergone a great deal of domestication. Historically, timber elephants in Asia have been captured from the wild rather than bred in captivity. This was mainly because they cannot be used for work until they reach around five years of age, during which time they must be fed and watered at considerable cost. It was, therefore, far more economical to simply capture an elephant from the wild at a suitable age (Mar 2001). In recent years, most Asian countries have banned the capture of wild elephants (with the exception of Burma, although it is know that illegal trade is still rife in most countries (WCMC and WWF-International 2001b). Captive breeding in camps has therefore increased in recent years, and some have met with relative success (e.g. Mar 2001, see also Chapter 9), despite the fact that their mating behaviour is difficult to control (Clutton-Brock 1999). But, given that the ban on capturing elephants from the wild only came into force 30 years or so ago, it is unlikely that more than two generations have been born in captivity. Furthermore, many of the calves born in camps have been sired by wild males, which are free to mate with tame females while they roam the forests at night (Gröning & Saller 1998). Therefore, elephants imported to zoos from Asian timber camps are not likely to have undergone sufficient genetic selection to be classed as domesticated.

As for zoo-born animals, numbers have been extremely low, although there has been increasing success in the past few years (see Chapter 9). Of those born in zoos, very few have produced young themselves (see Table 6). According to the studbooks, the first Asian birth in a European zoo from captive-bred parents took place in June 16th 1984 at Rotterdam Zoo in the Netherlands. Three years later, the same was achieved in African elephants at Howletts Zoo Park in England on April 16th 1987, closely followed by another calf six months later at the same zoo. Although breeding rates have continued to improve (see Chapter 9), only 10 second generation captive born Asian and 14 African elephants are currently held in European zoos, and only a few third generation African elephants (see Table 6). Although some of those imported from Asian timber camps may have been born within camps, records are not available.

Table 6. Number of generations born in zoos for the current population held in European zoos

Information on the identity of sires and dams and the origin of individual elephants were taken from the 1999 Asian and 2001 African elephant EEP studbooks to determine the number of generations born in captivity for each individual. Elephants with their birthplace recorded as 'wild', 'unknown', or an Asian country were not counted as having been captive born. Captive born individuals were classed as 1st generation if their parents had not been born in captivity, or 2nd generation if at least one parent had been, but their grand-parents had not. The few elephants that were the 3rd generation born in captivity had at least one grand-parent that had been captive born.

No. generations captive born	No. Asian elephants (% current population)	No. African elephants (% current population)
*None	263 (81.2)	160 (81.6)
1st generation	51 (15.7)	19 (9.7)
2nd generation	10 (3.1)	14 (7.1)
3rd generation	0	3 (1.5)

*Includes elephants caught from the wild, imported from Asia and those of unknown parentage

Given the long generation time of elephants, it is perhaps not surprising that there have been so few generations born in captivity. However, given that breeding begins at around 15 years of age (although far younger zoo elephants have bred, see Chapter 10), a second-generation captive born calf could be produced within 30 years. Although this is a minimum figure, it still appears highly likely that, in an ideal world, far more than 10 Asian and 14 African second-generation captive born elephants would be produced within the 100 and 40 years, for Asian and African elephants, respectively, that records go back. Instead, therefore, the problem is more likely to lie in the lack of captive breeding, rather than a lack of time (discussed in detail in Chapter 9).

Regardless of the causes of such a finding, the fact remains that the majority of zoo elephants have not been bred for any length of time in captivity, and although a few individuals may have undergone some changes within generations, there has been no real scope for genetic changes through artificial selection between generations at a population level. For this reason, zoo elephants must be considered wild, rather than domesticated, animals.

Summary

- Elephants have a very long history of being tamed and trained by man, dating back some 4000 years. Today, Asian elephants are still used in logging camps, religious ceremonies and for wildlife tourism in Asia, as well as being kept in zoos and circuses all over the world. Training African elephants is far less common and the majority of captive ones can be found in zoos and circuses.

- Elephants are sometimes said to fulfil a conservation role in modern zoos. However, the conservation organisations WWF, IUCN and the African Elephant Specialist Group (AfESG) do not consider that captive breeding makes a significant contribution to elephant conservation, due to the currently low breeding rates and high levels of mortality (see Chapters 7 and 9). There are also issues regarding the cost of *in situ* elephant conservation compared to *ex situ* and the value of zoo elephants for conservation education.
- According to the Captive Elephant Database, there are currently at least 1713 elephants held in various types of facilities world-wide. Zoos hold 634 Asian and 453 African elephants, and Europe has the greatest number (330 Asian and 230 African), most of which are included in the studbooks.
- The current zoo population in Europe consists primarily of elephants caught from the wild (59.7% Asians, 83.3% Africans). The remainder have probably been imported from timber camps (21.0% Asians) or born in zoos (19.4% Asians, 14.7% Africans). Over the years, there has been an increase in the number of Asian imports and zoo-born elephants, and a corresponding decrease in the number caught from the wild, which is probably due to the imposition of trading restrictions.
- Data from the CITES Trading Database shows that most wild caught elephants have been imported from Burma (where capture from the wild is legal) and Zimbabwe (where elephants are listed in Appendix II).
- The biggest importer of wild elephants in Europe is Germany, although the Netherlands has imported slightly more Asian elephants.
- Due to the lack of sustained captive breeding, and hence genetic selection, despite their long association with man zoo elephants must generally be regarded as wild, not domesticated, although most have been tamed. For example, there are no third generation zoo-bred Asians and only 10 second generation (3.1% of the population), plus only 3 (1.5%) third generation and 14 (7.1%) second generation Africans. There is also no evidence that timber elephants have undergone artificial selection, as breeding is not controlled and females are able to mate with wild males.

Chapter

4

General husbandry

This chapter reviews general aspects of elephant husbandry that may affect the welfare of zoo elephants. We first define the main systems used to handle elephants in zoos, and review the prevalence of each. Aspects of the physical environment of zoos are then considered, including: enclosure size; substrate type; the time spent indoors; temperature and lighting conditions; and the availability of enrichment items such as pools and wallows. Throughout, where data are available we compare these with the ways elephants are kept in extensive conditions, and the relevant aspects of their behaviour in the wild. We then consider specific aspects of husbandry, including the practice of chaining, diet, and the use of environmental enrichments. The potential effects these aspects of the captive environment could have on elephant welfare are then reviewed.

Handling systems in use

The Elephant Management Task Force of the AZA has defined four different styles that are currently in use to manage captive elephants, as follows (Otten 1994):

- **Free contact (or Hands On)**: Direct handling of an elephant when the handler and the elephant share the same unrestricted space;
- **Protected Contact**: Handling of an elephant when the handler and the elephant do not share the same unrestricted space. Typically in this system the handler has contact with the elephant through a protective barrier of some type, while the elephant is not spatially confined and may leave the work area at will;
- **Confined Contact**: Handling of an elephant through a protective barrier where the elephant is spatially confined, as in an elephant restraining chute (ERC); this is a subset of protected contact and so will not be discussed as a separate category (AZA 2001);
- **No Contact (or Hands Off)**: Handling of an elephant with no contact made unless the elephant is chemically sedated.

The most common system used to handle female and young male Asian elephants in European zoos is free contact, used in 79.7% of zoos surveyed in 1999 (Griede 2000, summarised in Table 7). This is followed by no contact, used in 32.8% of zoos and lastly protected contact, used in 21.9% of zoos. With adult bulls, however, the situation is rather different. The majority of zoos use ‘no contact’ with at least some of their bulls (51.0% of zoos), 41.9% employ free contact and 35.5% use protected contact (Table 7). These data include facilities that use a combination of systems with different elephants: 26.6% of zoos with females and young males, and 32.3% of zoos with adult bulls and this is why the figures do not sum to 100%. No such survey exists for African elephants. In North America, free contact is being phased out by the AZA in favour of the more modern protected contact system (Hutchins & Smith 1999). This is reflected by the number of zoos that have already changed over. The AZA Annual Report for 1998 - 1999 (Lankard 2000) shows that out of 77 U. S. facilities with elephants, 44.2% were using free contact, 32.5% were practising protected contact, and the remainder (23.3%) were using both.

There is a great deal of controversy about which system offers the greatest benefit to the elephants. The primary difference between free contact and protected contact is the training methods used. Free contact employs traditional training methods derived from the mahouts (see Chapters 3 and 6). These methods rely on the establishment of dominance over the elephants, involving the use of physical punishment (e.g. with an ankus/elephant hook), as well as restraint and sometimes deprivation, and 100% compliance is required from the elephants (e.g. Fernando 1989; Koehl 2000). In contrast, training in protected contact does not involve these methods and participation in training sessions is voluntary (Desmond & Laule 1991). Training is reviewed in more detail in Chapter 6, where we also consider the possible effect each method has on elephant welfare.

Table 7. The prevalence of different handling systems used with Asian elephants in European zoos

A survey of European zoos holding Asian elephants was carried out by Griede (2000) in 1999. Results reported included the prevalence of different handling systems used. A total of 68 zoos were included of which 66 reported the handling system in use. (See text for a description of the different handling styles).

Handling system	Females and pre-pubescent males		Bulls	
	No. facilities	% facilities	No. facilities	% facilities
Free contact (FC)	39	60.9	6	19.4
Protected Contact (PC)	1	1.6	3	9.7
No contact (NC)	7	10.9	12	38.7
FC + PC	3	4.7	5	16.1
FC + NC	4	6.3	1	3.2
PC + NC	5	7.8	3	9.7
FC + PC + NC	5	7.8	0	0
FC + 'Other'	0	0	1	3/2

The physical environment

"2.2 Animals in outdoor enclosures must be provided with sufficient shelter for their comfort and well-being….Enclosures must also be designed to allow for animals' normal defence reactions and appropriate 'flight' or escape distances.

Enclosures must of a size and design, and animals must be so managed as to:
a) avoid animals within herds or groups being unduly dominated by individuals;
b) avoid the risk of persistent and unresolved conflict between herd or group members, or between different species or age groups in mixed exhibits;
c) ensure that the physical carrying capacity of the enclosure and/or system is not over-burdened;…

Accommodation should take account of the natural habitat of the species and seek to meet the physiological and psychological needs of the animal. "

Secretary of State's Standards of Modern Zoo Practice
(DETR 2000)

Very little data are available on the general design of elephant enclosures in European zoos. Therefore, much of what we present in this section refers to the standards recommended by the EAZA (1997) and the AZA (2001). This is not necessarily representative of the current situation but rather shows what these organisations consider the minimum acceptable standards. There may well be zoos that do not meet these standards at the present time, particularly those with older exhibits, but as stated, these data are not available.

Climate

Elephants in European zoos experience a large variation in temperature depending on zoo location. The most northern zoo included in the EEP studbooks is Boras Djurpark Zoo Sweden (latitude c. 58^{o}), and the most southern one, the Tisch Family Zoological Society Gardens, Jerusalem (latitude c. 32^{o}). The climate zoo elephants experience in Europe thus ranges from very cold (e.g. Moscow: minimum monthly average temperature -10^{o}) to very warm (e.g. Jerusalem: maximum monthly average temperature 30^{o}) (Philip's 1997). The amount of rainfall also varies from very wet (e.g. Ireland: yearly rainfall 929mm) to relatively dry (e.g. Spain: yearly rainfall 474mm). In the wild, Asian elephants are adapted to cope with very wet conditions, as many native regions have monsoon seasons (e.g. Indonesia yearly rainfall: 1798mm), but countries within their natural range are generally far warmer than Europe, remaining over 20^{o}C most of the time, though occasionally falling to c. 0^{o}C (e.g. China). African elephants are also adapted to warmer climates. For instance the temperature in Zambia and Namibia ranges between 14 and 24^{o}C and rainfall is also generally lower compared to Europe (e.g. Namibia yearly rainfall: 23mm; Zambia: 836mm).

Although elephants may experience cold weather in their native countries on occasion, they do not experience snow or ice, indeed cold, wet weather can be fatal to elephants and due to their large size, once they have cooled down they take a long time to warm up again (Poole & Taylor 1999). For this reason, elephants in colder European zoos are often confined for a considerable portion of the time to protect them from severe weather (discussed in the following section). Such wet conditions have also been implicated in the development of the foot problems common in zoo elephants (see Chapter 8).

Very hot weather can also be detrimental to elephants. In the wild they adapt their behaviour to alter their body temperature, for instance by standing in the shade, covering themselves with mud or bathing in pools. This is an important consideration in enclosure design, particularly in regions where the outdoor temperature can reach over 27^{o}C (Poole & Taylor 1999).

Outdoor enclosures

Size

The EAZA recommends that outdoor enclosures measure at least 400m^2 for three elephants, i.e. 133m^2 per elephant, excluding safety barriers (e.g. moats, fences), with a further 100m^2 for each extra elephant. The AZA has lower standards for three elephants and above, and states that outdoor enclosures should be at least 167.2m^2 for single adult elephants, with an additional 83.6m^2 for each extra animal. This works out at 334.4m^2 for three elephants. However, the AZA also states that if there is no additional exercise area, the enclosure size should be increased (to an unspecified area). It also states that it will accept enclosures under these minimum standards in some circumstances, considered on a case by case basis during inspections.

Data on the average size of European elephant enclosure are not available, but a survey of Asian elephant enclosures in 20 European and North American zoos show a range of 100 to 48,562m^2, or 17 to 6937m^2 per elephant (Taylor & Poole 1998). Elephants held in extensive systems have access to far larger areas of forest, when they are not working. For instance, Taylor & Poole (1998) note that Asian elephants held in a timber camp in Tamil Nadu had access to 100,000m^2 of natural habitat in the evenings, and those in a Sri Lankan orphanage has access to 97,127m^2 of land when they were outdoors

As reviewed in Chapter 2, elephants roam over considerable distances. Even considering minimum wild home range sizes, the outdoor enclosures recommended by both the EAZA and AZA are in the region of 60 to 100 times smaller.

Landscaping: structural enrichments

> "4.4 Enclosures should be equipped in accordance with the needs of the animals with…pools, sub-strates and vegetation and other enrichment materials designed to aid and encourage normal behaviour patterns and minimise any abnormal behaviour."
>
> Secretary of State's Standards of Modern Zoo Practice (DETR 2000)

Both the EAZA and the AZA stress the importance of using natural substrates in outdoor enclosures and the AZA states that they must consist primarily of natural substrates such as soil, grass and sand. Sand and soil must also be available at all times to allow dust-bathing, which is a behaviour frequently seen in wild elephants (e.g. McKay 1973). Wild elephants also routinely scratch themselves against trees (e.g. McKay 1973) and both organisations recommend providing objects that the elephants can rub and scratch themselves against, such as rock structures or tree stumps.

The EAZA states that elephants must have access to a pool during the day either in the indoor or outdoor enclosure, with dimensions of 2 x 3.5 x 1m deep. Similarly, the AZA standards state that "while outdoors and weather permitting, elephants must have regular access to a water source, such as a pool, waterfall, misters/sprinklers, or wallow that provides enrichment and allows the animals to cool and/or bath themselves". Wild and timber elephants bathe every day and access to water is generally regarded to be absolutely essential (Shoshani & Eisenberg 1982), as is shade due to the risk of sunburn. Similarly, the

AZA states that all elephants must have access to shade when outdoors in daylight hours when temperatures exceed 27°C when they are exposed to direct sunlight.

Collectively, dust bathing, mud wallowing, scratching and bathing are thought to keep their skin in good condition. Likewise, these activities are also thought to have beneficial consequences for foot health, particularly when they dig around the edge of pools (e.g. Roocroft & Oosterhuis 2001). These are both reviewed in Chapter 8.

Enclosure barriers

Dry moats are associated with a high risk of accidents, as elephants can regularly fall into them resulting in injury, or even death (see Chapter 8). New enclosures use alternative methods, and both the EAZA and AZA recommend that the use of dry moats is minimised and eventually completely phased out. Of particular danger are moats that are deep, have very steep sides and have a hard bottom. When a dry moat is used, the EAZA recommends that it has a soft surface (e.g. sand) is wide enough for an elephant to turn round (over 2.5m), and is no deeper than 1.5m. The AZA provides similar recommendations of no more than 1m deep, less than 3m wide and/or hard bottomed, and also state that written protocols must be prepared on the procedure to extract an elephant that has fallen into a moat. In addition, the EAZA recommends that when handlers are not on hand, elephants should not have a dry moat as a barrier, thus requiring confinement indoors.

Indoor enclosure

Indoor enclosures are also available in zoos so that elephants can take shelter in adverse weather conditions. This is also where much of the husbandry, such as foot care and washing etc., takes place. These generally consist of barns, which are often divided up into separate stalls so that individuals can be held separately if needed.

Size

The EAZA recommends that indoor stalls, or boxes, should be at least 36m^2 per female and 45m^2 per bull. The total area inside should be at least 150m^2 for three cows with an extra 50m^2 for each extra cow, including the box. The AZA give slightly higher recommendations: at least 37.2m^2 (400ft^2) for a single animal, double (74.3m^2) for two and so on. In the case of bulls or calves with cows the minimum is 55.7m^2 (600ft^2). However, the AZA states that they will accept enclosures under these minimum standards in some circumstances, on a case by case basis during inspections. The EAZA also recommends that zoos building new enclosures should consider adding a quarantine/separation room which should be twice the size of a normal inter-connected elephant box (i.e. 72m^2 for females and 90m^2 for males). Data on the actual size of indoor enclosures in European do not exist, but according to a survey of 20 European and North American zoos by Taylor & Poole (1998), indoor enclosures range between 58 and 681m^2, representing 19 to 171m^2 per animal.

Physical conditions

The EAZA do not comment on the type of flooring required in indoor enclosures, but the AZA recommends that they must be "impervious to water, quick to dry, and sloped to a drain. Floor surfaces must be relatively smooth, but not enough that they become slippery when wet. Conversely, very rough surfaces may cause excessive wear or irritate footpads." Many facilities in the U.S.A. are now using rubber mats, or poured rubber surfaces instead of concrete (Scott Blais, pers. comm) as are some in Europe (e.g. Schwammer 2001). (See Chapter 8).

The EAZA recommends that indoor enclosures should be able to reach a temperature of 20^{o}C, and the normal temperature should be at least 15^{o}C. The AZA states that the indoor areas must be supplied with good ventilation and heating to achieve a minimum temperature of 12.8^{o}C. According to the EAZA, indoor enclosures should also be well lit during daylight hours, and have a "normal" dark period.

Aspects of husbandry

Chaining

Chaining has been used to restrain zoo elephants for many years, and began in Europe in the later half of the 19th century (Schmid 1998). Elephants are the only zoo species that are still managed in this way (Wiedenmayer 1995). Chaining is used in two circumstances: during close contact with humans, for instance during routine foot care, washing and minor medical procedures carried out by a veterinarian; and when elephants are confined overnight in indoor enclosures. Chaining in the former situation is only short-term and only lasts as long as the procedure, whereas elephants may be chained for a considerable period overnight (Wiedenmayer 1995). Elephants are usually chained by two opposing feet which are regularly alternated to prevent rubbing. When chained overnight, they are usually chained in a row, thus limiting social contact to one or two elephants each (Galloway 1991). Elephants must be trained to respond to commands to allow routine chaining and thus this practice is largely limited to free contact situations (Schmid 1998).

There are several reasons for overnight chaining, the primary ones being to prevent aggression between elephants while they are confined indoors, and to prevent accidents, such as falling into dry moats, when handlers are not on site (Wiedenmayer 1995). Roocroft (1991) also states that chaining prevents alterations in the social hierarchy while the handler is absent, and reduces the development of specific health problems, such as sores from continually lying on one side to avoid facing away from dominant animals. Another reason appears to be historical, as chaining was originally introduced to enable more animals to be kept in a small space (Schmid 1998). Some zoos still do not have the adequate facilities to deal with unrestrained elephants overnight and so continue to use chaining for this reason alone (Galloway 1991).

Taylor & Poole's (1998) survey revealed that 75% of European zoos chained or confined their elephants, 60% for eight hours or more per day. Unfortunately, the authors do not differentiate between tethering and indoor housing. Galloway (1991) surveyed the North American population and found that out of 100 facilities, chaining overnight occurred regularly in 48% of zoos, occasionally in 13%, and not at all in 39%. The length of time elephants are chained varies between facilities depending on how long they are confined indoors, which in turn may depend on climate, enclosure design and staff hours. Galloway's (1991) American survey showed that chaining generally took place when handlers were not present, which is around 16 hours per day, although there are reports of chaining occurring for 18 hours per day (e.g. Wiedenmayer 1995). These elephants are thus only able to move freely for approximately 33% of the day, whereas elephants in the wild are active for approximately 83% of the day (Eltringham 1982). The situation is likely to be similar in Europe, and Schmid (1998) notes that the majority of zoos in Europe chain their elephants for several hours per day.

Overnight chaining has been phased out in several zoos in recent years due to concerns about elephant welfare (e.g. Wiedenmayer 1995; Bradley 2000). None of the zoos in the U.K. now chain their elephants overnight, but chaining for routine treatment is the norm in zoos that handle their elephants in free contact (see Chapter 6). Recommendations have been put forward by the EAZA and the AZA to restrict the length of time elephants are chained. The EAZA recommends a maximum of three hours out of 24 per day (EAZA 1997), while the AZA standards are less stringent: "Chaining is acceptable as a method of temporary restraint (Fowler 1995). However, elephants must not be subjected to prolonged chaining (for the majority of a 24-hour period) unless necessary for veterinary treatment or transport." Chaining does not generally occur in timber camps in Asia (Taylor & Poole 1998). The possible welfare consequences of chaining are considered at the end of this chapter.

Time spent indoors

The time spent outdoors varies considerably between zoos, depending on the climate, enclosure design (e.g. presence of a dry moat), handler hours, and general husbandry within individual zoos (e.g. whether chaining is practised). There are no data to calculate an average time spent outdoors for elephants held in European zoos. However, in colder climates, elephants are generally kept indoors when the handlers are not on site, which, as mentioned above, is approximately 16 hours per day (Galloway 1991). This is similar to Green's (1989) estimate of 60% of the time spent indoors for elephants held in the U.K. due to the climate. Some zoos, however, allow free access between indoor and outdoor enclosures at all times (e.g. Schwammer & Karapanou 1997).

The EAZA do not make any recommendations about the length of time that elephants should spend outdoors. Similarly, the AZA standards do not state any minimum standards, but they do recommend that elephants be kept outside as much as possible (AZA 2001). They also state that zoos should "consider" designing their enclosures so that the elephants are able to have constant access to the outdoors.

Diet

> "1.1 Food must be presented in an appropriate manner and must be of the nutritive value, quantity, quality and variety for the species, and its condition, size, and physiological , reproductive and health status.
> Food should be presented in such a manner and frequency commensurate with the natural behaviour of the species"
>
> Secretary of State's Standards of Modern Zoo Practice
> (DETR 2000)

In this section, we review the dietary habits of elephants in the wild, expanding upon information presented in Chapter 2. We then present recommendations about the dietary standards for elephants in European zoos.

The diet of wild elephants

As discussed briefly in Chapter 2, wild elephants feed on a wide range of vegetation. Most consists of grasses, but a wide variety of other vegetable matter is also eaten, including leaves, stems, bark, roots, twigs, herbs, roots, flowers and fruit (Buss 1961; Wing & Buss 1970; Field 1971; McKay 1973; Nowak 1995; Sukumar & Ramesh 1995), the relative proportions shifting with the seasons (Field 1971; Sivaganesan & Johnsingh 1995). Browse (leaves and branches), although making up not more than 50% of intake (Field 1971; Sukumar & Ramesh 1995), is a very important source of carbon, and Sukumar & Ramesh (1995) have estimated that it contributes between 55% to 83% of organic carbon for protein synthesis in Asian elephants. Studies have shown that elephants utilise a great number of plant species, up to 75 species in the Asian elephant (Shoshani & Eisenberg 1982), but this is not to say they are indiscriminate feeders. Several studies have shown that elephants show preferences for specific plant species (Vijayakumaran Nair & Jayson 1992, Shoshani & Eisenberg 1982).

Wild adult elephants are estimated to consume between 150 to 300kg of food (wet weight) within a 24 hour period, varying with age, size and sex (McKay 1973; Hanks 1979; Eisenberg 1981; Shoshani & Eisenberg 1982; Macdonald 1984; Karoor 1992). However, due to the low digestive efficiency of elephants, only 35% to 46% of the ingested food is actually processed (McKay 1973; Shoshani & Eisenberg 1982; Roehrs *et al.* 1989; van Soest 1996; Kaufman 2001). Benedict (1936, cited in McKay 1973) calculated that an Asian elephant consuming around 150kg of food per day (wet weight), with a digestive efficiency of around 40%, would have an estimated digestible energy intake of 96,000kcal per day. As reviewed in Chapter 2, elephants are highly skilled at manipulating their food. For instance, elephants, particularly the Asian species, use their feet with great dexterity to dig up roots and scrape off vegetation close to the surface of the ground (Wing & Buss 1970). They also use their trunks with great skill to remove dirt, thorns or bark from their food before eating it (Wing & Buss 1970; Moss 1988; Stoinski *et al.* 2000).

The diet of zoo elephants

The diet fed to elephants in zoos is very different to that in the wild. The basis of zoo diets is dried forage, usually timothy hay, supplemented with some commercial concentrate feed (pellet), a small amount of produce (fruit and vegetables), vitamin and mineral supplements, and sometimes branches and leaves (browse), when available (Ange *et al.* in prep.; de Regt *et al.* in prep.; Dierenfeld & Dolensek 1988; Roehrs *et al.* 1989). Most zoo elephants do not have access to pasture grass (Dierenfeld & Dolensek 1988) and so all the necessary nutrients must be provided in this diet. For instance, Taylor & Poole's (1998) survey showed that 90% of European elephant enclosures did not provide an opportunity to graze. The frequency and manner in which food is provided differs between zoos: rations are fed in varying quantities and frequencies in different facilities. When available, browse may be provided as a supplement and enrichment which can be processed and eaten throughout the day, although availability in certain geographical locations can severely limit its use.

Quantity and nutrient content of food given to zoo elephants

The amount of food given to elephants varies between individual animals, as well as between different facilities. Different authors have quantified intake in several ways. For instance, Kaufman (2001) estimates that zoo elephants consume 1.5 to 1.9% of their body weight in 12 hours and, similarly, Roehrs *et al.* (1989) suggest an intake of 1.4% to 1.6% body weight. This compares favourably to recommendations of 1.5% to 2% body weight for elephants held in extensive systems (Krishnamurthy & Wemmer 1995). However, the correct weight of food provided to zoo elephants is largely dependent on the nutrient content of the diet. As mentioned above, wild elephants feed predominantly on very low quality vegetation, and so they would have to consume a greater volume of food compared to zoo elephants due to the higher quality of feed they are receiving. The nutrient content of zoo elephant diets has only recently been subject to examination by Ange *et al.* (in prep.) and de Regt *et al*. (in prep.), and it is from these reports that most data in this section are drawn.

Current recommendations for the nutrient content of zoo elephant diets (e.g. de Regt *et al.* in prep., see Appendix II; Ullrey *et al.* 1997) have largely been formulated using standards set by the National Research Council (1989 Standards) for adult horses (Ange *et al.* in prep.; Roehrs *et al.* 1989; Kaufman 2001). This is because relatively little is known about the dietary requirements of zoo elephants and the digestive system and metabolism of elephants most closely resemble those of horses (Ange *et al.* in prep.; Roehrs *et al.* 1989; Kaufman 2001), although elephants have a far lower digestion efficiency (Shoshani 1992). In addition, information on nutrients consumed by wild elephants make some contribution to guidelines (Ange *et al.* in prep.). This lack of knowledge is highlighted by the fact that the AZA currently is no specific standards on elephant nutrition (AZA 2001). Data on the nutrient levels consumed by zoo elephants are limited (Ange *et al.* in prep.), but the recent surveys of Asian elephant diets carried out by Ange *et al.* (in prep.) and de Regt *et al*. (in prep.) suggest that most zoos are not providing well-balanced diets.

De Regt *et al*. (in prep.) sent out questionnaires to all EEP-member zoos asking for details of the diet fed to their Asian elephants. From the 48 they received back, they were able to identify the major foodstuffs being used. More importantly, they were able to analyse this information using a program, the 'Animal Nutritionist', which calculates the nutrient content of each diet, and thus allows comparison with recommended nutrient levels (see Appendix II). There are five basic components to the diet fed to zoo elephants: pellets, roughage, grain, various produce, and a vitamin/mineral mixture. The first striking result from this survey is that within these broad categories, a wide range of food types is being fed to Asian zoo elephants (see Table 8).

Secondly, the nutrient content of 20 diets that were the same all year round, and 56 diets that changed from winter to summer, were compared by Regt *et al.* (in prep.) with recommended nutrient levels derived from a range of sources (see Appendix II). This highlighted several areas of concern. Most notably, the vast majority (86.8%) of diets had a fat content in excess of recommended levels. Information from eight questionnaires that had been filled out in detail, containing 13 diets for apparently healthy elephants, showed that the average fat content of these zoo diets was 2.9% dry matter, compared to recommended levels of 1.5% (see Table 9 and Appendix II). Many diets were also deficient in several vitamins and minerals. The largest difference between actual and recommended levels was for zinc, which was too low in 90.8% of zoo diets (on average 31.2mg/kg dry matter in detailed diets cf. recommended 40mg/kg dry matter). Iron was too low in 82.9% of diets, on average containing 38.2mg/kg dry matter according to the detailed diets, compared to the recommended level of 100mg/kg dry matter.

Table 8. Content of the diet fed to Asian elephants in European zoos

A total of 48 EEP zoos replied to a questionnaire by de Regt *et al.* (in prep.) quantifying the diet they feed to their Asian elephants. The results, presented in the table below, reveal a great diversity in the food types provided in different European zoos. Figures in parentheses show the number of zoos that included each particular food item in their diet.

Food category	Food type used in zoos
Pellets	Horse pellet (17), own pellet (8), Elevite (5), rhino supplementary (3), grass pellet (1)
Roughage	Meadow hay (38),branches (35), grass (20), straw (11), alfalfa/lucerne hay (11), leaves (4), heath (1)
Grains	Rolled oats (17), oats (11), wheatbran (10), maize/corn (9), wheat (6), barley (5), rice (3), linseed (3), linseed screenings (1), soy (1)
Various (greens, fruit, bread, etc)	Apple (47), bread (41), carrot (35), cabbage (24), banana (23), beet (19), potatoes (14), lettuce (14), orange (8), onion (5), beet sugar (5), pear (4), melon (3), tomato (3), lemon (2), cucumber (1)
Vitamin/mineral mixture	Salt (14), vitamix (7), own mixture (7), salvana PS (4), cod-liver oil (4), calcium carbonate (4), various (36)

Time taken to consume

The only data available on the time spent feeding come from general behaviour studies. For example, Schmid (2001) report that six female Asian elephants in Hamburg, Rotterdam and Münster Zoo spent on average 37.7% (range 29 to 64%) of observation hours (0800-1800) foraging and drinking. Schwammer & Karapanou (1997) report a similar figure of 34% (range 28 - 37%) of observations (no time period is provided) for a group of three African elephants in Vienna Zoo, prior to changes in the enclosure (the average after changes was 33%, range 32 - 34%). Elephants in extensive systems are reported to spend 6 to 8.5 hours per day foraging (25 to 35.4% of the 24 hour period), which is similar to that found here. In contrast, in the wild elephants feed for 60 to 80% of their waking hours (reviewed in Chapter 2).

Furthermore, Kurt & Schmid (1996) calculated that the average rate of food intake in adult Asian zoo elephants as 4.3kg of food per hour (dry weight) per elephant, which is far higher than their estimate of 2.3kg of food (dry weight) per hour in wild elephants. This reflects the ready availability of food given to zoo elephants that often requires little manipulation and is rapidly consumed.

Table 9. Nutrient content of the diet fed to Asian elephants in European zoos compared to recommended levels

A total of 8 EEP zoos replied with detailed answers to a questionnaire sent out by de Regt *et al.* (in prep.) quantifying the diet (13 diets in all) they feed to their Asian elephants. The average nutrient content of the 13 diets were calculated and compared to recommended levels (see Appendix II), revealing that most of the nutrients measured were either in excess, or deficient, in the zoo diets. Data are presented in rank order according to the percentage difference compared to recommended levels, with the exception of vitamin levels which showed a great deal of variation between zoos.

Nutrient	Average content of the 13 diets (St Dev)	Unit	% Difference compared to recommended levels
Fat	2.9 (0.5)	% dry matter	93.3% higher
Potassium	1.0 (0.4)	% dry matter	66.7% higher
Iron	38.2 (28.2)	mg/kg dry matter	61.8% lower
Calcium	0.5 (0.5)	% dry matter	25% higher
Crude fibre	27.0 (6.1)	% dry matter	22.9% lower
Zinc	31.2 (45.0)	mg/kg dry matter	22.0% lower
Crude protein	9.9 (1.3)	% dry matter	1% higher
Phosphorus	0.2 (0.1)	% dry matter	same
Magnesium	0.1 (0.1)	% dry matter	same
Sodium	0.2 (0.1)	% dry matter	same
Vitamin A	5235.4 (7759.0)	IU/kg dry matter	161.8% higher
Vitamin D	847.0 (1002.8)	IU/kg dry matter	185.7% higher
Vitamin E	20.14 (19.1)	IU/kg dry matter	86.6% lower

Environmental enrichments

Environmental enrichment, defined by Newberry (1995) as "an improvement in the biological functioning of captive animals, resulting from modifications of their environment", has become commonplace in most zoos (Mellen & Sevenich McPhee 2001). This definition is reliant on the modification having a beneficial effect on the animal, yet the "environmental enrichments" now commonly used in zoos are often not adequately assessed. In some cases assessment simply involves the keepers noting how much time each animal spends interacting with the item (Rutkowski *et al.* 1999). The objective of environmental enrichments also varies, for instance some may be aimed at increasing activity, others at reducing stereotypic behaviours. These obviously require more detailed behavioural studies. In zoos, therefore, the term environmental enrichment is generally used to refer to the actual environmental modification, regardless of whether the animal actually benefits in any way.

The AZA states that all facilities with elephants “must have a written environmental enrichment plan for their elephants and show evidence of implementation” (AZA 2001), but no data exist on the prevalence of such enrichments in elephant exhibits. There have been several publications reporting the use of different types of enrichments. Food-related enrichments are particularly prevalent, including food-hiding (Wiedenmayer 1998), scatter-feeding (Rutkowski *et al.* 1999), and the use of objects such as ‘feeder balls’ and ‘fruitsicles’ requiring the elephant to work for the food over relatively long time periods (e.g. Gilbert & Hare 1994; Harnett 1995). Other enrichments have also been tried, such as the presentation of novel scents (Hare & Gilbert 1994; Leach *et al.* 1998); the introduction of various objects (e.g. logs, tyres, sand, browse) into the enclosure (Green 1989; Haight 1993), and even the introduction of musical instruments (Melo 1999). The social environment is also purported to have an extremely enriching effect and it has been suggested that this is the most effective enrichment of all (Rees 2000, see Chapter 5). On the whole, the effect of such enrichments are limited to anecdotal accounts of observed changes in behaviour, such as an increase in activity and the amount of time occupied interacting with the item, and thus these need to be adequately evaluated.

Welfare concerns regarding general management and husbandry

Climate

It is clear that elephants are often held in countries that are far colder, and sometimes wetter, than they experience in their natural range. The may have a direct effect on their welfare, although elephants are generally regarded as being quite hardy and not greatly affected by cold temperatures. The degree to which zoo animals are affected by being outside their natural range is something that has not received a great deal of attention (Lindburg 1998). Wet, muddy conditions may promote the development of foot and joint problems (see Chapter 8).

Perhaps of more concern is the effect climate has on the time elephants are confined indoors, which can be for as long as 18 hours a day during the winter. The possible impact this has on elephant welfare is discussed in the following section.

Time spent indoors and chaining

Of particular concern is the large amount of time some elephants are confined in smaller indoor enclosures, particularly in colder countries, which can extend for up to 16 hours or more per day. Thus, according to minimum EAZA standards these elephants are spending the majority of the time in just 36 to 45m^2. Lindburg (1998) notes that this is a potential problem for all zoo species in temperate regions and provides a conservative estimate that during about five months of the year, collections are kept indoors on 70 to 80% of days. Furthermore, specific to elephants, many are chained when they are housed indoors. This severely restricts the performance of many behaviours, such as travel, exploration, food searching, play and social interaction (Wiedenmayer 1995; Brockett *et al.* 1999).

Chained elephants are usually able to have physical contact with just one or two other individuals, if any (Galloway 1991). This greatly limits both the degree of social interaction possible and the choice of social partner (Adams & Berg 1980). A study on chained circus elephants by Schmid (1995) showed that most elephants were separated from their preferred social partner, as indicated by the frequency of social interactions while off chains, when they were chained. Given the highly social nature of elephants (see Chapter 5), this is likely to have a detrimental impact on their welfare.

Chaining has also been associated with indicators of poor welfare. Elephants that are routinely chained overnight are said to experience a higher incidence of foot problems compared to those that are not restrained in this way (see Chapter 8). This is due to the damp, unhygienic conditions that result from the build up of urine and faeces overnight, which the elephant cannot escape from (e.g. Galloway 1991; Roocroft & Oosterhuis 2001). However, risks can be minimised by altering the design of the enclosure, for instance by having heated or sloping floors and/or using sawdust to mop up the urine (e.g. Schwammer 2001). Chaining has also been implicated in the development of joint problems such as arthritis in zoo elephants (e.g. Galloway 1991; Hittmair & Vielgrader 2000; West 2001), due to the reduction in movement. Furthermore, various studies have shown an association between chaining and the frequency of stereotypic behaviour. For instance, Gruber *et al.* (2000) and Schmid (1994) report far lower levels of stereotypy when circus elephants were in paddocks compared to when they were chained (reviewed fully in Chapter 10). A study by Schulte *et al.* (2000) also suggests that confinement indoors may increase the incidence of acyclicity in females (i.e. a lack of ovarian cycling), which is a possible causal factor in low breeding rates in zoos (see Chapter 9).

Chaining, and/or confining elephants in indoor enclosures for extended periods of time greatly limits the amount of time they can be active. A lack of adequate exercise appears to be a common problem in zoo elephants, leading to obesity, arthritis and other joint problems, and may be related to the lowered life expectancy of zoo compared to wild elephants (Kurt & Hartl 1995). This is discussed further in the section on '*Enclosure size*'.

The lack of exercise has also been suggested to be a contributory factor in excessive weight in zoo elephants (see following section on 'Diet). This has yet to be investigated, however Hardjanti (1997) notes that the female Asian elephants at London Zoo were heavier than those at Whipsnade Wild Animal Park, despite spending a smaller amount of time feeding. The author attributed this to the fact that elephants at Whipsnade have a larger enclosure, are regularly taken for walks out of their enclosure, and have to reach for some of their food which is hung from high posts.

Enclosure size

Taylor & Poole's (1998) survey showed that the minimum recommendations of the EAZA are obviously not being followed by all zoos. For instance, the minimum outdoor enclosure size they report allowed just $17m^2$ per elephant. There is also a wide variation, with some zoos far exceeding minimum recommendations (e.g. $6937m^2$ per elephant). No studies appear to have investigated the effect of enclosure size on elephant welfare. Work on other species have shown that small enclosures can be associated with indicators of poor welfare, such as the performance of stereotypic behaviours (e.g. polar bears, *Ursus maritimus*: van Keulen-Kromhout 1978; rhesus macaques, *Macaca mulatta*: Erwin & Deni 1979), high stress levels (e.g. domestic cats, *Felis chaus*: Kessler & Turner 1999); impaired immune functioning (e.g. pigs: Turner *et al.* 2000); and reduced reproductive performance (e.g. cotton-topped tamarins, *Saguinus oedipus*: Shepherdson 1995). Increasing the space available has been shown to reverse these effects, for instance decreasing, or even abolishing, stereotypic behaviours (dolphins: Greenwood 1977; e.g. polar bears: Kolter & Zander 1995), as well as promoting positive signs of welfare such as activity and behavioural variation (e.g. pine martens, *Martes martes*: Korhonen *et al.* 1995; common marmosets, *Callithrix jacchus*: Kitchen & Martin 1996).

Due to the lack of data for elephants, it is not possible to ascertain how enclosure size affects their welfare. Studies on wild elephants have show that they roam over very large areas, which, even considering the lowest home ranges reported, are 60 to 100 times the size of the minimum recommended outside enclosure size (EAZA 1997). Recent research on other zoo species has shown that average home range size in the wild is positively correlated with the performance of stereotypic behaviour displayed in captivity and infant mortality in carnivores (Clubb & Mason 2001; Clubb 2002). Thus, elephants with very large home ranges may possibly be similarly predisposed to develop stereotypies in captivity (discussed fully in Chapter 10). Anecdotal evidence from Garaï (1994) also suggests that elephants do prefer larger enclosures: when African elephants that had been translocated to a new area were given a choice between a pen ($625m^2$) and a paddock ($15000m^2$), they chose the larger of the two.

A further concern regarding small enclosures is that they are not large enough to allow individuals ever to avoid aggressors and/or dominant animals. For instance, Wiedenmayer (1995) states that small enclosures do not allow subordinate elephants to withdraw from threats and aggressive attacks. This is a known welfare problem for a range of species (e.g. Mendl & Held 2001), and given the problem with aggression in some elephant groups, this is likely to affect their welfare (see Chapter 10).

A lack of exercise is of concern due to the possible effect on elephant body weight and thus their health (see '*Diet*' section). Only two studies appear to have quantified the exercise obtained by zoo elephants in terms of the distance travelled over the course of the day. Schmid (1993) reports that the average distance travelled by six African zoo elephants was 3km. This only covers the time that elephants were housed outdoors, which was for 8.7 hours per day. Reimers *et al.* (2001) quantified the locomotion of six African females held in Vienna Zoo and found that they travelled an average of 3.1km (range 2.9 - 5.9km) between 0800 and 2000. It is not known whether these are typical values for zoo elephants, which would require further study, however the data reported by Reimers *et al.* (2001) were collected following major changes in the enclosure size, design and husbandry, specifically designed to increase movement. Notably, these elephants were not chained at night and were free to move between indoor and outdoor enclosures at all times. Also, distance travelled daily by Asian zoo elephants has not been quantified. The figures reported in these studies are still far lower than the distance travelled reported for wild African elephants, which is 12km per day on average, but sometimes as much as 17.8km (see Chapter 2).

Landscaping: structural enrichments

Hard, unyielding surfaces such as concrete and tarmac have been associated with foot and joint problems. Such substrates can also be slow to dry, another problem associated with foot infections (reviewed in Chapter 8). Conversely, elephants held in large enclosures with natural substrates are reported to have very healthy feet, despite having severe foot problems when they were held in conventional zoos (Buckley 2001).

The importance of having access to substrates that allow elephants to care for their skin, including dust-baths, wallows and scratching posts, is stressed by both the EAZA and AZA. Elephants have been reported to make their own mud wallows, and thus simply providing a suitable substrate may be sufficient (Daniel 2000). The digging required to making the mud wallows is also likely to be beneficial for foot health (Roocroft & Oosterhuis 2001). These benefits have yet to be quantified in zoo elephants, for instance whether elephants with access to these enrichments have healthier feet and skin, yet anecdotal evidence suggests this is the case (see Chapter 8), and wild elephants partake in these activities on a daily basis (McKay 1973; Moss 1988).

Access to water is also considered very important for elephants in zoos. Elephants in the wild bathe at least once a day (e.g. McKay 1973), and those in extensive systems are also bathed every day (Gadgil & Nair 1984). This is thought to improve skin health (see Chapter 8) and allow elephants to cool down in hot weather (e.g. Shoshani & Eisenberg 1982). It may be important to provide a additional water source for drinking, as it has been suggested that elephants will not use a pool for both (Adams & Berg 1980).

Diet

The data presented in this chapter revealed that most zoo elephants are not receiving a balanced diet. Inappropriate diet has been linked a significant number of health problems, and even several deaths of zoo elephants (Kaufman 2001). Overfeeding and deficiencies in various nutrients (e.g. calcium and vitamin E deficiency) have been linked to mortality, as well as foot and skin problems and various diseases (see Chapter 8).

There are several other potential problems regarding diet. First, the use of relatively high quality feed (compared to the diet of elephants in the wild) and the use of concentrate commercial diet means that food is consumed within a short space of time. Elephants are adapted to feed on coarse plant materials with a relatively low nutrient content and consequently spend a high proportion of their active time foraging in the wild (McKay 1973; Eisenberg 1981). Thus in zoos, a large amount of time which would be spent feeding in the wild is freed up (e.g. Dittrich 1976; Wiedenmayer 1998; Mason in press). The lack of sufficient stimulation of foraging activity is thought to be one of the main factors underlying the performance of stereotypies in captive ungulates (Dittrich 1976; Oftedal *et al.* 1996), discussed further in Chapter 10. Browse is used by some zoos as a supplement to the diet, which also provides enrichment due to the large amount of time and manipulation required to consume it. The AZA recommends that fresh browse is provided for these reasons, but do not state the frequency (AZA 2001), and many zoos find it extremely difficult to obtain the large quantities of fresh browse required, depending on their location and climate.

Second, most of the zoo diets examined had excessive fat contents. A survey by Kurt & Kumarasinghe (1998) of the weight of Asian females held in four European zoos revealed that they were between 31 and 72% heavier than similarly sized wild elephants, with some individuals 180% heavier. The data from this study, presented in Table 10, reveals that both groups of zoo elephants (trained vs. not-trained) had significantly higher body weights compared to wild elephants of the same age (trained: $t = -5.02$, $n = 6$, $p < 0.001$; not-trained: $t = -16.92$, $n = 4$, $p < 0.0001$), and also circus elephants (trained: $t = 4.57$, $n = 6$, $p < 0.01$; not-trained: $t = 10.21$, $n = 6$, $p < 0.01$). The largest difference can be seen in the youngest females (11 to 15 years of age). In addition, the group of elephants that were trained on a regular basis had significantly lower body weights compared to those that were not ($t = 5.22$, $n = 4$, $p = 0.01$). This may relate to the exercise gained during training, which is also likely to be affected by enclosure size and the amount of time spent confined and/or chained. In addition, the circus elephants surveyed had significantly lower body masses compared to both groups of zoo elephants (trained: $t = 4.57$, $n = 6$, $p < 0.01$; not-trained: $t = 10.21$, $n = 4$, $p < 0.01$), which may also relate to the frequency of training, as well as other factors such as diet.

Table 10. Body weight of female Asian elephants held in zoos and circuses compared to the wild.

The data below were provided by Kurt, and are summarised in Kurt (1998). Data show the average body weight of female elephants held in different facility types, compared to typical wild figures taken from Sukumar (1989) and Kurt (2001). Figures in parentheses represent body weight of captive elephants as a percentage of the average body weight of similarly aged animals in the wild.

	Body weight (kg)			
Age (years)	**Wild***	**Circuses**	**Zoos A (moderate, regular training)**	**Zoos B (not trained)**
11 – 15	1725	2174 n = 27 (126.0%)	2734 n = 22 (158.5%)	3058 n = 16 (177.3%)
16 – 20	2140	2426 n = 38 (113.4%)	3002 n = 19 (140.3%)	3757 n = 25 (175.6%)
21 – 25	2420	2772 n = 21 (114.5%)	3259 n = 12 (134.7%)	4205 n = 15 (173.8%)
26 – 30	2650 (100%)	3051 n = 16 (115.1%)	3409 n = 15 (128.6%)	4274 n = 2 (161.3%)
31 – 40	2835 (100%)	2984 n = 14 (105.3%)	3276 n = 11 (115.6%)	-
Over 40	2965 (100%)	3058 n = 16 (103.1%)	3089 n = 13 (104.2%)	-

This appears to be a particular problem for female elephants, which are not only heavier but also have a greater thorax circumference than wild elephants with the same shoulder height (Kurt & Hartl 1995). This discrepancy between the sexes can be explained by the observation that male elephants tend to use additional calories for growing taller, whilst females tend to store resources, resulting in greater relative body weights (Kurt & Kumarasinghe 1998). This does not appear to have been studied in African elephants, although due to similarities between the species, and husbandry styles in captivity, it may be assumed that this is also a problem for them.

Environmental enrichment

No-one has yet scientifically assessed the effectiveness of different forms of enrichment for elephants, for example their effect on levels of physiological stress or stereotypic behaviour. A lack of stimulation may be particularly detrimental to elephants as they are highly intelligent animals. They have relatively large brains with highly convoluted hemispheres, similar to that in humans (Sikes 1971; Eisenberg 1981; Eltringham 1982). Advanced cognitive abilities are also indicated by their long maturation period (e.g. Douglas-Hamilton 1972; Sukumar 1989); tool use abilities similar to those of higher apes (e.g. Chevalier-Skolnikoff & Liska 1993; Hart *et al.* 2001); their ability to solve discrimination tasks quickly (Chevalier-Skolnikoff & Liska 1993); and their long memories (e.g. Rasmussen 1995; Bekoff 2001). It is therefore important that the effect of different environmental enrichments be adequately assessed in zoo elephants.

Handling regimes, and in particular training methods, are discussed fully in Chapter 6.

Summary

- Elephants are currently managed using three main handling systems: free contact (hands on); protected contact, and no contact (hands off). Free contact is used in 79.7% of European zoos with female Asian elephants and juvenile males, 32.8% use no contact and 21.9% use protected contact. With bulls, 51.0% of facilities use no contact management, 41.9% use free contact, and 35.5% use protected contact. These figures include facilities that use more than one system.
- Elephants in European zoos are often held in colder, and wetter (in the case of African elephants) conditions compared to their natural environment. The effect of climate on welfare is not known, but of particular concern is very cold weather below freezing, and the amount of time elephants are confined in small indoor enclosures during adverse weather conditions.
- The EAZA recommends outdoor enclosures measure at least of 400m^2 for three animals, with another 100m^2 for each additional animal. The AZA recommends at least 167.2m^2 per elephant, with an additional 83.6m^2 for each additional elephant. These recommendations are not based on hard data and are likely affected by what is physically feasible in zoos, rather than from the viewpoint of maximal welfare. It is clear that some zoos do not meet these minimum standards, while others far exceed them. In contrast, elephants held in extensive systems have 100,000m^2, or just under, of natural habitat. Wild elephants roam over considerable distances in the wild, the minimum being between 60 to over 100 times larger than these recommended enclosure sizes.
- The use of natural substrates and enrichments such as sand, mudwallows, trees and other large objects is recommended by the EAZA and AZA. They seem important for foot and skin care, and allow the expression of natural behaviours. Pools are also considered essential for these reasons. Elephants in the wild and in extensive systems engage in these activities on a regular, often daily, basis.
- Other environmental enrichments are used in some zoos, although the actual effects on elephant behaviour and welfare are rarely rigorously assessed.
- Dry moats as a barrier are dangerous and can cause injury or death. Alternatives such as electric fencing are recommended by the EAZA and AZA.
- Minimum standards of the EAZA for indoor enclosures are 36m^2 per female and 45m^2 per male. The AZA states that each animal should have 37.2m^2, or 55.7m^2 in the case of bulls and females with calves. Data on European zoos suggest some do not meet these criteria, while others far exceed them. The effects of indoor enclosure area on elephant welfare are not known. In colder climates elephants are often confined for 16 hours or more per day, which is likely to be detrimental given the small area available and the frequent lack of enrichments indoors (e.g. pools, wallows).
- The use of hard surfaces, such as concrete and tarmac, is anecdotally associated with foot and joint problems, but for hygiene reasons, surfaces are recommended to be impervious to water and quick drying. Some facilities now use rubber mats, or poured rubber surfaces.
- Chaining occurs for routine maintenance (e.g. foot care, washing) and overnight when elephants are housed indoors. Elephants are the only zoo species managed in this way.

In the U.S.A., 48% of zoos regularly chain their elephants overnight, and an additional 13% do so occasionally, and elephants are generally chaining for 16 hours per day. No quantitative data are available for European zoos but it is believed to still be common, although not in the U.K.. The large amount of time elephants are confined is also of concern regarding the lack of exercise, and the subsequent implications for elephant health.

- A dietary survey of European zoos revealed that most were deficient in various vitamins and minerals (e.g. zinc, iron, vitamin E), while 86.8% had a fat content in excess of recommendations. In another survey of European zoos, 90% did not provide grazing opportunities within the enclosure. Elephants in the wild feed on a wide range of low quality vegetation, and elephants held in extensive systems are allowed to graze on natural vegetation. The effect of diet on elephant welfare has yet to be assessed, but the relatively short time zoo diets take to consume is of concern as this has been linked to the development of stereotypic behaviours in other species; furthermore the effects on body weight may well be a problem.
- A study found that female zoo elephants were 31 to 72% heavier than their wild counterparts. This is likely related to the high fat content of the diets and a lack of exercise due to small enclosures and long periods of confinement and/or chaining. In the same survey, elephants that were regularly trained had less of a weight problem than those that were not, but both were heavier than their wild counterparts.

Chapter

5

Social aspects of the zoo environment

In this chapter, we consider the social environment of elephants in zoos and how it could affect their welfare. We begin by reviewing the social system of female and male elephants in the wild, and then focus on the social grouping in zoos. Aspects covered include the size, age structure and sex ratio of groups in both individual facilities and the zoo population as a whole. We also consider the degree of relatedness that may exist between group members. The movement of elephants between facilities, and hence social groups is then considered. This includes the frequency of transfers, the number of individuals that are transferred together, and the age at which they are moved. We then summarise the main differences between the social environment of elephants living in zoos, extensive systems and the wild, and end by considering what impact these may have on welfare.

Elephant social systems in the wild

The degree of sociality differs to a great degree between male and female elephants, and so each sex is considered separately here. Most research has been carried out on wild African elephants, and long-term studies, which have yielded large amounts of data on social structure, have been carried out on herds living in Lake Manyara National Park, Tanzania (Douglas-Hamilton 1972) and Amboseli National Park, Kenya (Moss 1988). The behaviour of Asian elephants in the wild has received less attention, but data are reported by Laws (1975), McKay (1973), Eisenberg (1971) and Kurt (1974). The evidence suggests that the basic social structure is similar between the Asian and African species and so for the purpose of this review both species are considered together, although where research suggests a species difference, this will be highlighted. Further details of wild sociality, for example typical age structure, are given later in the chapter.

Females

Female elephants are highly social, far more so than males (Kurt 1974; Moss & Poole 1983), and have the largest social network of any mammal yet studied other than humans (Poole 2000). Adult females and their offspring live in tight-knit, stable family groups, with social ties extending from mother-offspring bonds to families, bond groups and clans (Douglas-Hamilton 1972; Moss & Poole 1983; Sukumar 1989). Families are the basic social unit with females staying in their family group throughout their lifetime (Moss & Poole 1983; Sukumar 1989). Thus families typically contain an old, experienced female (the matriarch), who leads the herd, her dependent offspring, and adult daughters with their immature offspring, including pre-pubescent males (Buss 1961; Douglas-Hamilton 1972; McKay 1973; Laws *et al.* 1975; Moss & Poole 1983; Sukumar 1989). Family units typically comprise of, on average, between six and eight individuals (range 2 - 40) in Asian herds (McKay 1973; Kurt 1974; Eisenberg 1981; Sukumar 1989; Katugaha *et al.* 1999), and four to twelve (range 2-29) in African savanna herds (Douglas-Hamilton 1972; Laws *et al.* 1975; Barnes 1983; Moss 1988; Poole & Thomsen 1989; Dublin 1996). There have been reports of solitary females, but they are rare, and usually refer to females in very poor physical condition, separated from their herd and with probably with not much time to live (Laws *et al.* 1975; Moss 1988). More details of group sizes are given in Table 12.

Family units are very stable over time, with splits occurring only rarely when groups become very large, although small sub-groups often leave the main herd for short periods of time (Moss 1988). Different family units associate in ‘kin’ or ‘bond’ groups, consisting of up to five family units (Moss & Poole 1983; Sukumar 1989), which themselves often aggregate in large ‘clans’ of sometimes hundreds of individuals, particularly during the dry season when resources are scarce, although these are less stable than family groups (Douglas-Hamilton 1972; Moss & Poole 1983; Sukumar 1989). Female elephants thus have a very extensive network of social relationships within the population, and recent research has revealed that some African matriarchs can recognise individuals from 14 families, totalling around 100 individuals, by their vocalisations alone (McComb *et al.* 2000).

Females thus remain within their natal herd throughout their lifetime and social bonds are extremely strong and long lasting between family unit and bond group members, as shown by the spatial associations and behavioural interactions between individuals (Douglas-Hamilton 1972; Moss 1988; Sukumar 1994; Poole 1999). Bonds are manifest in, for example, the group defence of young against predators, frequent social interaction and allomothering behaviour (Lee 1987; Moss 1988). Bonds are renewed through frequent contact and greeting ceremonies (Moss & Poole 1983). These ceremonies occur during reunions, and can be very intense, involving much activity, physical contact, vocalisations, and general 'excitement'. Characteristic greeting behaviours include placing the trunk tip in the mouth, on the temporal gland, or between the legs of the conspecific (Langbauer 2000). These convey the strength of the social bond between two elephants (Moss & Poole 1983; Sukumar 1994). Bonds between other members of their clan, which come into contact regularly within their shared dry season home range, are not so strong, and hence greetings are less intense.

Calves are nutritionally dependent on their mother's milk for the first 6 to 24 months (Laursen & Bekoff 1978; Shoshani & Eisenberg 1982; Dublin 1983; Lee & Moss 1986). Weaning occurs gradually over a long period of time and usually is not complete until the birth of another calf, at around three to six years of age (Shoshani & Eisenberg 1982; Lee 1986; Lee & Moss 1986). The mother-calf relationship lasts long after weaning, at least with female calves which interact more frequently with, their mothers remain in their natal herd throughout their lifetime, but calves become more and more independent as they grow and develop social relationships with other herd members (Lee 1986). Female calves maintain this strong bond as they grow, as is common among species with this type of social structure (Lee 1986); Males calves, in contrast disperse at between 10 and 15 years of age (e.g. Moss 1988; Sukumar 1989).

Female elephants also frequently show 'affectionate' mother-like behaviour to calves that are not their own, protecting and assisting them in times of distress, and occasionally allowing them to suckle (Douglas-Hamilton & Douglas-Hamilton 1975; Lee 1987; Rapaport & Haight 1987). This behaviour is widespread among many long-lived mammals, and is known as allomothering (Reidman 1982). This may form the basis of the special bonds observed between specific herd members (Gadgil & Nair 1984; Moss 1988). Captive elephants that are unrelated and approximately the same age also appear to be capable of forming similar special relationships (Garaï 1992).

Males

Research on male elephants paints a very different picture (Poole 1982; Sukumar 1994). Male calves become more independent and at an earlier age compared to females, for example moving farther away from their mother and interacting with her less compared to female calves of the same age (Lee 1986). As with females, weaning occurs between the ages of three to five years (Shoshani & Eisenberg 1982; Lee 1986; Lee & Moss 1986). However, independence then increases between the age of four and six years when, unlike female calves, they begin to move between different bond groups (Eisenberg *et al.* 1971; Desai & Johnsingh 1995; Poole 1999). When sexual maturity is reached, between the ages of nine and fifteen, they tend to drift away from the clan and disperse to establish their own home range (Eisenberg *et al.* 1971; Douglas-Hamilton 1972; Moss 1988; Sukumar 1989; Desai & Johnsingh 1995; Poole 1999). Some authors report that males are forcibly expelled from the group by the matriarch (e.g. Sikes 1971; Douglas-Hamilton 1972), but others state that males appear to initiate their own departure (Lee 1986).

Although they tend to remain around the periphery of the herd with other young males for a number of years (Moss 1988), and may frequently associate with females (Poole 1982; Sukumar 1994), it is not until they reach the age of approximately 25 years of age that they generally show the patterns of association that characterise mature adult males (Moss 1988; Poole *et al.* 1988; Desai & Johnsingh 1995). Once males have become independent, the nature of social interactions with other elephants depends largely on their sexual state. When not sexually active, males either roam around alone or associate together in bull groups. These typically contain two to four males, although aggregations of up to 25 have been reported (Sukumar 1989; Kurt 1974; McKay 1973; Douglas-Hamilton 1972; Laws 1975; Moss 1988; Dublin 1996; Barnes 1983; see Table 12). Males that regularly associate in small bull herds greet each other, although in a more restrained manner than females, by touching each others' mouths, smelling each other and sometimes gently sparring (Moss & Poole 1983; Sukumar 1994). The degree of sociality and strength of social bonds shown by bull elephants are still relatively unknown. Some authors believe that males do not form any long-term bonds with other males, and aggregate in a random fashion (e.g. Laws & Parker 1968; Croze 1974). However, some males do spend a great deal of time with one another (over 30% of observation time) and do so consistently from one year to the next. This suggests that at least some males do develop strong associations (Moss & Poole 1983). The genetic relationship between these individuals is as yet unknown, but Moss (1983) suggests from her observations that they may be related males.

Sexually active males display distinct behaviour patterns, roaming extensively in search of oestrus females (Eisenberg & Lockhart 1972; Jainudeen *et al.* 1972a; Moss 1988). These males are usually in musth and show greatly heightened aggression towards other males, as well as inanimate objects and humans (Jainudeen *et al.* 1971; Hall-Martin 1987; Moss 1988; Poole 1989b; Kurt & Touma 2001). Musth males are thus found either alone, or in association with family units that usually contain at least one oestrus female (Eisenberg & Lockhart 1972; Jainudeen *et al.* 1972a; Poole 1987). Once they fall out of musth, they go back to the normal pattern of mixing with other males in bull herds or roaming around alone.

Group size in zoos

> "4.5 Animals of social species should normally be maintained in compatible social groups. They should only be kept isolated for the benefit of conservation and welfare needs of the group, and where this is not detrimental to the individual specimen."
>
> Secretary of State's Standards of Modern Zoo Practice
> (DETR 2000)

The AZA recommends that facilities should hold at least three females whenever possible and state that all new enclosures have this capability (AZA 2001). However, they also state that "It is recognized that some socially aberrant adult females currently exist and these elephants can be managed singly if the institution has made every effort to introduce them to a social group and the SSP agrees that the anti-social behavior is not correctable." Roocroft & Zoll (1994) in contrast recommend that a herd size of at least six females is necessary to meet the social needs of elephants. With males, the AZA accept that they can be housed singly, but recommends they should have the ability to hear, smell, see and/or touch other elephants (AZA 2001).

Methods

Aspects of the social situation in zoos are reviewed and discussed in this section and compared to the social system in the wild. Data from the EEP studbooks provided data on group size and the structure of the population that was living in European zoos by 1st September 1999 (Asians) and 2001 (Africans).

Results for group size and structure in zoos

Group size

Data on group size were available for 112 facilities, most of which housed each species separately (72 housed Asians, 37 housed African). Out of a total of the 72 facilities with Asian elephants, most housed three individuals or fewer (61.1%), as did two of the three facilities that housed Asians and Africans together. Most of the 37 facilities with Africans housed four elephants or fewer (59.5%). The modal (i.e. most common) group size in facilities with Asian or African elephants was two females and zero males, found in 18.1% facilities with Asians and 13.5% that housed Africans (see Table 11). Most facilities that housed males only had one. Group size ranged from a solitary male (4.2% facilities with Asians, 8.1% with Africans) or female (13.9% facilities with Asians, 8.1% with Africans) up to 15 Asian elephants (5 males, 10 females) in Emmen Zoo in the Netherlands, and 16 Africans (5 males, 11 females) in Howletts Zoo Park in the U.K.

Table 11. Social groupings in European zoos

The EEP studbooks yielded data on the number of elephants held in each facility. Facilities that kept both species were only included if they replied to our enquiry asking whether they housed both species in the same enclosure. Those that did are included in the 'both species' category below. It should be noted that these data do not account for the fact that some elephants may be housed individually, which is likely to be the case for adult males, and so these represent maximum group sizes.

No. males	No. females	Asians		Africans		Both housed together	
		No. zoos (%)	No. ind. (%)	No. zoos (%)	No. ind. (%)	No. zoos (%)	No. ind. (%)
0	1	10 (13.9)	10 (4.0)	3 (8.1)	3 (1.7)	0	0
	2	13 (18.1)	26 (10.4)	5 (13.5)	10 (5.7)	1 (33.3)	2 (20.0)
	3	5 (6.9)	15 (6.0)	1 (2.7)	3 (1.7)	1 (33.3)	3 (30.0)
	>3	7 (9.7)	35 (13.9)	3 (8.1)	14 (8.0)	1 (33.3)	5 (50.0)
1	0	3 (4.2)	3 (1.2)	0	0	0	0
	1	7 (9.7)	14 (5.6)	4 (10.8)	8 (4.6)	0	0
	2	5 (6.9)	15 (6.0)	3 (8.1)	9 (5.2)	0	0
	3	5 (6.9)	20 (8.0)	5 (13.5)	20 (11.5)	0	0
	>3	8 (11.1)	47 (18.7)	5 (13.5)	25 (14.4)	0	0
2	1	1 (1.4)	3 (1.2)	0	0	0	0
	2	0	0	0	0	0	0
	3	2 (2.8)	10 (4.0)	0	0	0	0
	>3	3 (4.2)	29 (11.6)	5 (13.5)	39 (22.4)	0	0
3	2	1 (1.4)	5 (2.0)	0	0	0	0
4	>8	1 (1.4)	13 (5.2)	1 (2.7)	15 (8.6)	0	0
5	1	1 (1.4)	6 (2.4)	0	0	0	0
	>6	0	0	2 (5.4)	28 (16.1)	0	0
TOTAL		72	251	37	174	3	10

The group sizes found here are similar to those reported by other authors for the European and North American zoo populations (see Table 12). Schulte (2000) reports that the most common grouping in North American facilities is one Asian female or two African females, with no males. A similar range of group sizes was found by Taylor & Poole (1998) in their survey of European and North American zoos, ranging from 3 (1 male:2 females) to 15 (3 males:12 females), and Schulte (2000) also reports that 57.5% and 75% of facilities that housed Asian and African elephants, respectively, housed three or fewer females and no males.

Table 12. Group size of elephants in zoos, extensive systems and in the wild

Data on group sizes, taken from a range of sources, are shown in the table below as a means of comparison between zoos, extensive systems in Asia and herd sizes of free-living elephant populations.

Location	Species	Modal group size (m:f)	Range (m:f)	Location	Ref
Zoo	Asian	2:0	0:1/1:0 - 5:10	Europe (1902 - 1999)	1
		2:0	-	North America	2
		-	1:2 - 1:10, 2:4 - 2:7	Europe & North America (sample of 20 zoos)	3
	African	0:1	0:1 - 5:11	Europe (1960 - 2001)	1
		0:1	-	North America (years?)	2
Extensive system	Asian	3:4 or 4:3 when not working	c. 1,220 - 1,633 in total*	Timber camp, Burma	3
		Mixed working groups	31:20*	Timber camp, India	3
		23:31	23:31	Orphanage, Sri Lanka	3
Wild	Asian	Mixed herd†: 6 - 8 Bull herd‡: 2 - 3	Mixed herd†: 2 - 40 Bull herd‡: 2 - 25	India, Sri Lanka, Ceylon	4
	African savanna	Mixed herd†: 4 - 12 Bull herd‡: 2 - 3	Mixed herd†: 2 - 29 Bull herd‡: 2 - 11	Tanzania, Uganda, Kenya	5
	African forest	Mixed herd: 3.5 - 5.0 Bull herd: 1 - 2.3	Mixed herd: max. 8 Bull herd: min 1	Central African Republic, Gabon, Congo	6

*Mixed group; †Family unit containing females of all ages and pre-pubescent males; ‡ Group of adult males that form loose associations. References: 1- This report (data from EEP studbooks); 2 - (Schulte 2000); 3 – (Taylor & Poole 1998); 4 - (McKay 1973; Kurt 1974; Eisenberg 1981; Sukumar 1989; Katugaha *et al.* 1999); 5 - (Douglas-Hamilton 1972; Laws *et al.* 1975; Barnes 1983; Moss 1988; Poole & Thomsen 1989; Dublin 1996); 6 - (White *et al.* 1993; Turkalo & Fay 1995; Querouil *et al.* 1999).

It is not possible to tell from the studbook data how large actual group sizes were, as some individuals, particularly adult males, are likely to be kept separately from the others within the same facility. For example, Schulte (2000) found that out of fifteen North American facilities that housed more than one male of either species, ten did not allow any physical interaction in the same area, although some were able to see, smell and/or touch others through barriers. Taylor & Poole (1998) also surveyed a sample of European and North American zoos, and found that males were always kept separately from females. Thus, it can be assumed that the majority of facilities that house males keep them separate from females.

In contrast to these findings, Taylor & Poole (1998) looked at extensive systems in Asia and found that elephants were kept in large mixed groups of between 51 to almost 3000, although in one timber camp this was reduced to groups of seven when they were working (see Table 12). This is more akin to the social system in the wild, where, as mentioned at the beginning of this chapter, family units contain between six and eight Asian elephants, or four to twelve African elephants. Female elephants in European zoos are therefore kept in far smaller groups compared to the wild and extensive systems. A solitary state is far more common in wild adult males (see section on male '*Elephant social systems in the wild*'), but they are also often observed in all male groups when not sexually active, a situation which is not replicated in zoos.

Sex ratio in zoos in comparison with the wild

There is a bias towards housing females for both species, as only 51.4% of facilities with Asians and 67.6% with Africans housed male elephants, and considering only those that house sub-adult and adult males (over 15 years of age) this reduces to 37.5% and 43.2% of facilities with Asians and Africans, respectively. Taking the European population as a whole, the sex ratio was 1:4.5 for Asian elephants and 1:3.4 for Africans. Considering only elephants that would be considered to be adults in the wild (i.e. over 15 years according to Sukumar 1989), the sex ratio for the entire population is 1:6.6 for Asians and 1:5.4 in Africans. This estimate is less extreme than the 1:10 proposed by Kurt (1995) for Asian elephants held in European zoos and circuses, but still highlights the lack of adult males in the population (see following section). The difference in these estimates may be due to the increase in captive breeding success in the last five to ten years, which has introduced more males into the population (see Chapter 9).

In facilities that did house males (51.4% that held Asians, 67.6% with Africans), the most common modal number held was one, although some held as many as five (Asians: Emmen Zoo; Africans: Howletts Zoo Park and Ramat Gan Zoological Centre in Israel). In zoos that housed both sexes, the average (median) sex ratio was 1:4 for both Asian and African elephants.

In extensive systems, Taylor & Poole (1998) report a sex ratio of 1:0.6 females in an orphanage and 1:1.3 females in timber camps (see Table 12). However, Kurt (1995) reports a sex ratio of 12:5 for elephants in camps in Kerala. The ratios reported by Taylor & Poole (1998) are similar to the sex ratio found in the wild, which is roughly 1:1 in undisturbed populations (e.g. Douglas-Hamilton 1972; McKay 1973; Kurt 1974; Njumbi 1995; Katugaha *et al.* 1999), although ratios can become greatly skewed towards females due to selective poaching (WWF 2000). Thus, although females constitute a far greater proportion of the zoo population than males, this is not unheard of for wild populations. In addition, males tend to suffer higher mortality in difficult times, such as during droughts, which can also affect sex ratios (Moss 1988).

The predominance of females in zoos is largely due to the practical problems and financial constraints of housing adult males, which are so notorious for becoming unmanageable and aggressive (Schulte 2000), that zoos have so far imported primarily females. Given that most zoos in Europe do not currently have the facilities to house adult bulls (Amelia Terkel, pers. comm), this will pose a serious problem if captive breeding success continues to increase, as the sex ratio at birth is approximately 1:1 (see Chapter 9). As yet, although zoos are aware of the impending problem, nothing has been planned for the future (Amelia Terkel, pers. comm), but unless something is done within the next few years, there will soon be more bulls than suitable facilities.

Age structure of the zoo population

Data were available for a total of 271 Asian elephants (50 males, 221 females) and 195 African elephants (43 males, 152 females). The structure of elephant populations in European zoos, in terms of age and sex, are compared with data from wild populations and a population of Asian elephants living in an extensive system in the following sections.

Age structure of the Asian elephant zoo populations compared to extensive systems

Kurt (1974 and 1995) provided data on the structure of an Asian elephant population in a timber camp (extensive system) in Tamil Nadu, India. Data were not provided in full and so figures were estimated from the histograms given in this text. The age classes used by Kurt differ somewhat to those used for the zoo population, and for the sake of simplicity, we split the number of males and females equally between years when age classes overlapped. For example, data on the number of elephants that were 20-30 years old were split equally between the age classes 20-24 and 25-29 (see Figure 4).

Comparison of the Asian population held in European zoos with a captive population kept in an extensive system (timber camp) revealed several differences (see Figure 4). Infants under five form a far smaller portion of the zoo population (8.7%) compared to the extensive system, where infants are the most common age class present (15.1%). Within individual zoos, only 18.1% of facilities held infants (9.7% with males, 12.5% with females), and 27.8% had individuals under 10 years (20.8% with males and also females), which include 15.9% of the total zoo population. This is similar to Taylor & Poole's (1998) sample of European and North American zoos. They found that only 30% had young males (0-10 years of age) and 15% had young females in the group. Similarly, data presented by Schulte (2000) show that only

12.6% of the Asian population in North American zoos were less than, or equal to, 10 years of age.

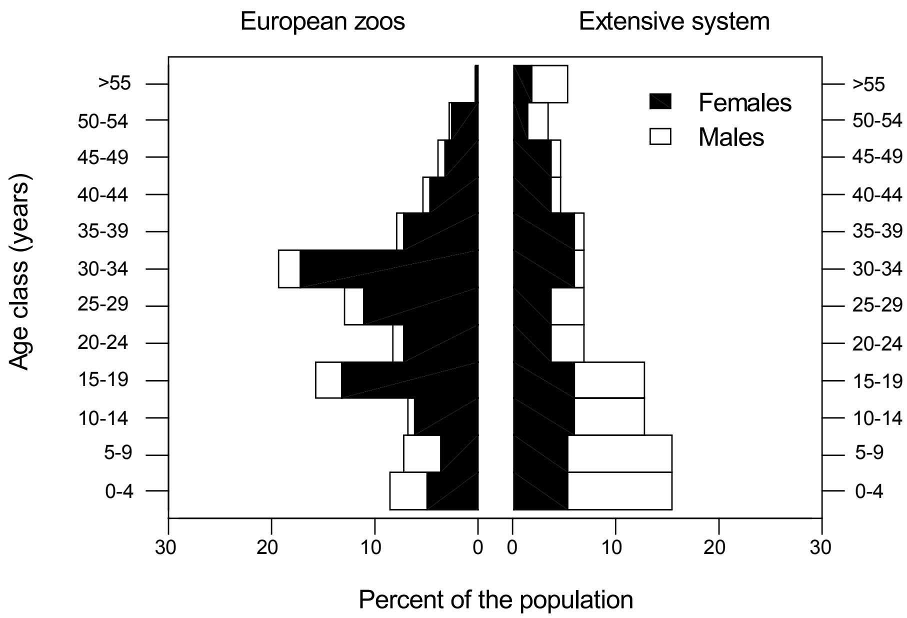


Figure 4. Age structure of Asian elephants held in European zoos compared to those in an extensive system in Asia

The graph above shows the composition of the current population of Asian elephants held in European zoos, as listed in the 1999 EEP studbook. The structure of a typical population in an extensive system in India (Tamil Nadu timber camp) was taken from Kurt (1995).

In the zoo population, the most common age group in females was between 30 and 34 years (17.3% of the total population). However, the age classes 0 - 4 and 5 - 9 years held the greatest number of males, each with 3.6% of the total population (see Figure 4). As already mentioned, elephants in the extensive system were mainly under 10 years of age.

Zoos have a smaller proportion of males in almost all age classes compared to the extensive system. Overall, males constitute nearly half of the population in the extensive system (49.5%) whereas they only make up 18.1% of the entire zoo population. There are also far fewer older male elephants in the zoo population compared to the extensive system (see Figure 4). Adult bulls (over 15 years of age according to Sukumar 1989), comprised just 10.1% of the zoo population, compared to 22.8% in the extensive system. Males in this age group were housed in 37.5% of facilities with Asian elephants, and almost all of these only housed one, with the exception of Port Lympne Zoo Park in the U.K.

Similarly, only 9.5% of the zoo population consisted of adult bulls (over 15 years), compared to 18.5% of the extensively held population. Most striking of all, however, was the lack of bulls over around 34 years of age in zoos (see Figure 4). These made up 8.5% of the population in the extensive system, compared to 2.5% in zoos. The latter were restricted to just eight zoos (11.1% of facilities), whereas 55.6% of facilities housed females in this age group. In contrast, old females made up a larger portion of the zoo population (25.1%) than extensively held elephants (15.7%).

Age structure of the Asian and African elephant zoo populations compared to wild populations

Kurt (1974, 1995) also provided data on the structure of Asian elephant populations in the wild, based on field observations of an undisturbed population in Sri Lanka. The same procedure described at the beginning of the previous section was used here to split Kurt's data into similar age classes as the zoo data. Data for a typical population of wild African elephants were taken from Njumbi (1995) who summarises data on the Amboseli National Park population in Tanzania, which is a relatively undisturbed population. A similar system was used in cases where age classes overlapped.

Similar differences were found between the age structure of the elephant zoo populations compared to wild populations (see Figure 5a). Infants (under five years of age) were by far the most common age class in the wild populations and comprised a far greater portion compared to zoos for both Asian (29.1% cf. 8.7%) and African elephants (23.2% cf. 10.8%). Infants were only held by 18.1% of facilities with Asians (9.7% with males, 12.5% with females), and 27.0% with Africans (18.9% with males, 16.2% with females). Asian elephants under 10 years of age constituted 15.9% of the total zoo population, and were found in 27.8% of facilities (20.8% had males and also females). Young African elephants under 10 years of age were found in 32.4% of facilities (24.3% had males and/or females) that held this species, and made up 16.9% of the total zoo population (see Figure 5b). This is much higher than the figures reported by Schulte (2000) for the North American zoo population, which showed that only 1.6% of the African population was less than, or equal to, 10 years of age.

Rather than infants, the most common age class in the zoo population was 30 to 34 years in the Asian elephant (17.3% of the population, see Figure 5a and the previous section) and 15 to 19 years in the African both overall (25.6%) and also separately for males (6.2%) and females (19.5%, see Figure 5b). As in the previous section comparing zoo data with extensive systems, the Asian zoo population contained fewer mature males compared to those in the wild. Bulls over 15 years of age, which were found in 37.5% of facilities, made up 10.1% of the zoo population compared to 22.75% of the wild population (see previous section for more details). Figures for adult bulls (over 22.5 years, see previous section) were more similar, as they comprised only 9.5% of the wild population and 6.9% of the zoo population (found in 25.0% of facilities).

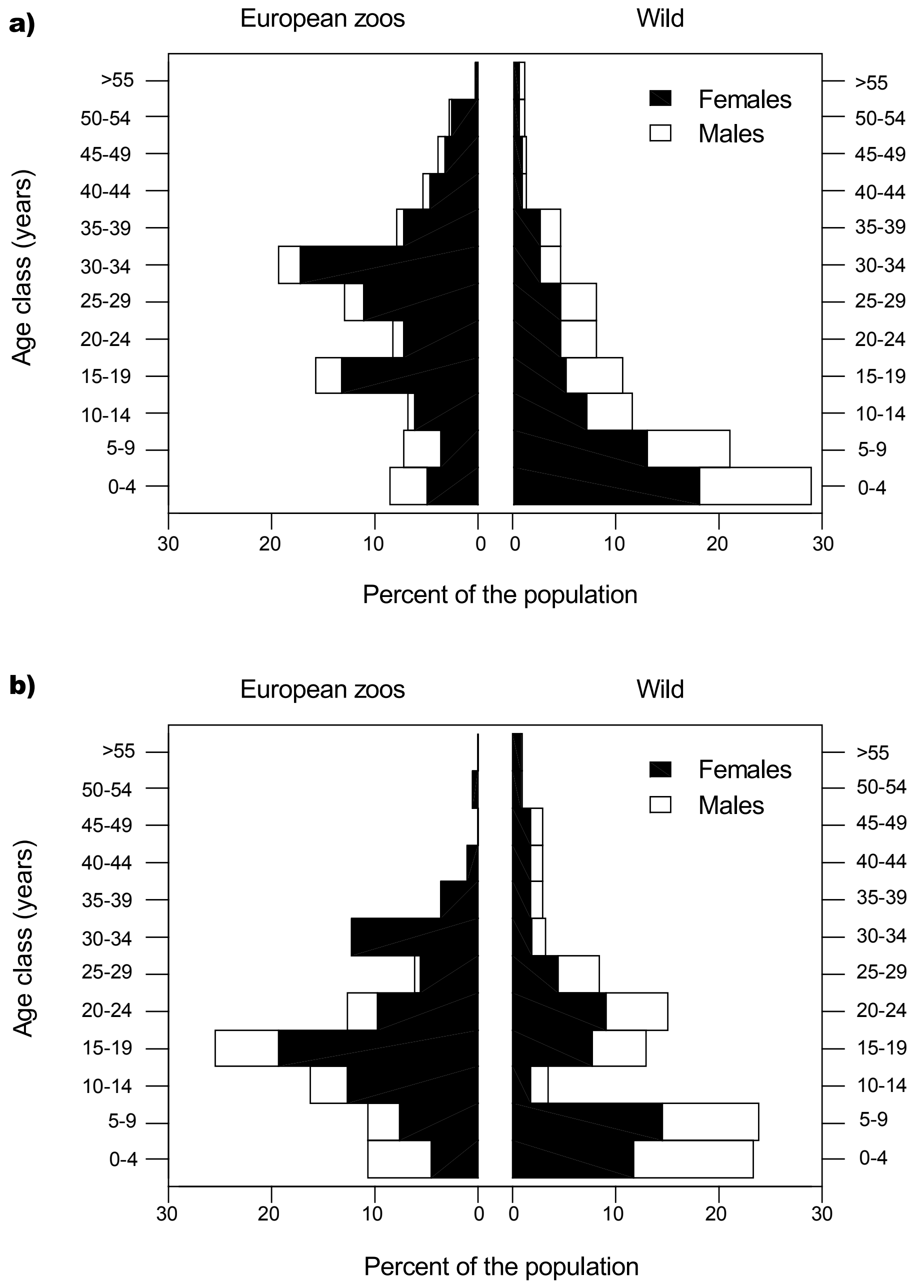


Figure 5. Age structure of a) Asian and b) African elephants held in European zoos compared to a wild population

Data on the composition of the current Asian elephant zoo population in Europe were taken from the EEP studbooks. Data for typical wild populations were taken from Kurt (1974 and 1995) and Njumbi (1995), for Asian and African elephants, respectively.

Again, males constitute a small proportion of the population in both Asians (18.1%) and African (22.6%) zoo elephants, compared to wild populations (Asians: 42.0%, Africans: 42.5%). Asian males over 15 years of age are found in 38.9% of facilities that house this species, yet they only comprise 10.1% of the total population. Bulls of this age make up 22.8% of the population in extensive systems, and 18.5% in the wild. Over half of facilities that house African elephants have a male over 15 years of age, but again they only comprise a small portion of the total population (9.7%), compared to 20.1% in the wild. This is because most facilities only hold a solitary bull once they reach sexual maturity, which occurs at around this age (see Chapter 9). Only two facilities held more than one bull over 15 years of age (Howletts Wild Animal Park in the U.K., with two bulls, and Parque de la Naturaleza de Caberceno, with three).

Older females, over 34 years of age, comprise a slightly larger portion of the Asian population compared to the extensive system (18.0% cf. 15.7%), and far more than in the wild (5.0%). Whereas the proportion of African females in this age group are similar in zoos (5.1%) compared to the wild (6.9%). Asian males over 34 years of age comprise a slightly greater portion of the population in zoos (17.0%) compared to the both the extensive (8.5%) and wild population (4.0%), yet these represent only 13 zoo males. The oldest living African male at this time was only 27 years old, and only eight females in this data-set were 34 years or above (4.1% of the population). African zoo elephants over 34 years made up 10.5% of the population (3.7% males and 6.9% females).

Age and sex structure of individual zoo groups

The age structure within individual groups mirrored this pattern. Individuals held by each zoo were categorised into one of four age classes based on the system used by McKay (1973). Data were provided in the form of graphs, and therefore there may be a slight degree of error in the precise cut-off points between each category. Categories differed slightly for males and females and were as follows: infants (both sexes: 0-3 years); juveniles (males: 3.1-15 years; females: 3.1-12 years); sub-adults (males: 15.1-22.5 years; females: 12.1-20 years); and adults (males: >22.5 years; females: >20 years). This gave an idea of the age-span represented within each group.

Overall, the results show that the most common age class in zoo groups was adults, followed by sub-adults, juveniles and finally infants (see Table 13). The average (median) number of age classes represented within each zoo was one (range 1-4), found in 65.9% and 44.5% of facilities that housed Asian and African elephants, respectively. The majority of these were adult elephants, almost exclusively in the case of the Asian elephant, but sub-adults were almost equally as common in the African elephant (see Table 13). Only three facilities (3.7%) that housed Asian elephants and five (10.6%) that housed Africans had a group with representatives from all four age classes.

Table 13. Range of age classes held in individual European zoos

Data from the EEP studbooks were used to look at the age structure of groups within individual zoos. This therefore assumes that elephants held in the same zoo were also housed together, and so these data probably overestimate the number of age classes represented in social groups. Figures in parentheses represent the data as a percentage of all facilities, but due to the nature of this measure, facilities may be represented more than once, and so percentages do not add up to 100. See text for definitions of each age class.

Species	Age class	No. facilities with at least one elephant within each age class	No. facilities with only this age class
Asian	Infant	8 (9.8)	0
	Juvenile	18 (22.0)	2 (2.4)
	Sub-adult	28 (34.1)	4 (4.9)
	Adult	71 (86.6)	48 (58.5)
African	Infant	8 (17.0)	0
	Juvenile	19 (40.4)	2 (4.3)
	Sub-adult	32 (68.1)	6 (12.8)
	Adult	36 (76.6)	7 (14.9)

Degree of relatedness between group members

The majority of elephants currently held in zoos have been captured from the wild or imported from Asian timber camps (see Chapter 3). It may be possible that some of these individuals are related in some way, but this would be impossible to determine without comprehensive genetics research. The history of elephants born in captivity is, however, recorded in studbooks, including the identity of the sire and dam. It would thus be possible to trace back individual histories for captive born elephants to build up a web of the genetic relationships between some of the individuals housed together, and hence determine the degree of relatedness between these individuals in each group. This is beyond the scope of this review, but it was possible to look at the origin of elephants in each facility, and determine whether or not captive born elephants were kept in the same group as their mother.

Data from the studbooks show that 20 facilities (17.7%) had a group containing the mother of at least one other member of the group. Eighty-four facilities (74.3%) held elephants whose mothers had either been caught from the wild, imported from Asia or were of unknown origin. It is likely that most of these were unrelated to other members of their group, given the range of different origins and the number of transfers that have probably gone on in the group's history. This is very different to the situation in the wild for female elephants, which stay in their family unit throughout their lifetime (see the beginning of this chapter). However, there have been observations of unrelated elephants forming functional herds in the wild (Poole pers. comm., cited in Schulte 2000). This is an area that requires further research, not only to determine the relationship between group members, but also the possible effect this could have on individuals.

Changes in group composition

Elephants are often moved between zoos, either permanently or for 'exchanges' of varying lengths for breeding purposes (Schulte 2000). Data from the studbooks were used to investigate how often this occurs, the age at which elephants are transferred, and the number transferred together. This excludes initial transfers from the wild, but includes all transfers out of European zoos to other facilities. The studbooks cover only the population in European zoos, and therefore it does not have details of transfers that occur after an individual has left Europe.

Transfer frequency

The majority (70.0%) of Asian elephants were not transferred between facilities after their initial arrival into a European zoo (see Figure 6a), and this was true of both males and females (67.8% males; 70.7% females). Similarly, 62.9% of African elephants had not been moved between facilities (58.7% males; 64.1% females, see Figure 6b). A total of 99 (19.1%) Asians and 63 (31.2%) Africans had been transferred once, and a small proportion had experienced two or more moves (10.8% Asians; 5.9% Africans), including some Asian females that had been transferred four to five times. Females are usually transferred between facilities for breeding purposes, but this is not reflected in the data.

A correlation analysis was carried out to determine whether there has been any trend in the number of transfers over the years. A Pearson's correlation showed an increase over the years ($r = 0.081$, $p = 0.049$, $n = 722$), which appears to be due to an increase within the past 30 years (see Figure 7).

These data support the findings of Ryan & Thompson (2001), who note that the North American population of Asian and African elephants experience relatively few transfers per year (18-30 African, 10-66 Asian) compared to other, smaller, species managed through Species Survival Plans, and a similar frequency to that of the western lowland gorilla population. This is nevertheless in excess of what would occur in the extensive systems or in the wild, where females generally remain in the same social group and location throughout their lifetime.

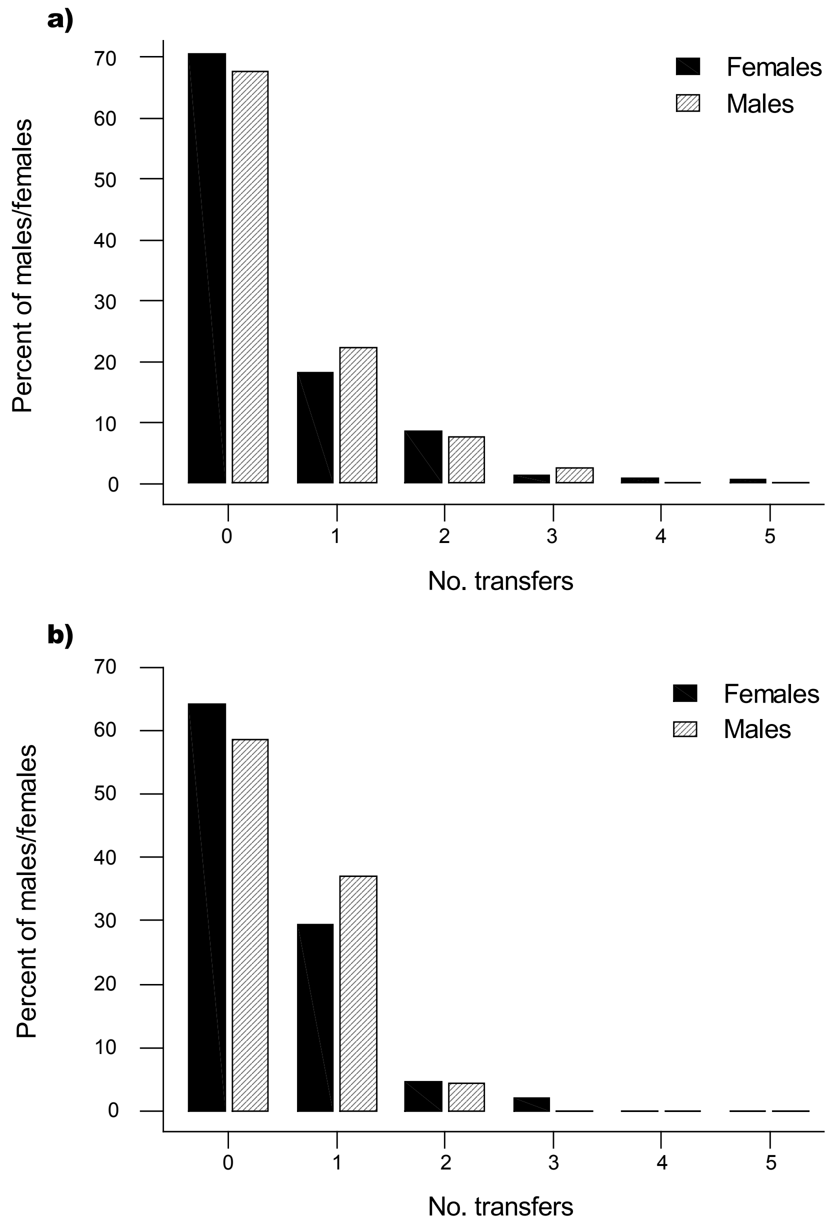


Figure 6. Number of transfers experienced by a) Asian and b) African elephants held in European zoos

The total number of transfers experienced by individual African elephants within European zoos are shown above. These data do not include initial transfers from the wild or Asian countries, nor elephants moved to non-studbook facilities.

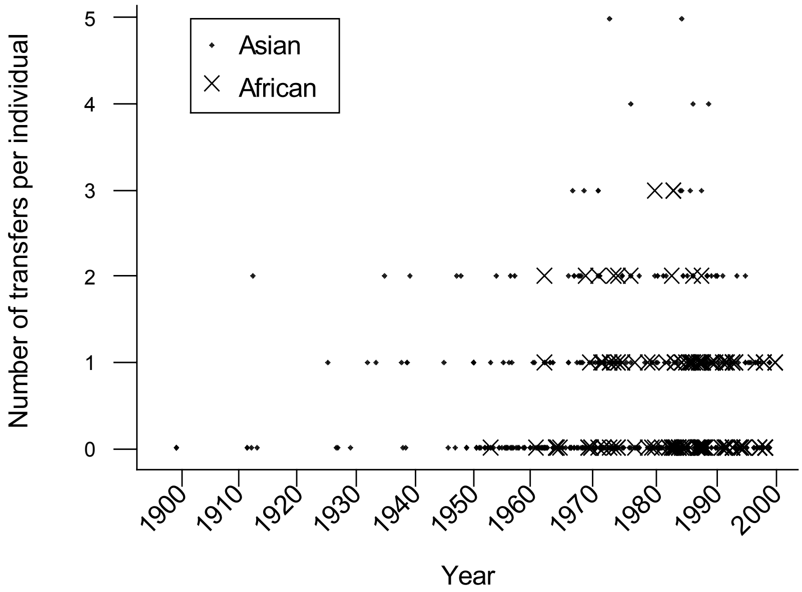


Figure 7. Number of transfers experienced by elephants held in European zoos over the years

Analysis revealed that there has been a significant increase in the number of transfers experienced by individuals over the years. This appears to be largely due to an greater number of transfers over the past 30 years.

Group size at transfer

Information from the studbooks also yielded data on the number of elephants that were transferred together. Group size was determined by the date of transfer and destination listed in the studbooks. Data were available for a total of 194 Asian elephant and 65 African elephant transfers, where one transfer describes the event which may involve a variable number of elephants. The median group size per transfer was one (range 1 - 6), showing that most elephants were transferred alone (Asian: 90.2%; African: 76.9%). A total of 7.7% Asian and 16.9% African elephant transfers involved a pair, and only 4.1% (Asian: 2.1%; African: 6.2%) involved three or more elephants. See Figure 8.

Age at transfer

Details of transfers, including age and group size, were of interest from a welfare point of view, as this information could yield data on the age at which calves were removed from their mother. The AZA recommend that the minimum age this should occur is three years especially for females (AZA 2001). This issue is important as research on a range of other species, discussed fully in the next section, has shown that premature separation from the mother can be highly stressful, and the effects can persist throughout an individual's lifetime.

Results show that most transfers occurred when elephants were under 10 years old, for both species (69.7% Asians, 79.2% African transfers, see Figure 9). The median age when Asian elephants were transferred was 4.9 years (range 0-50) for females and 4.8 years (range 0-27) for males.

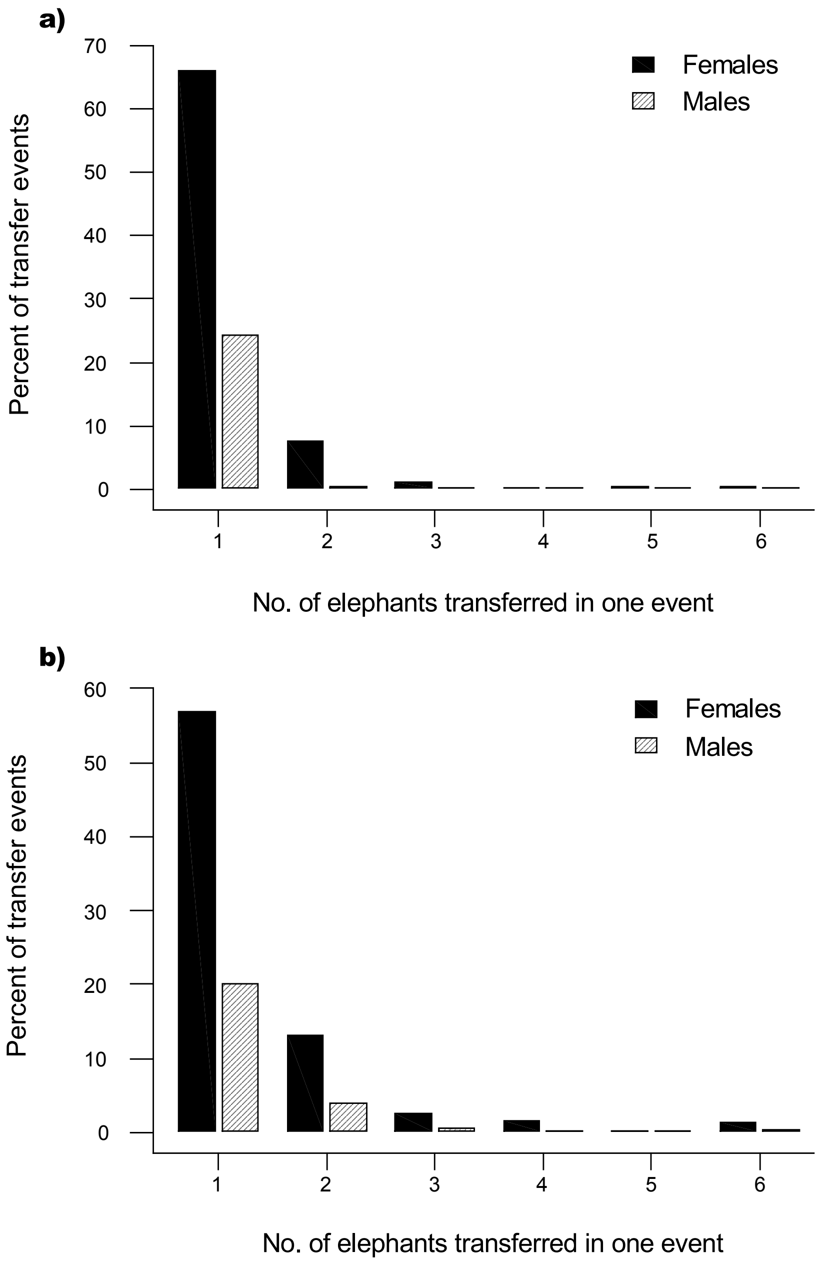


Figure 8. Group size at transfer for a) Asian and b) African elephants held in European zoos

The figure above shows the how many Asian and African elephants were transferred together during each 'transfer event', which could involve more than one elephant. These data include all transfers and therefore individuals will be represented more than once if they experienced more than one transfer.

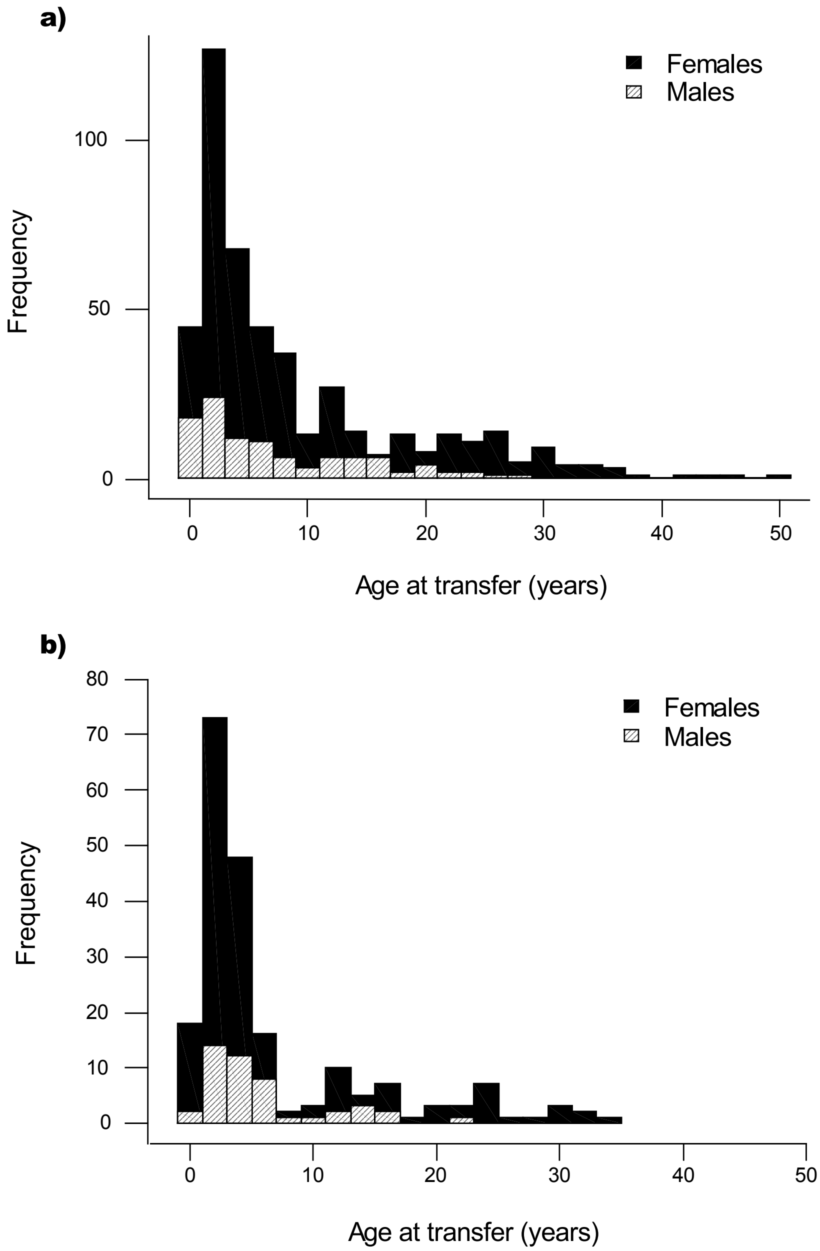


Figure 9. Age at transfer for a) Asian and b) African elephants held in European zoos

The age of elephants when they were transferred was calculated. These data include all transfers and therefore individuals will be represented more than once if they experienced more than one transfer.

In African elephants, females were most likely to be transferred when they were 6.7 years of age (range 0.6-33) and for males this was 5.7 years (range 1.0-22). A highly significant increase in the age at which elephants were transferred was found over the years ($r = 0.418$, $p < 0.001$, $n = 826$), although this could partly be due to the greater number of transfers experienced by all elephants in recent years, as this analysis included data on all transfers.

Age at first transfer for captive-born calves

Information on transfers involving captive-born calves were particularly interesting from a welfare point of view, as these data accurately reflect the age calves were removed from their mother by the zoos. Studbooks provide data on the age at which captive-born elephants experienced their first transfer and whether or not their mother, or any other group member, was transferred with them (see Table 14 for a summary). Data were available for a total of 52 Asian calves (24 males: 28 females) and 11 African calves (7 males:4 females) that had experienced at least one transfer. This represents 67.9% of Asian and 65.8% of African elephants born in captivity, suggesting that most have experienced at least one transfer. However, looking just at those elephants that have made it to five years of age (living and dead) brings this down to 33.8% of Asians and 37.5% of Africans, showing that in fact most calves over five experience at least one transfer.

For Asians, the average (median) age that females captive born elephants were moved was 3.4 years (range 1 day - 21.2 years). The female transferred at one day was from Hannover Zoo to a circus in 1968, and the next youngest female was eight months old. In males, the average age at first transfer was 2.9 years (range 10 days - 13.7 years). The 10 day old male was transferred from Ramat Gan Zoo to Jercausallem Zoo in 1994, and all other calves were over seven months old. See Table 14. None of the 52 individuals were transferred with their mother, and only 13.5% of calves (4 males and 3 females) were accompanied by a companion from the group, six of which were transferred with a young sibling and one with an older female from the group (28 years old). In African elephants, females experienced their first transfer at the average age of 3.0 years (range 2.0 – 4.0) and males at the age of 3.7 years (1.5 – 5.3). Most were accompanied by a companion from the herd (all females and 4/7 males): two half-sisters were transferred together along with their mother, and the remainder were transferred along with a young sibling (see Table 14).

Removal prior to natural weaning is not a practice that occurs in extensive systems in Asia. In general, elephants remain within the facility and are cared for by the same mahout and their relatives, throughout their entire lifetime. Furthermore, as summarised in the first section of this chapter, calves in the wild are generally not fully weaned until they reach three to six years of age (Lee & Moss 1986), and in females calves the bond with their mother remains extremely strong much later into life. The welfare implications of such early removal from the mother, as well as from the herd, are discussed in the section that follows.

Table 14. Age at separation from mother in captive born calves held in European zoos

The age at which captive born calves were moved to other facilities, and the number of companions from the group that accompanied them, are given below.

	Asian			African		
	Male	Female	Both	Male	Female	Both
No. calves transferred						
Total no. captive born calves	70	91	163	20	19	39
No. calves transferred at least once (% captive born calves)	24 (34.3)	28 (30.8)	52 (31.9)	7 (35.0)	4 (21.1)	11 (28.2)
Age at transfer						
Median age at transfer (years or days, d)	2.8 (10d-13.7)	4.5 (1d-21.2)	3.4 (1d-21.2)	3.7 (1.5-5.3)	3.0 (2.0-4.0)	3.7 (1.5-5.3)
Number of calves less than 1 year old (%)†	4 (16.7)	3 (10.7)	7 (13.5)	0	1 (25.0)	1 (9.1)
Number of calves less than 5 years old (% transferred calves)†	18 (75)	15 (53.6)	33 (63.5)	4 (57.1)	4 (100)	8 (72.7)
Companions						
No. transferred with mother (% transferred calves)†	0	0	0	0	2 (50)	2 (18)
No. transferred with a companion other than their mother (% transferred calves)†	4 (16.7)	3 (10.7)	7 (13.5)	4 (57.1)	4 (100)	8 (72.7)
Relationship with companion, other than their mother (no. ind.; sibs – siblings; F - female)	half brother*	sister (2)* older F (2)	sibs (6)* older F (1)	half bro. (2)* half sis. (2)*	half brother*	sibs*

*Young calves (<10 years); †Percentage of calves that have experienced at least one transfer

Welfare concerns regarding social aspects of the zoo environment

The issues raised in the previous section can be separated into two main topics. The first relates to differences in overall social structure between zoos and the wild. These could impact the welfare of elephants in several different respects (some of which are explored in detail in the chapters that follow and so are simply mentioned here). The second concerns the practice of transferring individuals between different facilities, a process that involves separation from the herd, and integration into new groups. The possible effects of these experiences, particularly on young calves, will be discussed in detail here.

Differences in the social environment between zoo and wild elephants

The extensive family-based social structure of wild herds is almost never replicated in zoos. Instead, the majority of elephants are held in small groups of (probably) unrelated elephants, most of which are adults, with only a very small proportion of infants or juveniles. Furthermore, males are often removed from the group and housed alone once they reach sexual maturity, to reduce the amount of handling required by keepers, as adult males are notorious for being aggressive, especially during periods of sexual activity (Eisenberg *et al.* 1971; Kurt & Hartl 1995; Schulte 2000). This could impact the welfare of elephants in a number of ways, which are discussed below.

Smaller group size

At the most extreme level, 19.4% of facilities with Asians and 10.8% with Africans house single elephants, representing 14 Asian and 4 African elephants. The AZA state that it is inappropriate to house single animals, but males over the age of six may be held separately, although they must be able to see, touch, smell and/or hear other elephants (AZA 2001). Studies on a range of social species have shown that isolation can be a strong stressor, causing a range of physiological and behavioural symptoms that suggest that the experience is unpleasant (Mendl & Newberry 1997), such as increases in heart rate, locomotion and plasma corticosteroids (cows, *Bos primigenius*: Adeyemo & Heath 1982; sheep: Cockram *et al.* 1994; Apple *et al.* 1995); a reduction in immune functioning (rats, *Rattus norvegicus*: Popovic *et al.* 2000; mice, *Mus musculus*: Wu *et al.* 2001); and attempts to escape which can develop into stereotypic behaviours (pigs, *Sus scrofa*: Gonyou 2001).

However, even the modal group size of two females is far smaller than in the wild. Roocroft & Zoll (1994) believe that the minimum group size should be at least six, but the AZA recommend that a minimum of three females are kept together (AZA 2001). Due to the shortage of female elephants, however, they will accept some zoos with smaller group sizes if they can prove they have approached the SSP to obtain more elephants. The reason that the AZA chose three as the minimum group size is unclear, but likely represents a compromise between attempting to provide a social group for the elephants balanced against the difficulty in housing larger groups and obtaining new elephants. Groups of this size are seen in the wild, but it is likely these represent sub-groups of the family unit that have temporarily split off from the main herd (e.g. Moss 1988), and on average for larger groups are seen (Table 12). Furthermore, these are groups of related animals, which is unlikely to be the case in zoos. The effects of this are as yet unknown, but research on elephants suggests this can result in a lack of strong social bonds being formed.

The AZA's recommendation that males can be housed alone from six years on is even more different from what occurs in the wild. Although males show some independence at this age, some may still be suckling from their mother (Lee & Moss 1986), and they do not actually leave the group until they reach around 9 to 15 years of age (Eisenberg *et al.* 1971; Douglas-Hamilton 1972; Moss 1988; Sukumar 1989; Desai & Johnsingh 1995; Poole 1999). Even then they may be forcibly expelled from the group by the matriarch (Sikes 1971; Douglas-Hamilton 1972), although not always (e.g. Lee 1986). The effect that solitary housing has on males has not been subject to study, and it is often assumed that because males are often found alone in the wild, it will not have any detrimental affect. However, wild males often associate in bachelor groups once they leave the herd, most commonly containing two to three males, but groups of up to 29 have been observed. The effect this has on their welfare therefore deserves further study.

The search for the optimal group size for captive species has so far eluded research scientists. This may be due to the fact that the 'optimal' size is dependent on a diverse array of factors, including the status of individuals and resource availability (Lindberg 2001). Most research has been carried out on livestock species, where the focus has been on determination of the maximum group size that can be attained with the minimal costs to welfare. Less work has been done on the minimum group size, however research suggests that this too can be detrimental to the welfare of highly social species (e.g. sheep: Fisher & Matthews 2001). In elephants, given that the effects of small groupings are unknown, it is therefore sensible to look at the most common group size in the wild. This is between six and eight Asian elephants, and four to twelve Africans for mixed herds consisting of females and pre-pubescent males, and two to three in bachelor herds. Thus a more reasonable group size may be based on these figures, bearing in mind structure of these herds.

Social housing is also recognised as a highly effective "enrichment", as social partners act as 'social enhancements'. Studies on other species have found this to be far more effective than traditional inanimate environmental enrichment devices, at promoting species-specific behaviours and reducing undesirable abnormal behaviours in captive species (e.g. rhesus macaques: Schapiro *et al.* 1996 a & b; Schapiro *et al.* 1997).

Differences in age, sex and familial structures

Potential for lack of learning and experience

In social species with long life spans, such as elephants, learning plays an essential role in the acquisition of new skills (Dublin 1983). In the wild, elephants learn a range of essential behaviours from their elders, such as how to forage (e.g. Buss 1961), where to find resources (e.g. Crook 1971; Leuthold & Sale 1973; Hanks 1979), and how to care for young (e.g. Woodford & Trevor 1970; Sikes 1971; Douglas-Hamilton & Douglas-Hamilton 1975; Lee 1987). The transmission of these skills is facilitated by the structure of the herd in the wild, which contain elephants from a range of overlapping age classes and hence experience, and the long generation time of elephants (Dublin 1983).

Some of these skills are no longer needed in captivity, such as being able to find watering holes during drought periods, yet others, such as maternal skills, are still very important. However, the structure of groups in zoos is such that learning these behaviours may be impaired. Many elephants in zoos simply do not possess the skills to pass on to subsequent generations, as they have not lived in the wild or been housed with more experienced elephants (most groups consisting of similarly aged females). This has been suggested to be a causal factor in the higher frequency of infanticide in zoo elephants, particularly those that have not been housed with older, experienced females (Kurt & Hartl 1995), an issue that is discussed fully in Chapter 8. A lack of social experience has also been implicated in some reproductive problems, such as a lack of libido or inadequate sexual behaviour observed in bull elephants, which impair captive breeding success (reviewed in Chapter 9). Group size and structure has certainly been found to affect reproductive in other social species, such as the gorilla (Beck & Power 1988). This issue is explored further in Chapter 9.

Potential inadequate socialisation

A comprehensive study on the social behaviour of zoo elephants, to determine whether they display an impoverished array of social behaviours, has yet to be done. However, several small studies have been carried out on captive elephants in other types of facilities. Poole *et al.* (1997) studied the social behaviour of a group of four unrelated adult females in an elephant orphanage in Sri Lanka (Pinnawela). Even though they had been together since the age of 1 to 2 months, they found that there were no well-defined bonds between them, despite having strong bonds with their own offspring. In contrast, a high level of social interactions was observed between the four adult males in the study. The authors suggest that the lack of strong bonds between females reflect the way social bonds are formed in wild family units: vertically from mother to daughter to grand-daughter and so on (see the first section in this chapter). In contrast, males form bonds with their peers once they leave their natal herd, and so are more inclined to bond with unrelated males.

Despite the lack of strong bonds found in this study, Garaï (1992) found evidence of “special relationships”, similar to that found in the wild, between specific females living in three European zoo herds. These females showed highly agitated behaviour when their preferred social partner was removed from the herd, including vocalisation and increased locomotion, and showed the greatest number of interactions once they were returned. However, unlike wild herds these close relationships are usually restricted to subgroups of two animals rather than including the whole group (Garaï 1992).

Thus the probability that elephants in most zoos are unrelated could impair the formation of social bonds between females in some, but not necessarily all, cases. This merits further study. This may not affect males, but as discussed in the previous section, most zoos only house one bull elephant anyway, thus preventing the formation of social bonds with other males.

In the wild, intense poaching has caused the formation of large groups of unrelated, frequently very young, elephants (e.g. Nyakaana *et al.* 2001). The social relations between individuals in these artificially produced herds have not been subject to study, but Njumbi (1995) notes that many females in one such population were lacking their tails, which is probably due to high rates of aggression. Indeed, aggression is known to be a major factor in preventing unknown females joining herds in the wild (Moss 1988), and this may be a potential cause for concern. No study has yet compared rates of aggression between elephants in zoos and in the wild, but this is generally known among elephants handlers that aggression can be a problem in zoos, particularly between specific elephants that appear to take a dislike to each other. Indeed, one of the advantages of free contact systems is said to be that the handler can intervene in fights between elephants (Schmid 1998), considered in more detail in Chapter 10.

Movement between facilities

Early removal from the mother

The results presented in this section show that 32.1% of Asian and 34.2% of African captive born elephants (or 66.2% Asians and 62.5% Africans that reach at least five years of age) were removed from their mother and transferred to another zoo at least once. On average, this occurred when they were around three years of age, although several calves under one year of age have been removed, a practice also reported by Haufellner *et al.* (1993, cited in Kurt & Mar 1996). This also occurs is some intensively kept Asian populations (Azeez et al. 1992, cited in Kurt & Mar 1996), yet it is considered to increase infant mortality in extensively kept timber elephants (Krishnamurthy 1992).

Studies of wild elephants have shown that at three years of age most calves are still suckling from their mothers, as are some at five and up to eight years of age (Lee & Moss 1986). The AZA recommend that the minimum age calves should be removed from their mother is three years of age (AZA 2001), while the EEP state five years as an acceptable minimum

(Terkel 2001). However, there is great concern among elephant experts who believe this is still far too young (e.g. Dr Marion Garaï, pers. comm., and Dr Iain Douglas-Hamilton at the International Elephant and Rhino Research Symposium, 2001).

Research on a range of species has shown that early separation from the mother is highly stressful. Young mammals that are subject to early weaning show elevated cortisol levels, high levels of vocalisations and locomotion and disrupted activity (cows: Veissier *et al.* 1989; Rhind *et al.* 1998; sheep: Fisher & Matthews 2001; horses: Waran 2001). Premature weaning and/or separation from the mother are also known to have long-term deleterious consequences on the welfare of various species. As adults, early weaned animals develop more abnormal behaviours (e.g. cats: Hart & Hart 1985; mink: Mason 1994); and can show impaired reproductive performance (e.g. mink: Gilbert & Bailey 1969). This does not appear to relate to the loss of nutrition from the mothers milk, but instead to the breaking of the bond with the mother, as removal can have a profound effect even after weaning (e.g. oral stereotypy in mink: Mason 1992). This is because mothers may act as a secure base from which young can explore their surroundings, or where they can retreat to when they are frightened or tired (Bowlby 1988). Maternal deprivation can also affect how an animal reacts to adverse events in the future. For example, in humans it increases later susceptibility to psychological disorders (Rutter 1981).

Early separation may also impede the learning of essential species-specific behaviours. For example, Fisher & Matthews (2001) found early separation of lambs from their mothers led to deficient grazing strategies, such as learning what foods to avoid, the location and seasonality of resources. Immune functioning may also be affected. Experiments on pigtail monkeys showed that a 10 to 14 day separation from the mother or peer group during their first year of life led to impaired immune functioning when they were five to six years old (Laudenslager *et al.* 1985). Also, the separation of infant gorillas from their mothers when they were just over two years old led to behaviour that was extremely similar to depression in humans (Hoff *et al.* 1994).

The degree to which animals are affected by early separation may be dependent on sex. For example, Mason (1992) notes that female farmed mink show twice as much stereotypies (see Chapter 1) as males, who disperse far earlier in the wild as if females are therefore more affected by the premature weaning. Although this has yet to be studied in elephants, one would expect those separated at a young age from their mothers to display more abnormal behaviours, and for this to be greater in females. Stereotypic behaviours are reviewed in Chapter 10.

Isolation and the breaking of social bonds

Movement of elephants between facilities also breaks established social bonds between females (Kurt & Hartl 1995). This is a particularly unnatural experience for females, as family units are very stable in the wild and the permanent absence of an herd member would generally only occur through dispersal (males only) or mortality (see the beginning of this chapter).

The unexpected removal of a social companion is a potentially strong stressor in several highly social species (e.g. Grandin 1989; Hennessey 1997). Separation generally elicits reinstatement behaviour in both parties, consisting of searching (locomotion) and vocalisation (signalling), interspersed with periods of energy-conserving depression (Newberry & Swanson 2001). This may be accompanied by altered feeding and sleep patterns, cessation of play, elevated corticosteroid levels (see Chapter 1) and changes in heart rate and body temperature, all indicate stress (e.g. Adeyemo & Heath 1982; Clarke 1993; Cirulli *et al.* 1996; Koolhaas *et al.* 1997). These responses may wane quite rapidly in some species as they adapt to the separation, but some long-lived, intelligent species, including elephants as well as primates and dolphins, display behaviour indicative of prolonged "grief" (Reite 1985; Moss 1988; Masson & McCarthy 1996; Newberry & Swanson 2001). These effects may be reduced by accompaniment with a social partner, and this is often exploited when transporting primates (Boccia *et al.* 1997).

In zoo elephants, Garaï (1992) reports that the temporary removal (for 30 minutes) of a female from a zoo group elicited reinstatement behaviour (labelled "arousal behaviour"), including locomotion and vocalisation, in all remaining elephants, most notably in their preferred social partner. Aggression directed towards elephants or inanimate objects, and stereotypic behaviour was also observed after separation, which may indicate frustration (displacement behaviour) and arousal. In addition, Kurt & Garaï (2001) note that when elephants held in an elephant orphanage in Sri Lanka were separated from their social partners, the frequency of stereotypies increased, indicating arousal and/or stress (see Chapter 10). Thus, observations indicate that separation may be stressful for female elephants, particularly from their preferred social partner, at least in the short-term. The only research that appears to have looked at the effect of separation was carried out by Schmid *et al.* (2001). They studied the behaviour of seven female Asian elephants, three of which were transferred into an existing group of four. Two were transferred together (3 and 27 years of age), while the other was moved alone (11 years of age). Behavioural observations prior to, and six months after, transfer revealed no consistent change in behaviour in the transferred elephants. However, one female (27 years old) did show a significant decrease in feeding and increase in stereotypic behaviour. The youngest elephant actually showed a decrease in stereotypies, which may have been due to removal from her aggressive mother who sometimes attacked her, while the 11 year old showed a trend towards increased stereotypy. Measures of urinary cortisol one week after transfer were not significantly altered in the two older females that were sampled. These results led the authors to conclude that there was no clear indication that transfer into a new group caused long-term stress. However, further study must be done before conclusions can be drawn from this very small sample size (particularly given the great number of confounding variables due to the past experience of each individual and the differences in husbandry). For instance, the decrease in feeding and increase in stereotypy observed in one female was attributed to the change in feeding management, and possible social conflicts with the matriarch, respectively.

Other studies suggest that the transfer of females between facilities may well have a long-term effect on their welfare. For instance, this practice may affect maternal care. For instance, in another study, Kurt (1995) notes that eight females that remained in the same location throughout their lives accepted their calves, but five out of nine females that attacked and later refused their calf had previously experienced two or more changes in location. However, another contributory factor is that the successful breeders were all raised with an old experienced female, while the other group were not (discussed further in Chapter 9). From these studies, Kurt concludes that “shifting single females from one zoo to another is a rather questionable practice for captive propagation of a highly social species with extreme matrilinear reproduction pattern”.

The results presented in this chapter also reveal that very few transfers of captive-born calves involve more than one animal, and only two African elephants were transferred along with their mother. Transfer with a familiar companion, particularly a ‘friend’ is known to reduce the stressful effects of removal in other species such as primates (e.g. Boccia *et al.* 1997). This is thus a further welfare concern, and merits further study.

Disruption of the social hierarchy

In general, the introduction of strange individuals to a stable group usually causes a disruption in the social structure (e.g. Barash 1972; Brakel & Leis 1976). Studies on a range of species have shown that this can lead to changes in physiology and behaviour indicative of stress (Dobson *et al.* 2001). These include an increase in aggression (e.g. dairy cows: Lamb 1975; Brakel & Leis 1976; pigs: Tan *et al.* 1991), a reduction in body growth (e.g. cows: Nakanishi *et al.* 1991; pigs: Tan *et al.* 1991; Ekkel *et al.* 1995), greater inactivity and enhanced plasma cortisol response (e.g. pig-tailed macaques, *Macaca nemistrina*: Barnett *et al.* 1984; pigs: Blecha *et al.* 1985), and a reduced immune response (e.g. deer, *Cervus elephus*: Hanlon *et al.* 1995; pigs: de Groot *et al.* 2001). Reintroduction into the same group even after a very short period of separation can cause significant problems with aggression in pigs (Ewbank & Meese 1971), but does not appear to cause a problem in sheep (Fisher &

Matthews 2001). These changes may result from a lack of opportunities to escape from aggressors and due to placing animals in unnatural groupings, for instance consisting of young animals without their mothers or other older individuals (Le Neindre *et al.* 1992). These changes may be short-lived and persist only until the new dominance order has been established (Lindberg 2001).

The introduction of a new elephant into a herd is thus likely to disturb social relations within the group, and it has been suggested that this could lead to foetal resorption in pregnant animals (Schmidt pers. comm, cited in Kurt & Hartl 1995). In the wild, there are rare reports of elephants joining other groups. For example, Moss (1988) reports the case of one young female who drifted away from her own family unit and gradually spent more and more time in association with another. Moss also states that this was probably a related herd, and on the whole such instances are rare, and instead unknown females are usually chased off by the matriarch (Moss 1988). In zoos, new elephants are introduced in small stages, but fights and injury can result all the same. In free contact situations, the handlers lead the integration and are known to intervene in aggressive confrontations (Schmid 1998). Even reintroducing the same elephant back into a herd may cause problems, such as in the case of a female who was subject to a great deal of aggression after being reintroduced into a herd in which she had lived for 16 years after a two year absence (Garaï 1992). This, and other observations, led Garaï to conclude that the dominance hierarchy had to be re-established after each change in group structure, and is not necessarily related to age as it is in the wild. In the long term, Schmid *et al.* (2001), in the study mentioned in the previous section, found no significant change in the behaviour of four female Asian elephants six months after three new females were introduced. However, as already discussed, this study was based on a small sample size and is confounded by various factors.

Summary

- Groups of females are much smaller in zoos compared to the wild. The AZA recommend that a minimum of three females are held together, but the most common group size in European zoos is two (both females) and solitary females are held by several facilities. In contrast, elephants in extensive systems are kept in large mixed groups containing between 51 and almost 3000 individuals, although when working, groups typically contain only around seven individuals. Females in the wild, which remain in their natal herd throughout their lifetime, associate in stable groups of between six and eight elephants, on average, in Asian elephants, and between four to twelve in Africans. Possible welfare concerns regarding small group sizes are stress and a lack of stimulation.
- Most facilities with males only housed one. The AZA state that this is acceptable from the age of six years onwards, a time when some males would still be suckling in the wild and none would have dispersed from their natal herd. After dispersal, which occurs between 10 and 15 years of age, males are found either alone or associated with two to three other males, on average. As mentioned above, extensive systems keep males in groups containing a large number of males and females.

- There is a lack of males in the European zoo population, particularly adult bulls. Male Asian elephants comprise a far smaller portion of the population in zoos compared to an extensive system (18.1% cf. 49.5%) and wild populations (Asian: 18.1% cf. 42%; African: 22.6% cf. 42.5%). Adult bulls (over 15 years) in particular are lacking, making up just 10.1% and 9.7% of the Asian and African zoo population, respectively. This contrasts with an extensive system, where adult bulls made up 22.8% of the Asian population, and also the wild, where they constitute 18.5% of the Asian, and 20.1% of the African, population. Even in facilities that do house both sexes, there are four females to every male.
- Young calves are relatively rare in zoos. Infants under five years of age comprise a far smaller portion of the population in zoos compared to extensively held Asian elephants (8.7% cf. 15.1%) and wild populations (Asian: 8.7% cf. 29.1%; African: 10.8% cf. 23.2%). Infants were also confined to just a few facilities, being found in 18.1% with Asian elephants, and 27.8% with Africans.
- In the zoo population, middle-aged females are very common compared to wild and extensively held populations. Females between 30 and 34 years were the most common age class of Asian elephants found in zoos, compared to infants in an extensive system and wild population. However, in Asian males, infants were the most common age class, which is likely due to the large number of male calves born in the last few years (see Chapter 9). In African zoo elephants, the most common age in males and females was 15 to 19 years, compared to infants in the wild population. Old animals are very rare due to high mortality (see Chapter 7).
- Elephant groups within facilities do not have different age classes represented. Most facilities (65.9% with Asians and 44.5% with Africans) housed elephants belonging to just one or two age classes: adult Asian elephants; adult and sub-adult Africans. Only 3.7% of facilities that housed Asian elephants and 10.6% that housed Africans had a group with representatives from all four age classes. This has possible implications for the acquisition of learnt skills, such as sexual behaviour and maternal care (see Chapter 9).
- There is a probable lack of relatedness between members of the same group within zoos. Only 17.7% of facilities housed a group containing the mother of at least one group member. This, along with the fact that most (74.3%) facilities held elephants with wild-born parents, makes it unlikely that many individuals in the zoo population are related to other group members, although this has yet to be subject to rigorous study. In the wild, females stay in their natal herd for their entire lives, and associations of unrelated females are rare. Wild bulls do seem to associate with unrelated males in bachelor herds, although it has been suggested that they may share some degree of genetic relationship. This may affect the forming of strong bonds between females, as seen in the wild, and possibly aggression within zoo groups (see Chapter 10).
- Movement between different facilities, and hence social groups, is relatively common. In the zoo population, 30.0% of Asian and 37.1% of African elephants have been transferred to a different facility at least once, in addition to transportation from the wild or Asian camps. There has been a significant increase in the number of transfers experienced by individuals over the years. The majority of transfers involved only one elephant (90.2% Asian and 76.9% African transfers), showing that most were not accompanied by a group member to the new facility.
- This movement between facilities often occurs when elephants are still juveniles. Musth transfers (69.7% of Asian, 79.2% of African transfers) occurred when the elephants were under 10 years of age. The average (median) age at transfer was 4.8 and 4.9 in male and female Asian elephants, respectively, and 5.7 and 6.7 years in male and female African elephants, although there appears to have been a significant increase in age over the years. In extensive systems, elephants typically remain in the same facility, and hence social group, throughout their life. Similarly, in the wild, females stay in the same herd throughout their life, but males leave the herd when they become sexually mature at

10 and 15 years of age. Although remaining to be fully investigated, removal from social partners may cause stress in both the transferred and remaining group members, and aggression may increase due to readjustment of social hierarchies.

- Captive-born zoo elephants are removed from their mother when they are still infants. The AZA state a minimum age of separation from the mother of three years, but the EEP recommend five years. The average (median) age that captive-born calves were moved to a different facility was 2.9 and 3.4 years in male and female Asian elephants, respectively, and 3.7 and 3.0 years in male and female African elephants. Most calves would still be suckling from their mother at this age in the wild. None of the Asian elephants were transferred to the new facility with their mother, and only a few were moved with a companion (13.5%). Although based on a far smaller sample size (11 cf. 52 transfers), most African elephants were transferred with a companion from their present original facility (72.7%) and two (18.1%) were transferred with their mother. Such early weaning has several possible welfare implications, including: the experience of at least short-term stress; susceptibility to the development of stereotypies; impaired immune functioning; and impaired reproductive performance.

Chapter
6

Elephant handling and training

In this chapter we tackle the contentious issue of elephant training in zoos. After a general introduction to the issues currently in debate we summarise the basic principles of animal training in general. We then discuss each type of elephant training in turn, beginning with traditional elephant training. The basic principle behind this method, namely domination, is critically analysed by reviewing elephant societies in nature and the methods used by handlers to establish and maintain dominance. An overview of the methods used to train elephants in this system is then provided, and we end the section on traditional training by considering the possible impact that the techniques used could have on elephant welfare. We then go on to review the possible alternatives to traditional training, namely protected contact training, passive management, and no training (under no contact management), looking at the possible effects each method has on elephant welfare. The question of whether elephants actually benefit from being trained is then discussed, concentrating on the various suggested benefits. We end by summarising the main findings of the chapter.

Elephant training – an overview

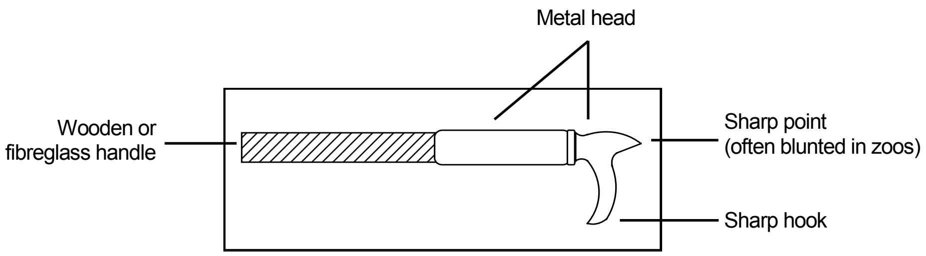
Training involves teaching an animal to perform, or abstain from, a behaviour required by the trainer, in the appropriate context and/or on command (Poole 1989). Training has become an increasingly common component of zoo animal management in recent years (Dineley 1984; Mellen & Ellis 1996). More and more people are commenting on the advantages of training, specifically for facilitating routine husbandry and veterinary procedures and enabling animals to participate in public displays (e.g. Dineley 1984; Kirkwood *et al.* 1989; Shellabarger 1990; Malina & Trainer 1999; Bobko 2001).

As reviewed in Chapter 3, elephants have a centuries-long history of training and this, along with the methods used, set them apart from all other wild mammals held in zoos. Until recently, zoo elephants have largely been imported directly from Asia and Africa (see Chapter 3). In fact, the traditional training methods used today in zoos largely derive from these mahout techniques, mixed with some circus training methods (e.g. Koehl 2000, see Chapter 3). Today, training in zoos is primarily used to facilitate husbandry, maintenance and health care, such as chaining to allow foot care, washing and routine veterinary procedures such as blood draws (Mellen & Ellis 1996). This is probably the reason that training has persisted over time, as well as the numerous purported benefits, such as physical and mental stimulation (e.g. Koehl 2000, discussed later in this chapter). For instance, the AZA have made elephant training mandatory so that various maintenance and veterinary procedures can be regularly carried out (AZA 2001), yet the same is not required for other large mammals such as rhinos, giraffes, walruses, etc. However, training is also used to teach other behaviours for entertainment, including headstands, hind-leg stands and sitting (Mellen & Ellis 1996). These have been called 'power behaviours' due to the great effort required on the elephant's behalf. Thus, overall, the reason that zoo elephants, as opposed to other large terrestrial mammals, are trained to this day, appears to be largely historical.

Training is thus common for elephants, but the exact nature and degree vary between zoos. The type of handling system in use largely governs what type of training, if any, is practised, and this in turn is governed by several factors: the sex, age and character of elephants; the expertise and viewpoint of the elephant handlers; the past experience of the zoo; and the facilities available (Priest 1994; Mellen & Ellis 1996). The three main handling systems used today were defined in Chapter 4 as: free contact (hands on); protected contact; and no contact (hands off). As reviewed in Chapter 4, free contact is the most common system used in Europe, followed by no contact and lastly protected contact. Within the same facility, different methods are commonly used with different individuals (Griede 2000). However, through visiting zoos and talking with elephant handlers during the preparation of this report it would appear that the type of training actually practised does not necessarily fall into these distinct categories, but instead varies along a continuum. For example, within free contact systems the most extreme method involves completely free contact, where the elephants are trained to respond to many commands; handlers demand 100% compliance; and training is practised for a considerable period of the day, for instance in the form of shows or rides. At the other end of the scale within the same system, handlers still practise traditional training, but only interact with the elephants infrequently, for instance to carry out foot care or bring them into the indoor enclosure; they allow the elephants to disobey commands on occasion; and they do not go through commands regularly with the elephants. There also appears to be some overlap between free and protected contact training, arguably due to a lack of adequate handler training. For example, handlers that have changed over to protected contact training may continue to use the traditional elephant hook (see Box 3) during training sessions and attempt to establish dominance over the elephants: methods used in traditional, free contact, systems (discussed further later in this chapter).

Box 3. <u>The elephant hook or ankus</u>

The elephant hook, also known as the ankus or bullhook, is a traditional tool used to train and handle elephants. It consists of a two to three foot long handle made of wood or fibreglass, with a metal head topped with in a point and a sharp hook (see the diagram below). The hook is used to 'guide' elephants during training by hooking it under folds of the skin and applying pressure to move the elephant, or parts of its body, in the desired direction (see the section on training specific behaviours for more detail). The elephant hook can also be used to deliver physical punishment (see the section on the use of physical punishment).



Schematic drawing of a typical elephant hook

Elephant training is currently a very contentious issue. This is mainly due to the techniques involved in traditional training, which have been highlighted in several high profile cases in recent years, reviewed in the '*Traditional elephant training*' section. The basic principle behind traditional elephant training is that control is maintained by the handler through domination, which involves the use of physical punishment (Fernando 1989; Koehl 2000). This has been called into question more and more in recent years, not only by animal welfare groups (e.g. PETA 2000; CAPS 2001), but also by prominent elephant experts (e.g. Poole 2001) and elephant handlers themselves (e.g. Buckley 2001). Furthermore, the question of whether dominance is actually attained is questionable, and is dealt with in this chapter. Keeper safety issues in this system have also been raised given the many injuries and deaths that have occurred (e.g. Lehnhardt 1991; Priest 1994, see Chapter 10). Overall, this has fuelled changes in the training and management of elephants in zoos, and in recent years, alternatives to traditional 'mahout-style' training have been developed and implemented in many facilities (e.g. Desmond & Laule 1991; Buckley 2001). Primarily, many zoos have now moved from a free contact system to protected contact management, for which a new training method was developed (Desmond & Laule 1991). Protected contact differs in a number of respects from traditional training, the main ones being that the handler is physically protected from the animal and so does not need to dominate the elephant, no physical punishment is used, and the participation of the elephants is entirely voluntary (Desmond & Laule 1991). 'Passive control' is another training method developed over the past ten years or so, but is presently only used in handful of facilities. It shares the qualities listed above for protected contact training, although it is unique in that no form of punishment is practised and it can be used in both free and protected contact systems (Buckley 2001).

However, little progress has been made in the debate about which training method conveys the greatest benefit, and least cost, to elephants, in terms of their welfare. To date, no one has collated the data necessary for testing the purported advantages and disadvantages of each training style although there are a number of different, very strongly held, opinions within the elephant profession as to what constitutes best practice: "the only thing two elephant trainers can agree upon is that a third trainer is doing it all wrong" (Mellen & Ellis 1996). Assessment is also hindered by the mystery and secrecy that surrounds traditional training techniques (Adams 1981); the large amount of variation in the methods used between different facilities; and the general lack of comprehensive written guidelines on training techniques, with methods thus largely perpetuated through word of mouth (Adams 1981; Priest 1994). There are only two institutions that regularly hold elephant training courses: Riddle's Elephant and Wildlife Sanctuary, Arkansas, U.S.A. and the recently established course at Vienna Zoo, Austria (Schwammer 2001). Each institution therefore follows its own philosophy, training new employees in methods developed and implemented by each institution's handlers (Roocroft & Oosterhuis 2001). This makes it difficult to identify what is 'common practice', let alone identify what the consequences of different practices are for the animals. However, some data are available, and inferences can also be made from studies carried out on other species, such as livestock and laboratory animals. The aim of this chapter is therefore to approach the issue from a scientific point of view by reviewing the available information so that where possible informed conclusions can be made about the pros and cons of each type of training method, in terms of the welfare of the elephants.

An overview of animal training: general principles

Teaching an animal to perform a required behaviour requires learning, and trainers employ various techniques to help the animal learn the task. This involves a process called conditioning, whereby the animal forms an association between a stimulus (or cue) and a response, i.e. the required behaviour (McFarland 1987). There are two main types of learning that are exploited by animal trainers: classical and operant conditioning. The principles that underlie these forms of learning are reviewed in this section, along with other forms that are less frequently used by trainers.

Adherence to the subtleties of these principles not only increases the rate at which learning, and hence training, occurs, but also ensures that the correct behaviour is being learnt. Conversely, incorrect or inappropriate application of these principles not only hampers animal learning, but can also lead to frustration on the part of the animal (e.g. Mazur 1998; Pryor 1999), which itself is known to cause aggression and the development of stereotypic behaviours (e.g. Broom & Johnson 1993, see Chapter 10). In the elephant training literature it is clear that there is some confusion regarding the terminology of learning theory, as well as the application of basic training techniques (see the section on operant conditioning for examples). With this in mind, this section aims to provide the reader with a general understanding of the key principles underlying animal training.

Classical conditioning

One type of learning sometimes used to train animals is classical conditioning. This was made famous by Ivan Pavlov's (1927) experiments with dogs that were conditioned to salivate when they heard a tone. First of all, Pavlov measured how much the dogs salivated when food powder was blown into their mouth. This salivation is an untrained or reflexive response. He then exposed the dogs to a tone just before the food was presented. Initially, the dogs salivated when they received the food powder, but over time they began to show this response simply when they heard the tone, showing that they had learned the association between the food powder and the noise, i.e. that **associative learning** has taken place (McFarland 1987). In learning theory terms, classical conditioning thus occurs when an initially irrelevant cue, or the conditioned stimulus (e.g. the tone), produces an unconditioned response (e.g. salivation) after being paired with the unconditioned stimulus (e.g. the food) (Domjan & Burkhard 1986; Mazur 1998). Thus, a natural response is elicited by a novel cue.

This type of learning is very important in animal training and is commonly used by trainers to condition animals to respond to a previously irrelevant stimulus, i.e. a conditioned stimulus. For example, an elephant can be trained to lift its leg by pairing a novel cue (the verbal command) with the natural withdrawal response (the leg lift) when the back of the leg is stimulated with a hook. Repeated pairings of the hook and the command eventually conditions the elephant to lift its leg on command (e.g. Adams 1981). Animal trainers will often use classical conditioning to create a '**bridge'** by repeated pairings of the bridge (e.g. a whistle) and a reward (e.g. food). This is used to bridge the gap between performance of the desired behaviour and the animal receiving the reward, which can otherwise present a practical problem (such as giving a fish to a dolphin immediately after it has performed a jump). Praise can also be used in a similar manner. Without such a bridge, learning would be hampered because of this time delay (Pryor 1999). In a similar manner, classical conditioning is also used in animal training to pair an action with a **verbal command** through repeated pairings of the two, so that eventually the action is performed when the animal hears the appropriate command.

Operant (instrumental) conditioning

In operant conditioning, an association is formed between a behaviour and a consequence, as opposed to classical conditioning where an association between two stimuli is learned (Domjan & Burkhard 1986). In this case, learning is dependent on what happens *after* the animal does something. A classic example is a series of experiments (later called the 'puzzlebox experiments') carried out by Edward Thorndike (1898), who was the first person to conduct a systematic study of this subject (McFarland 1993). He placed hungry cats into a box that was locked by a system of latches and observed their behaviour whilst trying to escape to reach some food that they could see but not reach. He repeated this many times and observed that during subsequent trials the cats tended to repeat the same behaviour they had been doing at the moment they managed to open the door during the previous trial. Thus, the act of opening the door was instrumental in their learning, in that it increased the frequency of the behaviour immediately preceding this response.

This principle is used by trainers to manipulate an animal's actions by directly altering the immediate consequences of a specific behaviour. This is done by one of four methods, summarised here from information provided by Dickinson (1980), Nevin (1973), Domjan & Burkhard (1986) and Mazur (1998). The first two methods cause an *increase* in the performance of the desired behaviour, and are hence called reinforcers. **Positive reinforcement** *increases* the occurrence of a specific behaviour by providing a *pleasant* stimulus immediately after the behaviour to be reinforced. Positive reinforcers are rewards, i.e. things that the animal wants, such as food, praise, comfort or security and they can be primary (unlearnt) or secondary (learnt). Typical examples include giving a dolphin a fish for jumping, or praising and petting a dog for coming when called. Conversely, **negative reinforcement,** or avoidance, describes the use of an *unpleasant* stimulus to *increase* the frequency of a behaviour. For example, aversive pressure on the reins, and hence bit, is removed when a horse turns in the desired direction, thus pulling on the reins reinforces turning (Pryor 1999); and the application of an electric shock to a laboratory rat very effectively reinforces an escape response that will cause avoidance of the shock (Mackintosh 1974). The second two methods, in contrast, train the animal to *decrease* a specific behaviour. Punishment is commonly used to refer to the addition of an unpleasant stimulus, such as shouting or hitting which occurs only when the animal does an undesired behaviour. This is sometimes called positive punishment in line with reinforcement terms, although this is rarely used (Mazur 1998). For example, squirting a cat with water each time it jumps on the table reduces the chance that it will do it again, although it is imperative that the punishment immediately follows the unwanted behaviour so that the animal is clear what behaviour is being punished (e.g. Domjan & Burkhard 1986). This is clearly very different from negative reinforcement in terms of the outcome (i.e. the behaviour decreases), yet confusion of the two terms is a relatively common mistake in the elephant training literature (e.g. Adams 1981, p177). Finally, omission (sometimes called negative punishment) is also used to reduce the likelihood that a specific behaviour will be repeated by *removing* or *omitting* a *pleasant* stimulus when this behaviour is performed. A simple example would be the withdrawal of pocket money from a child that was misbehaving (Mazur 1998), or walking away from the fish bucket when a dolphin becomes aggressive, a common technique use in animal training known as '**time-out**' (Dineley 1990; Braslau-Schneck 2001).

In summary, to *increase* the performance of a specific behaviour, rewards (positive reinforcement) or aversive stimuli (negative reinforcement) are used and to *decrease* the performance of a specific behaviour aversive stimuli (punishment) are used or rewards are omitted (omission).

It should be noted that the use of punishment during training is a highly controversial issue, not only due to ethical considerations regarding the use of physical punishment, but also due to the efficacy of punishment in general due to several unwanted side-effects (Martin & Pear 1992). These include the stimulation of aggression and the generalisation of punishment to locations and/or people (e.g. Kazdin 1975; Ledoux 1994; discussed fully in the section "*The effects of physical punishment and negative reinforcement: chronic*'). Many learning theorists and trainers thus regard punishment as ineffective, and a method that should only be used as a last resort in dangerous situations (e.g. Azrin & Holz 1966; Kazdin 1975), while others believe that it should be replaced entirely, and often far more effectively, by the other methods outlined here (e.g. La Vigna & Donnellan 1986; La Vigna *et al.* 1989; Pryor 1999).

It is essential that the animal knows precisely what behaviour is being reinforced, and thus the appropriate stimulus must be delivered as soon after performance of the behaviour as possible. This is a principle that may be overlooked by elephant trainers, particularly in traditional systems where punishment may be delivered well after the event (see section on maintaining handler dominance later in this chapter for more details), in which case the animal will not know what behaviour is being punished and will thus be ineffective at reducing the undesired behaviour (Mazur 1998). There can also be difficulties delivering positive reinforcement immediately, for instance if the animal is behind a barrier or in a swimming pool, and so, as described in the previous section, **bridges** (commonly dog whistles) are frequently used to fill the gap between performance and reinforcement using classical conditioning. The use of such a reliable, salient stimulus also overcome the problems of 'overshadowing' and 'blocking', which can cause a behaviour to become associated with a secondary, unwanted, stimulus (Mackintosh 1974). Another common tool used in operant conditioning is **targets**, which consist of a long pole with an enlarged end. The animal is conditioned to move towards the target using positive reinforcement, usually along with a bridge. As the animal learns the association between their behaviour (movement towards the target) and a reward (food and praise) the trainer can move them to desired locations within the enclosure by moving the target. A similar procedure can also be used to train animals to move particular parts of their body (e.g. arm, leg) towards a target (e.g. Dineley 1984; Desmond & Laule 1991).

Training more complex behaviours

The desired behaviour may not be performed straight away and so the animal's behaviour can be **shaped** using a process called **successive approximation** (Dineley 1990; McFarland 1993). This involves reinforcing any small movement that approximates the desired response, and/or punishing undesirable ones, and then gradually changing the reinforcement criteria until the required behaviour is reached (Mazur 1998). These methods, along with the use of secondary reinforcers, can be used to train quite complex behaviours by shaping each element separately and gradually linking a series of trained behaviours into a **chain** (McFarland 1987).

Habituation

Habituation is another aspect of learning used in animal training. This describes the reduction in response that occurs after repeated presentations of a stimulus (McFarland 1987). Trainers often exploit this form of learning when the want to get an animal used to a new object. For instance, when trainers first introduce a target (see above) the animal is likely to be afraid of the new object initially. Repeated presentation of the target, during which nothing untoward occurs, results in reduced responsiveness until the animal no longer reacts to the stimulus at all. Thus the animal's initial unconditioned response (e.g. withdrawal) '**extinguishes**' as it learns that the unconditioned stimulus is not really biologically important, which in this case is that it is not really aversive. A similar procedure may be employed to habituate an animal to being handled (Dineley 1990) or remaining still during basic veterinary procedures such as receiving an injection (Desmond & Laule 1991).

These techniques are used to varying degrees by elephant handlers. There are currently three training methods in use today, summarised at the beginning of this chapter: traditional training, protected contact training and passive control. The following sections describe these techniques and explore their underlying principles and the effect they have on elephant welfare.

Traditional/free contact elephant training

5.1	Handling must be done with care, in order to protect the animals' well-being, and avoid unnecessary suffering
7.3	All training programmes should provide a net welfare benefit to the animal. Training methods should be based on positive reinforcement. Where negative reinforcement is used it must never compromise the welfare of the animal. Written protocols should be established in zoological collections, which clarify approved, and where appropriate non-approved, training methods.

Secretary of State's Standards of Modern Zoo Practice
(DETR 2000)

A recent survey of the Asian elephant zoo population in European revealed that the majority of zoos (79.7%) keep at least some of their female and young male elephants in a free contact situation (26.6% use a mixture of handling systems), although only 41.9% use free contact with adult bulls (Griede 2000, see Table 7). These elephants are trained using traditional methods that have their origins in Asia with the mahouts (Kurt & Hartl 1995, Koehl 2000; see Chapter 3). These methods rely on the social dominance of the handler over the elephant and frequently involve the use of physical punishment, as well as positive reinforcement, to establish and maintain this position, a principle that also underlies traditional training of dogs and horses (e.g. Fisher 1989; Davis 2001; Sullivan 2001). Indeed, many trainers believe that there is no other way to train animals (Kiley-Worthington 1989), although new methods are becoming more widely accepted, such as protected contact training in elephants (Desmond & Laule 1991, see later in this chapter), 'clicker' training in dogs (Pryor 1999; Davis 2001) and horse-whispering (e.g. Farmer-Dougan & Dougan 1999).

From both a practical and welfare perspective, there are two main aspects of traditional training that warrant inspection. The first is the principle of social dominance that underlies this method. The second is the use of physical punishment. In the sections that follow, these two issues will be reviewed and discussed.

Training specific tasks

Due to the secrecy that surrounds traditional elephant training, and the highly sensitive nature of the issue, it is often difficult, if not impossible, to ascertain exactly what occurs within individual zoos, particularly behind closed doors. Furthermore, as mentioned at the beginning of this chapter, the precise methods during training vary considerably between facilities, making it difficult to determine what is common practice (Priest 1994). Since no direct study has been made of the prevalence of different training methods, and none of the questionnaires we sent out to U.K. zoos were returned, it has been impossible in this review to determine the frequency of the different methods used. Instead, here we just summarise the methods known to be in use today. Although some of the more extreme training methods (e.g. electric prods) may only be used in a handful of zoos, it is nevertheless imperative that these methods are brought to the fore, and the impact that they have on elephant welfare assessed.

Elephants are commonly trained to respond to 20 to 30 commands (Molter 1980; Schmid 1998), although with special training some may learn as many as 100 commands (Lewis 1971, cited in Hart 1994). The AZA wishes to standardise the use of commands, and lists a set of commands and behaviours that all handlers must known in the AZA Schools for Zoo and Aquarium Personnel Principles of Elephant Management (PEM) Course Notebook (AZA 2001). The techniques used are based on getting the elephant to perform the behaviour while the handler repeats the appropriate command. The elephant then learns to associate the behaviour with the command and this is reinforced by the use of positive and negative reinforcement. At the same time, punishments such as verbal reprimands and physical punishment (positive punishment) reduce undesired behaviours (see section '*Operant (instrumental) conditioning*' for definitions of these terms).

The technique used to get the elephant to perform the behaviour initially takes one of three main forms. First, an unpleasant stimulus (usually the ankus) is used to make the elephant, or part of the elephant's body, move to the desired position. For instance, to train an elephant to lift its leg, the handler prods the underside of the leg with the point of the ankus (mahouts: Efthyvoulidis 1980; Adams 1981) or gives it a few strokes with a cane (mahouts: Fernando 1989). The elephant moves its leg away from the source of discomfort causing the aversive stimuli to cease, and thus negatively reinforcing the leg lift. At the same time the handler repeats the appropriate command, so with the repetition, the verbal command acts as a conditioned stimulus through classical conditioning. The elephant must maintain the position for a specific time, usually a few seconds, and this is reinforced by applying pressure with the ankus if the elephant lowers its leg before the handler issues the appropriate command (the general command 'alright' is used in the U.K. to signal that the elephant can cease the current action). Again, this command comes to act as a conditioned stimulus for the action. Praise and rewards are also provided after the elephant performs the appropriate action, further reinforcing the behaviour (positive reinforcement). With time the handler no longer has to use the ankus and can simply say the appropriate command, although the ankus is used as a guide if the elephant does not respond. A similar process is used to teach elephants other simple movements such as moving forwards and backwards and side to side, raising and lowering the trunk, and the salute (raising the trunk and front foot at the same time). Some animals are also taught to trumpet, or 'speak', on command using a similar method. Scott Riddle is seen teaching this to elephants at Blackpool Zoo (on video footage taken by CAPS 1998) by poking the sensitive underbelly, or 'armpit', with the point of the ankus so the elephant cries out. This is negatively reinforced by the cessation of the jabbing when the elephant vocalises, and positively reinforced by praise afterwards. The performance of the vocalisation is then paired with a verbal command in a similar way to that described above.

Second, other behaviours are taught by physically moving the elephant, or a part of their body, into position by hand or by using ropes. For example, to get an elephant to lie down, ropes are tied to the legs and body of the elephant and then a number of people pull on the ropes until the elephant is forced to lie down (Adams 1981). The elephant is then restrained by tying its legs together and attaching the ropes to a stake in the ground. The handler then repeats the appropriate command while touching the top of the head with their hand or an ankus (Adams 1981). Adams (1981) also states that at this stage "sometimes negative reinforcement may be required to keep the elephant from resisting to obey commands." This appears to actually be a reference to punishment (a common mistake) as the handler wants to extinguish, rather than reinforce a behaviour (see section '*Operant (instrumental) conditioning*'). Indeed, video footage of elephant training at Milwaukee Zoo

(Humane Society of the United States) shows two handlers hitting an elephant with an ankus, at what appears to be full strength, to stop the elephant attempting to stand up. Once this behaviour has been trained, it can then be modified using similar techniques to get the elephant to sit up, sit on a tub, and stand on their hind legs; these are most common in circus acts but can also be seen in some zoos (Clubb, pers. obs.).

Third, the handler can coax the elephant to perform the desired behaviour and then provide reinforcement to increase the performance of the behaviour. For example, Koehl (2000) describes training an elephant to push a log by hiding a treat underneath, waiting until the elephant pushes it and then positively reinforcing it verbally. This is later paired with a verbal command and the process is repeated until the elephant responds on command. Natural behaviours can also be reinforced in a similar manner, i.e. by forming an association between the behaviour and a command using rewards. For instance, this method is used to teach circus elephants to defecate on command prior to entering the ring to prevent this occurring when they perform behaviours such as hind leg stands (Rob Atkinson, pers. comm.).

More complex behaviours can be taught using a combination of the techniques outlined. For instance, on the footage mentioned above, Scott Riddle is seen training an elephant to pick up a stick with its trunk, put it into its mouth and hold it there. First of all Riddle physically moves the trunk around the stick to hold it. He then pokes the trunk with the ankus so that the elephant moves it away from the discomfort and hence up towards its mouth (negative reinforcement). The trunk is then moved so that the stick is pushed into the mouth, and the trunk poked with the ankus to get the elephant to release it. This is repeated many times, and then paired with a verbal command.

During traditional training, it is stressed by handlers that obedience must be absolute, although as mentioned at the beginning of this section the degree to which this is insisted upon can vary between facilities. For instance, the AZA standards stress that “behaviors should be reinforced so that all elephants attain close to 100% compliance upon request of the elephant staff” (AZA 2001). Failure to obey is therefore be quickly and strictly dealt with. Similarly, in the case of mahout training in Asia:

> “The animal should always be made to obey a command and failure to obey should be admonished. Every attempt should be made to impress on the animal that there is no way it may disobey a command. Although the animal may be punished, for example with a few strokes of a cane or the ankus, the use of such physical influence should be minimal.” (Fernando 1989)

The procedure used in zoos to deal with disobedience may in some cases be severe (see next section). However, as already discussed, in other zoos, disobedience may simply result in the elephant handler repeating the commands with the more basic form of the behaviour, as though they were teaching the elephant all over again.

Issue one: the use of 'dominance' in traditional elephant training

The use of dominance is the basic tenet underlying traditional elephant training. The belief is that the handler takes on the role of the dominant herd member, the **alpha animal**, and hence maintains control of the elephants, by employing methods similar to those used by wild elephants (e.g. Iliff 1980; Priest 1994; Cheeran 1996; Koontz & Roush 1996; Koehl 2000). For instance:

> "When it comes to man-elephant interaction, man should take the upper-hand or the role of the dominant individual of the herd, and acceptance or submission will come naturally." (Cheeran 1996, p12)
>
> "The number one rule before you try anything, is to have full established dominance, in the same natural way as elephants are dominated by their group leader. Respect and love in combination…Without respect, and total general obedience, the elephant may some day not follow your command even if it gladly will do the trick for someone else, better equipped with [a] positive but strong sense of leadership…The trainer is not only [the] trainer, he is part of the herd, and he is the leader of the herd, the alpha animal." (Koehl 2000)
>
> "I was the herd boss because I controlled the females. They worked for me and responded to my commands." – Morgan Berry, trainer of elephants and referred to as the 'elephant guru' (Iliff 1980, p179)
>
> "These guys [elephants] live in a physical world, they don't negotiate…" Scott Riddle, elephant trainer, talking about the use of physical punishment in elephant training (CAPS 1998).

Thus, the handler ultimately aims to be incorporated into the natural hierarchy of the group, becoming the most dominant member and hence maintaining complete control over them (e.g. Koontz & Roush 1996; Koehl 2000). This philosophy is not restricted to elephant training. For instance, members of the Fulani tribe have employed a similar strategy for centuries to manage and control their cattle (Lott & Hart 1977). Furthermore, as with elephants, it is commonly assumed that dogs "behave towards people as though they were conspecifics which have been incorporated within their hierarchy" (Rooney *et al.* 2000), or as Hediger puts it, "…as a socially superior member of its own species – as a member of the pack" (1965). However, research on dogs has shown that they react differently to humans than to other dogs when playing, suggesting that under these circumstances at least, this assumption is erroneous (Rooney *et al.* 2000).

The basic belief behind traditional elephant training is therefore that the handler is behaving in the same way as the dominant group member, and using similar methods to establish dominance as the elephants themselves do in the wild. For instance, handlers often say that hitting an elephant when it misbehaves is no different to what elephant mothers do when disciplining their calves (Lee Sambrook, pers. comm). We will review the rationale of this assumption in the following sections.

A brief overview of dominance in wild animals

Dominance is a feature of social organisation that serves to resolve, and thus minimise, conflict between members living within a social group (de Luca & Ginsberg 2001; de Wall

1989; Drews 1993). There are many different definitions of dominance, but Drews (1993) conducted a comprehensive review of the subject and presented the following definition: "Dominance is an attribute of the pattern of repeated, agonistic interactions between two individuals, characterized by a consistent outcome in favour of the same dyad member and a default yielding response of its opponent rather than escalations. The status of the consistent winner is dominant and that of the loser subordinate."

Through the expression of dominance, each group member 'knows their place' in the social hierarchy, such that any given individual will have some companions that are subordinate to it, and some which are dominant, with the exception of the group leader which ranks above all others (Barash 1972). Many hierarchies are linear, which means the group leader dominates all other animals, the second ranking dominates all but the group leader, and so on (Barash 1972; Wilson 1980). However, there are variations in hierarchical structure. For instance, some species have very simple 'autocratic' hierarchies, whereby all members are dominated by one individual or pair, and there is no difference in rank between all the subordinates (e.g O'Riain *et al.* 2000). Other species have more complex social systems that involve branching or circular structures (Harcourt 1987), although the latter is thought to be somewhat unstable and breaks down to a linear structure over time (Wilson 1980).

Dominance is thus often, but not always, established through single or repeated threats or fighting (Dimond 1970; Wilson 1980). The winners of these encounters become dominant, and the losers subordinate. Damage to either opponent is minimised through the use of threat, appeasement and/or avoidance behaviours (McFarland 1987), and once established, dominance is usually maintained with the minimum of aggression (Wilson 1980). Instead, subordinates communicate their acceptance of the dominant status of other group members through ritualised displays (e.g. appeasement and reassurance behaviours, ritualised fights and greeting displays) and passive avoidance (Barash 1972; de Wall 1989). This is facilitated by the behaviour and physical appearance of dominant animals in more stable groups, which clearly identify them as the group leader, e.g. 'status signs' and 'badges of status' (Wilson 1980; Krebs & Davies 1993). For instance, the lead male in a wolf pack has a very 'regal' posture, approaching others very directly and confidently, thus making him instantly recognisable as the dominant male without the need for overt aggression (Wilson 1980). Some hierarchies are thus remarkably stable, but in other, less stable, groups subordinates may regularly challenge more dominant animals and will eventually move up in rank when there is 'room at the top' (Barash 1972).

This raises the question of what determines whether an animal is successful in achieving dominance over another. Various aspects have been linked to social dominance. These include the animal's size and strength (e.g. Sinclair 1977; Woodroffe & Macdonald 1995);

age and experience (e.g. Dunbar 1980; Creel *et al.* 1992); sex and/or level of aggressiveness (Wilson 1980; Wingfield *et al.* 1990); and whether the animal has relationships with high ranking group members, both familial and otherwise (e.g. Missakian 1972; Frank 1986). In addition, the location of confrontations can influence their outcome; animals are far more likely to establish dominance over their opponent when they are in their home territory, and vice versa (Wilson 1980).

Given that the establishment and maintenance of dominance can be a risky business, why would an animal want to move up the ranks? Dominance within the group confers a range of benefits that increase the current and future fitness of the individual (Barash 1972). For example, dominant animals get preferential access to resources, such as food, safe refuges and mates (e.g. Deag 1977; Wilson 1980; Langen & Rabenold 1994; Gompper 1996), and individuals may be more likely to survive if they can attain a high rank (e.g. Harcourt 1987). Reproductive success often correlates with rank (e.g. Doolan & Macdonald 1997), partly because of the good condition of well-fed high ranking animals (e.g. de Luca & Ginsberg 2001) and enhanced attractiveness of dominants (e.g. Ninomiya & Kimura 1998), but also due to other effects such as the suppression of reproductive in subordinates (e.g. Dunbar & Dunbar 1977, Abbott 1989).

An overview of elephant dominance systems in the wild

A brief outline of the social system in wild elephants has already been provided in Chapter 5. This section describes in more detail what is known about the dominance relationships between individual elephants, namely how these are formed and maintained, and the role aggressive interactions play. These are somewhat different between males and females, and so each sex will be considered separately.

Females

There is a clear dominance rank between female elephants living within groups, and also between individuals belonging to different groups (Moss 1988). Within family units, which typically contain between four and twelve elephants (e.g. Douglas-Hamilton 1972; Kurt 1974; Laws *et al.* 1975, Sukumar 1989; see Chapter 5) the top ranking elephant is the matriarch. Dominance among the rest of the family unit is determined by a range of factors. Generally older, and hence larger, females rank above younger ones (Eisenberg *et al.* 1971; Sikes 1971; Dublin 1983). The genetic relationship between members also plays a role as females generally pass on their dominance to their offspring, and so the young of high-ranking females will tend to rank above those of lower ranking mothers (Dublin 1983). Thus a linear hierarchy may be evident, particularly in small herds, with the matriarch at the top and her offspring in rank order according to age. However, more complex hierarchies may also be found, especially in larger groups, as dominance is also affected by strength and individual disposition and so some individuals will rank higher than they would normally (e.g. Sikes 1971; Dublin 1983). A kin-structured dominance rank has also been observed between family units, bond groups and clans (Moss 1988; Sukumar 1989). This is affected by a range of factors including group size and age of the matriarch (Moss 1988). As reviewed in Chapter 5, the social grouping of elephant herds is remarkably stable over time, and this also appears to be the case for the dominance hierarchy.

Being the oldest, and hence most experienced, member of the herd, the matriarch is said to act as a 'repository of information' (Dublin 1983; Douglas-Hamilton 2001; McComb *et al.* 2001). She leads the group in co-ordinated group activities such as exploration, foraging trips and defence behaviours (Eisenberg *et al.* 1971; Sikes 1971; Moss & Poole 1983; Poole *et al.* 1988; Spinage 1994; McComb *et al.* 2001). However, in terms of decision making, Poole (2001) points out that the family unit is generally a democracy in the sense that the matriarch does not appear to make all the group decisions. This changes somewhat during times of crisis when a quick decision is required, in which case the matriarch takes the lead role. Matriarchs have been observed putting themselves at considerable risk to protect members of the herd, for instance, by leading attacks against intruders and trying to aid herd members when being shot at by poachers (Sikes 1971). In return, the matriarch benefits from enhanced reproductive success and greater access to resources (e.g. Dublin 1983; Sikes 1971).

Dominance is communicated through the use of displays, threats, avoidance and displacement of individuals from preferred resources (Moss 1988). Occasionally, aggressive interactions result in physical contact, for instance when an adult pushes another out of the way with her tusk (Moss 1988), but as Poole (2001) states, "an elephant matriarch does not rule by force or fear; she is a leader because the rest of the family trusts her to do the best for them. She has earned their respect." Lee (1987) recorded only 156 "overt competitive and aggressive interactions" between adult females over the course of two years in Amboseli National Park in Kenya. Aggressive interactions consisted of "pokes, trunk-slaps, shoves and threats resulting in avoidance", although females would occasionally kick a calf to prevent them from suckling. Similar interactions were seen between adults and young calves (0-24 months), but these were rarely initiated by females that were not the mother and were relatively infrequent (0.65/hr). The rarity of this is highlighted by Poole's (2001) statement that throughout her many years of observing wild elephants, she never saw calves being disciplined or punished. Furthermore, interactions resulting in injury have rarely, if ever, reported between females (Moss 1988). On the whole, interactions between females within the family unit and bond group are amicable except when they are competing for scarce resources (Poole 1994). Amongst other female members of the population, interactions are far less frequent and may involve aggression as well as friendly exchanges (Moss & Poole 1983).

Little is known about what happens to the dominance hierarchy following perturbations in the social structure, for instance when the matriarch dies, or when herd members are lost through poaching, although there have been a few reports of the death of matriarchs and the subsequent behaviour of the herd. Moss (1988, p214) reports a family unit finally splitting into two groups one year after the death of their matriarch, and following a period of instability during which group composition was very variable. Moss concludes from this, and other observations, that the loss of a matriarch generally has a “disintegrating” effect on the family. This is supported by her observations of a different herd whose matriarch frequently left the group with her juvenile offspring, and who were often observed in different grouping structures. Sukumar (1994) also notes that when a female Asian matriarch dies, each daughter splits off to form her own group with her own offspring. In the short-term, Sikes (1971) observed the second ranking elephant apparently assuming leadership after the matriarch was shot by poachers. This new leader, whom the author suggests may be the sister or eldest daughter of the matriarch and was already the ‘deputy’, led the herd rapidly away from the danger. The death of herd members can also instigate the fusion of the remnant group with another family unit (Moss 1988), and following heavy poaching, surviving elephants can unite to form very large groups, often composed largely of juvenile orphans (Njumba 1995). Notably, there appear to be no reports of confrontations between herd members to compete for leadership in such situations, but instead dominance is assumed through non-aggressive means.

Males

As reviewed in Chapter 5, once males reach maturity between the age of ten and fifteen years (e.g. Eisenberg *et al.* 1971; Desai & Johnsingh 1995; Poole 1999, see Chapter 5) they leave the family unit and can then be found alone or in association with, on average, one to two other sub-adult and/or adult bulls (e.g. Sukumar 1989; Douglas-Hamilton 1972, see Chapter 5). The social hierarchy of independent males thus encompasses the entire male population. Social ranking of individuals and the nature of social interactions between adult males vary greatly according to their sexual state. When not in musth, males have a very clear linear hierarchy based on size and strength (Eisenberg *et al.* 1971; Sikes 1971; Moss 1988; Sukumar & Gadgil 1988; Poole 1989b). From an early age, males assess each other through sparring, or play fighting, which is a non-aggressive test of strength. This begins with gentle investigation of each other with the trunk, tusks are then interlocked or rested on the others head, and they then proceed to push each other back and forth (Moss 1988; Sukumar 1994). Sparring is practised by males from an early age and is important in the formation and maintenance of dominance relationships in adulthood (Moss 1988; Sukumar 1994). Through these interactions, bulls know the relative strength and hence rank of all other males in the population (Moss 1988; Sukumar 1994). Dominance is maintained through the use of aggressive displays, threats, escape and avoidance (e.g. Sikes 1971), but rarely through fights (Moss 1988).

Male dominance relationships alter dramatically when they come into musth. Musth bulls roam around alone in search of receptive females, and tend to be avoided by other males (Eisenberg *et al.* 1971; Moss 1988; Poole 1989b). A bull in musth ranks above all non-musth males, even much older and larger individuals, with very few exceptions (Eisenberg *et al.* 1971; Kurt 1974; Poole 1987; Poole 1989b). Between two musth bulls, the dominance relationship appears to be based on body size (Eisenberg *et al.* 1971; Poole 1999). However, because musth is asynchronous, dominance relationships are constantly being tested and reassessed between musth males, and younger bulls regularly challenge males that would normally rank well above them (Eisenberg *et al.* 1971; Poole 1989b; Poole 1999). When bulls come into musth they show a dramatic increase in aggression, display little affiliative behaviour, and interact aggressively with other males, particularly those also in musth (Eisenberg *et al.* 1971; Jainudeen *et al.* 1972a; Gale 1974; Hall-Martin 1987; Poole 1987). They will even direct aggression towards other animals, human observers or inanimate objects they encounter (Kurt 1974; Poole 1987; Sukumar 1989). This can occasionally lead to serious fights between musth bulls, completely different from normal sparring, that frequently end in injury or even death (Hall-Martin 1987; Poole 1989b), especially when bulls differ greatly in body size or condition (Moss 1988; Poole 1999). However, such fights are rare as males actively avoid musth bulls and Poole (1989b) reports only 31 fights in 14 years of intense observation at Amboseli National Park (all of which involved musth males).

As with female elephants, there appears to be various benefits of attaining a high rank. Dominant bulls appear to have a far greater reproductive success compared to subordinates. For instance, although breeding is not seasonal, the timing of musth in high-ranking males is such that they come into musth during the period when most females are sexually receptive (Poole 1989a; Poole 1994). Larger males are also more successful at obtaining matings than smaller, subordinate, bulls (Moss & Poole 1983; Poole 1989a). There is also evidence of reproductive suppression mediated by

> aggression, as high-ranking males have on occasion been observed to 'force' younger males out of musth by attacking them (Poole 1994). Females also prefer to mate with old musth bulls, allowing or sometimes initiating mating, and soliciting guarding behaviour from them to repel the advances of younger or non-musth bulls (Moss 1983; Poole 1989a; Poole 1994).
>
> The relationship between females and males has not been extensively reported for the Asian elephant, and so most data comes from African elephants. Moss (1988) describes the relationship between African matriarchs and males which is dependent on the age of the bull. Males under 20 years of age are subordinate to matriarchs, but by 20 to 30 years of age when they are larger than the matriarch, they will usually dominate. Males in this age group will rarely be challenged when they come into contact with herds, such as when their foraging ranges overlap (Moss 1988). By 30 years of age males have unquestioned dominance over females, and will never be challenged. Instead, they will be greeted and welcomed into the herd when they meet (Moss 1988).

Dominance is therefore stable and linear, although a more complex structure is likely to be found in large herds. The primary determinant of dominance in wild elephants is size, for males (non-musth) in particular, but also for females. Dominance is communicated through the use of threats, avoidance and displacement of subordinates, in females and in addition, males engage in non-aggressive tests of strength which influence the ranking of individuals. Overt physical aggression is rarely seen, and when it does occur it does not tend to result in injury, except in rare cases of fighting between musth males.

Can humans replicate this system of dominance in captivity?

Considering the way in which dominance is established and maintained between elephants in the wild, the question is whether this could be, and indeed is, replicated in captivity and thus whether traditional/free contact training does in fact mimic the elephant's natural social system. In order to answer these questions, we first compare the way in which elephant handlers attempt to establish dominance over zoo elephants with the system in the wild, reviewed in the previous section, to determine whether they are likely to respond to these methods. Secondly, we discuss whether the available evidence supports the view that elephants recognise their handlers as dominant herd members, and if so, how this position in maintained, compared to the system in the wild.

Dominance in wild female elephants is achieved through a combination of large size, and thus old age, and having familial links to dominant females. Non-musth males also attain dominance through large stature combined with strength, whereas small males that are in musth regularly challenge these established relationships and may achieve dominance over larger males. The former two systems are very stable compared to musth males which tend to have unstable hierarchies. In captivity, handlers obviously cannot establish dominance through their size or strength, all things being equal, or through relationships with other dominant members in the group. What they can do, however, is make a superior show of strength when the elephant is unable to retaliate: the concept underlying the traditional method of 'breaking'.

Methods used to establish handler 'dominance' in traditional training: 'breaking'

In this section we review what is known about the process of breaking in both wild and captive born elephants, and go on to discuss these methods with respect to how dominance is established in the wild.

Training an untamed elephant involves the process of 'breaking'. This process often occurs before importation into Europe and the methods used by Asian mahouts are described by Hart (1994), Gale (1974) and Fernando (1989). Video footage of this process has also been made by the National Geographic Channel and the NSPCA (Carte Blanche 1998). The NSPCA recorded the breaking and training of a group of young South African elephants destined for export to zoos around Europe, nicknamed the Tuli elephants, by mahouts imported from Asia (see Box 4). Although details differ somewhat, particularly the degree to which physical punishment is used, the basic principles are the same. Elephants that have been born in captivity do not need to undergo this process, but undergo an alternative method described by Fernando (1989), reviewed later in this section.

Breaking involves several stages that are designed to make the animal accept the dominant status of the trainer. For example, a famous 'old-school' elephant handler, George 'Slim' Lewis, describes the endpoint as when the "elephant has given in and acknowledged you as both his master and his protector" (Lewis 1978). Breaking usually occurs in elephants under 20 years of age and is reported to take from ten to twenty days, but can take up to a month with older individuals (Gale 1974). The elephant is first restrained by tying it to a post, or sometimes to two tamed elephants, so that movement is severely restricted. Gale (1974) describes how the elephant is drained of strength by denying it food and water for two to three days and sleep for at least 24 hours. The elephant may then be subject to repeated beatings (Carte Blanche 1998) using the traditional elephant hook, also known as an ankus or goad (see Box 3). The National Geographic footage shows a young elephant being beaten, causing it to cry out and attempt to escape.

Box 4. The Tuli elephants

In July 1998, 30 African elephants calves were captured from a wild herd in the Tuli Reserve in Botswana for the animal dealer Riccardo Ghiazza. The elephants were between the ages of under two to six years of age. They were transported to a holding facility at the African Game Services in South African for taming before being shipped to various zoos and safari parks in Europe, China and Japan. Soon after, press coverage highlighted the use of mahout-style training methods and cruel treatment. This led to an investigation by the National Council of Societies for the Prevention of Cruelty to Animals (NSPCA), which included video footage being taken showing the premises and treatment of the elephants. This was then shown to several internationally renowned elephant experts including Dr Cynthia Moss, Dr Joyce Poole, Mrs Daphne Sheldrick and Dr Iain Douglas-Hamilton. Video footage showed the young elephants chained by two legs to a bare concrete floor in a large barn, unable to lie down properly. The training methods used by the mahouts included repeated beatings with long sticks, elephant hooks, rubber whips, and deprivation of food, water and sleep. These were condemned by the experts as cruel and ineffective. Criminal charges of cruelly were filed under the Animal Protection Act by the NSPCA against Riccardo Ghiazza, a trainer and two Indonesian trainers. Subsequently, a judge ruled that the elephants had been cruelly treated and awarded custody to the NSPCA. However, Ghiazza was able to export seven of the elephants to zoos in Switzerland (Basle Zoo) and Germany (Dresden and Erfurt Zoos). Four elephants were also destined for Fuji Safari Park in Japan and a circus in China. However, the export of these four elephants did not go ahead due to intervention by animal welfare groups and public outcry. Instead, nine of the remaining elephants were moved to a Private Reserve in South Africa and the remaining 14 were released into the Marikele National Park in South Africa. The ruling on cruelty charges is still pending.

Sources: (Anon. 1998; Carte Blanche 1998; Anon. 2001; South African Press Association 2002)

Footage of the Tuli elephants shows mahouts repeatedly beating them with long sticks to the point where the skin is broken and blood drawn (Carte Blanche 1998). A training session was described by an NSPCA inspector as follows:

> "One elephant was tied up in the warehouse .... When the elephant simply moved its trunk or shifted its weight, the mahouts would all hit it. Especially the mahout in front who would whip its face with a rubber whip. I counted that during this training session of 20 minutes, the elephant was hit, or stabbed, with an ankus a total of 136 times". (Anon. 2002)

Many of these elephants were covered in wounds, especially around the forehead and eyes (Poole 2001) and Cynthia Moss states that the elephants were obviously "severely traumatized" (Moss 2001).

Alternatively, Fernando (1989) makes no mention of deprivation or beatings, but instead describes how the mahouts "will stay with the animal day and night dousing it with buckets of water, offering food and continuously talking to it". Daphne Sheldrick notes that dousing is used as a further aversive stimulus to break the elephants (Carte Blanche 1998). Fernando later states that "the use of physical punishment…should not be considered as necessary for training an animal *except at* *the stage when the animal, fresh from the wild, is being broken in*," and in reply to a question from a participant in the conference states that "…in order to break the animal [elephant] there is no alternative to a stick or goad [ankus]…". He describes how the ankus is used to teach the elephant not to attack the mahouts. One mahout stands directly in front of the elephant, and another two stand either side of its trunk, each with an ankus pointing towards the elephant. Another two mahouts then caress the elephant from behind, chanting and talking to it continuously, causing the elephant to lash out at the surrounding mahouts. The elephant hurts its trunk on the hooks causing it to eventually cease responding to being handled. All references describe how mahouts continually speak to the elephants, often in a 'sing-song' voice, and gradually habituate them to being handled, eventually culminating in getting a mahout to sit on their back without protest (Gale 1974; Carte Blanche 1998). The elephant is considered to have been 'broken' when it no longer tries to escape or attack the mahouts and will tolerate being handled and having a man sit on their back (Fernando 1989).

However, Cynthia Moss describes the following, very different, method that she witnessed in an elephant training school in India, thus highlighting that there are variations in the aversive nature of the methods used.

> "The training methods displayed were those developed in Assam [India] over several centuries and involve no brutality. Only large soft ropes are used and only bamboo sticks; no chains, no hooks. With gentle treatment an elephant can be tamed down in 24 hours; with the help of trainer elephants it can learn to respond to several voice commands in four or five days. Watching the Assamese at work I could almost accept the idea of elephants in captivity. The methods I saw being employed in South Africa were in stark contrast and seemed unnecessarily brutal. These types of methods were unconditionally condemned at the meeting I attended in India. " (Moss 2001)

Therefore, not all elephants imported into zoos will necessarily have been broken using the harsh methods described, although it is impossible to tell just how many due to the lack of data on this subject.

These descriptions relate to training elephants that have been caught from the wild, but, Fernando (1989) also includes a section describing how the Burmese train elephants born in captivity. This entails a process of habitation beginning when the elephants are weaned at five years of age. Firstly, the elephant is restrained in a crush to restrict movement. Once it settles down and stops trying to escape, a mahout is lowered onto its back using a pulley system. The elephant first responds violently, and the mahout is raised quickly. At the same time, the elephant is trained to sit down on command by lowering a heavy block of wood onto its back so that it has to lower its body to avoid the pressure, during which the mahout gives the appropriate command. These two processes continue until the elephant will tolerate having a mahout sit on its back, and will sit down when the mahout issues the command whilst applied pressure to its back with his hand. The elephant is then removed from the crush and restrained by tying it to a tree, where it remains for 24 hours, being caressed by its trainer and commanded to stand up and sit down continuously. It is then bathed whilst attached to an elephant that has already been trained.

In an attempt to assert their dominance, handlers therefore compensate for their relatively diminutive stature by employing various methods, including restraint, physical punishment, and sometimes the deprivation of food, water and sleep. There is no equivalent to any of these methods in wild elephant societies. Elephants, primarily males, do test each other's strength and occasionally use physical aggression to convey their dominant status, and thus one might expect this system to work with male elephants. However, during aggressive encounters, the 'loser' is always able to escape from their aggressor and thus signal to them that they accept their subordinate position. In contrast, during breaking the elephant is unable to escape or avoid their aggressor (i.e. the handler), forcing them to suppress their natural behaviour and instead display an entirely unnatural one: standing still and not attempting to escape or retaliate.

Given the available evidence, and considering the dynamics of the social system of wild elephants, it is highly unlikely that elephants exposed to this sort of treatment recognise their handlers as a dominant member of their herd. The methods used by handlers during breaking, including the 'softer' methods, are very different to the ones elephants use themselves to convey a dominant status. For instance, Cynthia Moss describes the Tuli elephants as 'traumatized'. As Joyce Poole (2001) puts it: "In captive situations, with free contact [i.e. traditional training] one of the most basic social tenets is broken. Smaller individuals attempt to rank above larger individuals not by gaining the elephant's respect but through the use of discipline and fear." Furthermore, breaking involves social isolation (rarely seen in female elephants, see Chapter 5), very acute and intense exposure to extreme stimuli and a lack of control over their environment. Thus, the 'subordinate' behaviour of broken elephants is more likely to be a result of conditioning, habituation, fear and learning that they have no control over their environment (see section '*Potential effects of breaking'* describing learned helplessness). Further contrasts between the natural social system of elephants and the situation in zoos are discussed further in the following section.

Methods used to maintain handler 'dominance' in traditional training

In the wild, dominant elephants maintain their position by using threat displays and rare acts of aggression (seen primarily in musth males). Dominant females are also said to gain the trust and respect of the herd, which may also contribute to the maintenance of their status, although difficult to quantify, and males may engage in sparring matches to test the strength of their opponents. Subordinates elephants convey their status by actively avoiding dominant individuals and moving away from preferred locations or resources when approached by dominants (i.e. displacement).

In captivity, once broken elephant handlers employ various techniques in an attempt to assert their dominance over elephants given that they obviously cannot physically compete with them. These include a range of methods, such as the use of ropes and winches, the ankus, as well as the demeanour displayed by the handler. For example, Scott Riddle runs a traditional elephant training school in Arkansas, U.S.A., and travels to facilities around the world giving demonstrations on traditional elephant training. He states that "Intimidation is better than force itself…if that elephant thinks that I can best it physically, that's what I want." When asked how he bests them he replies "I intimidate them, I mentally intimidate them". He later goes on to say: "There's ways of shaking these guys up without touching them…you try not to get in a situation that you have to prove [that you can best them]. That's why ropes are important, chains are important, how you carry yourself…" (CAPS 1998). .

However, there are various reports of handlers having to re-establish their 'dominance' when an elephant fails to respond to commands. This may simply consist of making the elephant perform several behaviours on command, and repeating it until the elephant executes all the behaviours required. If the elephant still fails to respond, the trainer may 'take them back to school' and repeat the initial training technique starting from scratch (Lee Sambrook, pers. comm., see later section on the training techniques used). The handler may also get the elephant to repeatedly perform difficult tasks such as 'stretching out', where the elephant lies down with its belly on the ground and its legs stretched out in front and behind it, as seen being used by Scott Riddle (CAPS 1998). However, there are also reports of more severe methods being used, particularly when an elephant acts aggressively towards handlers. Scott Riddle states that "if the elephant goes after someone you have to discipline it" (CAPS 1998). This can involve the elephant being led indoors, chained up and repeatedly hit with the ankus and/or other implements (e.g. Fritsch 1988; HSUS 2001).

For instance, a female Asian elephant named Dunda was transferred from San Diego Zoo to San Diego Wild Animal Park where she received “discipline” for her misbehaviour. According to keepers at the zoo, this consisted of “chaining her four feet, hauling her down to her knees and repeatedly smacking her on the top of the head, where the skull is thick, with ax (sic) handles and the wooden end of elephant hooks” (Fritsch 1988). The handlers were not charged as the San Diego city attorney ruled that “discipline of Dunda, although seeming harsh to the uninitiated, is a technique accepted in the animal-training profession” and one which is used by “reputable animal facilities around the country to establish dominance over the animal”, based on evidence from elephant keepers and a statement made by officials at the Zoological Society of San Diego (Fritsch 1988). Notably, however, when Scott Riddle was asked his opinion of this case during the workshop at Blackpool Zoo (CAPS 2001) he states that the San Diego incident was handled badly and that the handlers “did not go about disciplining her in the proper manner.”

A similar case occurred some years later in El Paso Zoo, Texas, when handlers were recorded on video beating an elephant, Sissy, for several hours. Sissy was struck whenever she failed to obey a command. The zoo director, David Zucconi, said that the handlers “acted in compliance with established zoo policy” (HSUS 2001). This zoo was later charged by the United States Department of Agriculture (USDA) under the federal Animal Welfare Act. The USDA stated that “The methods used were unacceptable by any standards and can only be characterized as mistreatment….It is a shame that in this modern day trainers continue to resort to harmful and outdated training techniques”. El Paso later changed to protected contact. It should be noted that the guidelines currently being prepared by the Federation of Zoological Gardens of Great Britain and Ireland do address this aspect of husbandry.

In comparison with the social system of elephants in the wild, there are areas of similarity in traditional training. For instance, handlers also use threat displays and carry themselves with a certain ‘posture’ to convey their apparent dominant status. However, as discussed in the previous section, it is highly unlikely that the elephants view their handler as dominant, but instead have been conditioned to associate certain behaviours with either aversive or pleasant experiences. These threat displays may therefore induce fear, and invoke memories of previous ‘breaking’ or disciplining, which then leads to the elephant showing the appropriate ‘subordinate’ behaviour, i.e. compliance. Similarly, the practice of making the elephant repeat trained behaviours simply strengths conditioning. Acts of physical aggression, such as those reported above involving elephants being ‘disciplined’, are akin to breaking, albeit over a shorter time period, and are thus likely to have similar effects on welfare. Notably, they are also suspected to occur in U.K. zoos.

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Conclusions: does traditional training mimic the natural situation?

Considering the evidence presented in this section it is concluded that the breaking and training methods used in traditional systems are unlikely to establish the handler as a dominant member of the group. Instead, these methods probably enable the handler to control the behaviour of the elephants through conditioning, and hence do not mimic the natural social system of the elephant. However, further research should be conducted to elucidate how elephants perceive their handlers, for instance by comparing the behaviour of elephants around handlers in different systems, and also in comparison with their behaviour around dominant elephants in the group. For the purpose of this report, however, it will be assumed that the principle of dominance in traditional training is not attained.

Does traditional training work?

As mentioned in Chapter 6, handlers are at considerable risk from being injured, or even killed, by the elephants under their care, particularly in free contact situations due to the amount of direct contact between handler and elephants. Even in the system upon which free contact is based, ‘dominance’ does not always result in the peaceful subservience desired. Kurt (1992, cited in 1995) reports that only one accident has occurred in Tamil Nadu in 18 years, with a stock of 120 elephants. However, Kurt (1995) states that every seventh elephant kept in an intensive timber logging system in Sri Lanka is considered to be dangerous, while Benirschke & Roocroft (1992) report that it is alleged mahouts only live for four to five years once they start working with elephants.

Anecdotal evidence suggests that unsatisfactory training methods and, possibly related to this, high staff turnover may be causal factors involved in these incidents. For instance, the attack of a handler at Kansas City Zoo in 1982 was attributed to inadequate staff training, which resulted from a high turnover in staff (Anon. 1986). In extensive systems, Hart (1994) reports that drivers noted a change in one particular elephant from well tempered to unpredictable and aggressive, which they attribute to high handler turnover (Hart 1994). Similarly, Fernando (1989) notes that working elephants in Asia tend to become intractable with frequency changes in staff.

It has been suggested that by establishing themselves as the ‘dominant’ herd member handlers put themselves at risk because their position in the hierarchy is likely to be challenged at some future date (e.g. Desmond & Laule 1993; Koontz & Roush 1996). However, even if dominance were to be successfully achieved, given the current knowledge of elephant social systems, this is only likely to be of concern for handlers working with adult males in musth, as hierarchies in all other elephants are stable over time and are not challenged. Indeed, bull elephants are notoriously difficult to handle in captivity, perhaps as bulls, naturally quite solitary, are more likely to challenge dominance than accept it (Koehl 2000). However, handlers avoid working with musth bulls due to the aggressive and highly dangerous nature of bulls whilst in this state (e.g. Eisenberg *et al.* 1971; Gale 1974; Poole 1981).

A further possibility is that the methods used cause some 'resentment'. Anecdotally at least, cruel training and taming has probably always been a major reason for accidents in elephant keeping (Schmid 1998). The use of physical punishment is said to build up "resentment" in elephants who may later lash out at the handlers at some point (e.g. CAPS 2000). Retired vet, Bill Jordan, has stated that "…in my opinion such training (commenting on the use of electric prods for training elephants at Blackpool Zoo) could compromise keeper safety by building up resentment in the elephants and by giving the keepers a false sense of security" (CAPS 2000). Aggression directed at handlers is considered further in Chapter 10.

Issue two: the use of physical punishment in traditional elephant training

As discussed at the beginning of this chapter, the use of physical punishment is becoming and less and less acceptable amongst handlers working with other species (Priest 1994), and indeed humans (Mazur 1998), due to the ethical questions it raises and also the various undesirable side-effects that may occur (e.g. Kazdin 1975). There is little doubt that physical punishment does play a role in traditional elephant training. Traditional handlers generally accept this as a 'necessary evil' to maintain 'dominance', and hence control, over elephants in free contact situations. Incomplete dominance is generally believed to put the handler's life in danger (e.g. Koehl 2000; and also training wild cats: e.g. Walton 1956). The reasoning behind this is that the elephant is then in a position to incur the numerous purported benefits of free contact situations, such as being taken out for walks and given exercise, while the safety of the handler is ensured (but see Chapter 10 on aggression directed towards handlers) (Koehl 2000). As already stressed several times in the section, there are no explicit guidelines or standards when it comes to traditional elephant training. Methods are passed on largely through in-house training and thus techniques vary considerably between facilities. Likewise, the use of physical punishment also varies greatly, and may be influenced by who trained the handlers, their personality, and according to Koehl (2000), the level of control the handler has over the elephants, (questionable dominance being associated with greater use of physical punishment). It has therefore not been possible in this review to quantify a 'normal' degree of physical punishment used. What we can do, however, is review the comments of elephant professionals, refer to what is known about the methods used in elephant training schools (i.e. Scott Riddle's), and highlight cases that have been reported in the press.

Aversive stimuli, including pain/discomfort, are used for four types of reasons: a) breaking; b) maintenance of handler 'dominance'; c) training specific behaviours; and d) punishing non-compliance, handler-challenges and non-performance of specific trained behaviours. It is the latter we focus on here, as the other three points have already been dealt with in the previous section.

Several professionals have admitted that physical punishment is a recognised part of traditional elephant management. For instance, the following are sworn statements from Joel Parrott, Director of Oakland Zoo, and Tom Rider who is a former employee of Clyde Beatty Cole Brothers and Ringling Brothers Circuses. Both were called as expert witnesses to comment on elephant training during a hearing for the Captive Elephant Accident Prevention Act (see Box 5).

> Joel Parrott: "Unfortunately, the training can be severe, using techniques that include prolonged hitting by the elephant handler with clubs, stabbing with the point of the ankus, pitchforks, electricity, electric prods, prolonged chaining and food deprivation"
>
> Tom Rider: "When Pete [an elephant] did not perform her act properly, she was taken down to the tent, laid down and five handlers beat her with bull hook (ankus]…They [the elephants] were beaten all the time when they did not perform properly."
>
> (U.S. Government June 13, 2000)

However, other expert witnesses in the case, Deborah Olson (Director of Conservation and Science Programs for the Indianapolis Zoo) and David Blasko (Elephant Encounter Supervisor, Six Flags Marine World) claim that this sort of treatment is the exception rather than the norm.

> Deborah Olson: "While there have been rare incidents of mistreatment of elephants in North America these are clearly the exception."
>
> David Blasko: "Proponents claim that it [elephant training] is done by fear punishment…[but]…It relies on communication, patience, understanding and rewards, including favored treats, petting and attention."
>
> (U.S. Government June 13, 2000)

Chadwick (1992), in his book "The Fate of the Elephant", also reports that zoo elephant handlers may "have to just plain beat some elephant in a *last-ditch effort* to establish control before the animal kills someone or has to be destroyed itself." Notably, the same David Blasko, who was a handler at Marine World in Africa at the time, is quoted in Chadwick's book (1992) stating the importance of psychological methods of dominance in elephant training: "It's not the physical hurt you can give them; it's the mental punishment that finally controls them."

Scott Riddle is highly regarded by many handlers using traditional training. The Captive Animal Protection Society (CAPS) took some putative undercover footage during one of these workshops in Blackpool Zoo (CAPS 2001). During the workshop Scott Riddle offers some insight into the methods used during traditional training. He states that physical punishment is not always necessary and that "intimidation is better than force itself"…."if that elephant thinks that I can best it physically, that's what I want", although he does also state that "sometimes force is necessary" and "…if I need to hit an elephant, I'll hit it". In the same video footage, recording an elephant training course held at Blackpool Zoo, he can be seen regularly poking the elephants with an ankus, and a puncture wound near the top of the trunk can clearly be seen on the footage. The undercover investigator records 18 puncture wounds in one elephant on the fourth day of training.

Box 5. Captive Elephant Accident Prevention Act (CEAPA)

Congressman Sam Farr of California introduced this bill on 23 September 1999. The bill aimed to amend the US criminal code to prohibit the use of elephants in travelling circuses and shows and elephant rides. The main reason for the introduction of this bill was concerns for public safety around elephants, but the evidence presented also concerned the treatment of elephants during training. During consideration of the bill numerous experts were called as witnesses to give their opinion about elephant training and the risk that elephants pose to the public. These included zoo and circus representatives, animal and elephant trainers, animal welfare group representatives, and scientific researchers. As yet the bill has yet to go through.

Source: (PAWS 1999; Anon. 2000; Anon. 2000; US Government June 13, 2000)

In terms of recommended standards for zoos, the AZA consider the practices stated below to be inappropriate. Notably, Joel Parrott, the Director of Oakland Zoo, admitted breaking several of these standards in his statement for the CEAPA hearing (see p115).

a) Insertion of any implement into any bodily orifice, unless directed by a veterinarian specifically in connection with training for a medical or reproductive procedure
b) Striking an elephant with anything more substantial than an ankus (a traditional training tool used by elephant trainers)
c) Striking an elephant with any sharp object, including the hook of an ankus (Fowler 1995)
d) Striking an elephant on or around any sensitive area, such as the eyes, mouth, ears, or genital region
e) No tools used in training should be applied repeatedly and with such force that they cause any physical harm to an animal (i.e., breaking of the skin, bleeding, bruising, etc.)
f) Withholding or reducing an animal's daily-recommended amount of food and or water
g) Withholding veterinary care for any reason.

If properly executed training procedures are ineffective in eliminating aggressive or inappropriate behavior in a given animal, institutions should consider other alternatives, including transfer to a facility with more experienced staff or a different management system. Protracted and repeated use of corporal discipline in training is of serious ethical concern and AZA considers abusive training practices to be unacceptable. Further, elephants that are untrained, unexercised, or unable to complete minimum behavioral requirements may be considered neglected and thereby abused. (AZA 2001)

Several cities and towns have introduced ordinances prohibiting the use of painful training and handling methods for exotic animals (such as electric prods). These include Pompano Beach, Tallahassee, Florida; Colinsville and Woodstock, Illinois; Southampton, New York. (PAWS 2001). There are also various laws in the U.K. governing the use of hitting or prodding livestock in markets, during transport and at slaughter, yet none of these laws covers elephants (see Box 6). Due to the definition of the term 'animal', the only laws that currently over elephants are the Protection of

Animals Act 1911 and the Welfare of Animals (Transport) Order 1997. The former act does state that no person shall cruelly beat or ill-treat an animal, and this could cover some instances of the use of excessive force as the cases illustrated in the '*Training*' section. However, this would have to be assessed on a case by case basis. More specific regulations govern the treatment of animals during transportation (see Box 6), yet this obviously only protects elephants during transport and not whilst residing in a zoo.

Box 6. <u>Legislation governing the use of physical punishment</u>

Protection of Animals Act 1911
("animal" – all animals)
1.Cruelty.-(1) (a) If any person-
(a) shall cruelly (b) beat, kick (c), ill-treat (d)…torture, infuriate, or terrify any animal, or shall cause or procure, or, being the owner, permit any animal to be so used…such person shall be guilty of an offence of cruelty withing the meaning of this Act…

The Welfare of Animals (Transport) Order 1997
("animal" – all animals)
15.-(2) No person shall use excessive force to control animals
(3) … no person shall use –
(b) any stick, goad or other instrument or thing to hit or prod any cattle of six months or under;
(c) any stick (other than a flat stick or a slap marker), non-electric goad or other instrument of thing to hit or prod any pigs.

The Welfare of Animals at Market Order 1990
("animal" - cattle, sheep, goats and all other ruminating animals, pigs, rabbits and poultry)
6.- (2) …it shall be the duty of any person in charge of an animal at market to ensure that the animal is not, or is not likely to be, caused injury or unnecessary suffering by reason of -…
(c) the animal being hit or prodded by any instrument or other thing…
8.- (2) … no person shall use in a market –
(b) any stick, goad or other instrument or thing to hit or prod any calves; or
(c) any stick (other than a flat slap stick or a slap marker), non-electric goad or other instrument or thing to prod any pigs.

The Welfare of Animals (Slaughter or Killing) Regulations 1995
("animal" - cattle, sheep, goats and all other ruminating animals, pigs, rabbits and poultry)
12.-(1) No person shall strike, or apply pressure to, any particularly sensitive part of the body of any animal…
(3) No person shall inflict any blow or kick to any animal.
(4) No person shall cause or permit any animal to be treated in contravention of sub-paragraph (1)…or (3) above.

The Secretary of State's Standards of Modern Zoo Practice do mention training (see the quote at the beginning of the '*Traditional elephant training*' section). Although the use of positive reinforcement is stressed, they do not rule out, or even mention, guidelines as to the use of punishment. In fact, they appear to confuse the term negative reinforcement with punishment, and state that this "must never compromise the welfare of the animal." They also state that "all training programmes should provide a net welfare benefit to the animal". There lies the crux of the problem, as traditional handlers stress that although physical punishment is used, the benefits outweigh the costs in terms of the elephant's welfare (e.g. Koehl 2000). This will be discussed at the end of this chapter.

There have also been reports of the use of electric prods, or 'hotshots', on elephants. These are the same prods that are used to control the movement of livestock, such as cattle and pigs. They deliver a 5000 volt shock with a very low amperage (0.0015 to 0.0040 amps) which lasts a few seconds (Cox's Medical/Vet 'Animal Coaxer', product no. 408062). Cattle prods were used during training at Scott Riddle's training school at Blackpool Zoo (CAPS 2001). Two weeks prior to the school, Riddle was said to have used electric prods, as well as ropes and a winch to pull the elephants, to establish his dominance. A volunteer worker at Blackpool Zoo was claimed to have stated that the elephants were trained to 'speak' (trumpet) by "prodding them in the back of the leg [with an electric goad] and shouting the command 'speak'" (CAPS 2000). The zoo later admitted that "goads were used once or twice during training…the voltage discharge will give no long term damage" (CAPS 2001). Chadwick (1992) also states that electric prods are sometimes used in zoos with an elephant is proving particularly hard to manage, and the elephant may be hosed down with water before being prodded if it continues to act uncooperatively. There are also anecdotal accounts of electric goads being used in other zoos and safari parks, for instance to make the elephants run faster and as a form of punishment during training (e.g. Ali 1991). It was also recently discovered that the director of a renowned elephant sanctuary for orphaned elephants, Daphne Sheldrick, permits the occasional use of electric goads on calves to "show them the boundaries of good behaviour" (Sheldrick 2000). She states that they are never used to tame the elephants, and the prods are never used on calves that are fearful or angry, or adult elephants. Instead, calves receive a "tiny 'zing'" when they begin to play too boisterously to teach them not to knock people over, and this only occurs after they have already been disciplined with a verbal reprimand and "the waggling of a finger". Furthermore, it is done immediately after the unwanted behaviour has occurred, in line with the principles of punishment. Anecdotal evidence from elephant trainers suggests that these are especially aversive, as elephants that have had experience with them are said to be very wary of any object that comes towards them (Desmond & Laule 1991).

The AZA standards also consider use of electric prods, and state that:

> 'Electrical devices designed for use on livestock, such as commercially manufactured electric prods and shocking collars/belts, are prohibited as routine training tools or for handling animals during exhibition. Electric prods are permissible only as an emergency safety device; however, their use is restricted to situations in which keepers feel the imminent need to defend themselves against elephant attacks, or to protect an elephant from possible injury.' (AZA 2001)

In the U.K., the use of electric prods on livestock is under tight control (see Box 7). Accordingly, electric prods can only be used on adult bovines and pigs that refuse to move and which have room to move ahead, and shocks can only be applied to the muscle of the hindquarters. However, the only legislation that includes elephants is the Welfare of Animals (Transport) Order 1997, due to the definition of ‘animal’. Thus, under this legislation, the use of electric prods are prohibited for transporting elephants (see Box 7).

Box 7. Legislation governing the use of the electric prod

The Welfare of Animals (Transport) Order 1997
(“animal” – all animals)
15.-(3) …Subject to sub-paragraph (4) below, no person shall use –
a) any instrument which is capable of inflicting an electric shock to control any animal;
(4) The prohibition in sub-paragraph (3)(a) above shall not apply to the use of any instrument of a kind mentioned in that sub-paragraph, on the hindquarters of any cattle over the age of six months or on adult pigs which are refusing to move forward when there is space for them to do so, but the use of any such instrument shall be avoided as far as possible.

The Welfare of Animals at Market Order 1990
(“animal” - cattle, sheep, goats and all other ruminating animals, pigs, rabbits and poultry)
6.- (2) …it shall be the duty of any person in charge of an animal at market to ensure that the animal is not, or is not likely to be, caused injury or unnecessary suffering by reason of -
… (c) the animal being hit or prodded by any instrument or other thing…
8.- (2) Subject to paragraph (3) below, no person shall use in a market –
(a) any instrument which is capable of inflicting an electric shock to control any animals
(3) The prohibition in paragraph (2)(a) above shall not apply to the use of an instrument mentioned in that paragraph, on the hindquarters of any cattle over the age of 6 months or adult pigs which are refusing to move forward when there is space for them to do so.

The Welfare of Animals (Slaughter or Killing) Regulations 1995
(“animal” - cattle, sheep, goats and all other ruminating animals, pigs, rabbits and poultry)
8. No person shall use, or permit to be used, any electrical stunning or killing equipment or any other instrument which applies an electric current to animals -
(a) as a means of restraining any animal;
(b) as a means of immobilising any animal; or
(c) except in accordance with paragraph 11 of Schedule 3, as a means of making any animal move.
11. No person shall use, or cause or permit to be used, to make any animal move any instrument which administers an electric shock, except that such an instrument which has been designed for the purpose of making an animal move may be used on adult bovine animals and adult pigs which refuse to move, provided that
(a) the shocks last no more than two seconds each and are adequately spaced out;
(b) the animal has room ahead of it in which to move; and
(c) such shocks are applied only to the muscles of the hindquarters.

The Welfare of Animals (Transport) Order 1997
(“animal” – all animals)
15.-(3) …Subject to sub-paragraph (4) below, no person shall use –
(a) any instrument which is capable of inflicting an electric shock to control any animal;
(4) The prohibition in sub-paragraph (3)(a) above shall not apply to the use of any instrument of a kind mentioned in that sub-paragraph, on the hindquarters of any cattle over the age of six months or on adult pigs which are refusing to move forward when there is space for them to do so, but the use of any such instrument shall be avoided as far as possible.

Welfare concerns regarding traditional training

Traditional training has a number of potentially detrimental effects on elephant welfare: 1) When young, elephants have the extreme experience of being ‘broken; 2) Throughout life, elephants have the threat or actual experience of aversive stimuli, both acute and chronic, including physical harm; 3) It relies on intense ‘personal’ relationships with handlers, which may be transient and unstable due to high staff turnover; 4) It may result in training power behaviours and the potential adverse consequences for physical health. However, it also brings some potentially very real and important benefits: 1) Preventative health care (e.g. foot trimming) is easy to carry out; 2) Veterinary diagnosis/care is greatly facilitated and does not require anaesthesia; 3) Relationships with handlers may mean that the elephants perceive its herd size to be greater than it actually is; 4) Behaviours that are allowed or trained (e.g. walks outside their enclosure; rides; performing trained behaviours) by this approach may have psychological and/or physical benefits. In this section we review these pros and cons of traditional training.

The potential effects of breaking

Our review of breaking wild-caught elephants in Asia highlighted the use of several methods that are a welfare concern, namely physical restriction for prolonged periods; deprivation of food, water and sleep and repeated beatings with sticks or elephant hooks. As reviewed in Chapter 3, most elephants currently held in Europe have been caught from the wild (59.7% Asians, 83.3% Africans), 21.0% of Asians have been imported from Asia, probably timber camps, and a small proportion have been born in zoos (19.4% Asians, 14.7% Africans). Thus, it is possible that many elephants will have been subject to the harsh breaking described for wild-caught elephants, although it is not possible to tell just how many. The fifth of the Asian population imported from Asia may have been captive born in timber camps, due to the ban on trapping in the wild imposed by most Asian exporting countries. However, the biggest exporter of Asian elephants, Burma, still allows capture from the wild and therefore it is reasonable to assume that at least some of these elephants will have been subject to a similar breaking procedure. It is less clear what happens to African elephants prior to importation, but some zoos certainly do import partially trained elephants (Amelia Terkel, pers. comm.). Furthermore, it also unclear what occurs with elephants born in European zoos, although training can occur from an early age (Olson 2002). This is likely to be dealt with on a case-by-case basis given that captive breeding, until recently, has been negligible.

The detrimental effect breaking may have on elephants in Asian is highlighted by work on mortality in timber camp elephants in Burma. Mar (2001) reports a peak in mortality in Asian elephants living in these camps during the ages of four to five years of age. Although this has not been subject to formal study, the author notes that this coincides with the taming process. A rise in mortality is an obvious indicator of poor welfare (see Chapter 1), and although this requires further investigation, it is enough to be of great concern.

Immediate physical effects

Deprivation of basic needs such as food, water and sleep compromise the welfare of animals. These practices violate two of the ‘five freedoms’ which protect the welfare of farm and laboratory animals, reinforced by the Farm Animal Welfare Council

(FAWC) and the Home Office Licensing of the Ministry of Agriculture, Fisheries and Food (MAFF, now known as DEFRA). These are: *freedom from hunger and thirst*, by ready access to fresh water and a diet to maintain full health and vigour; and *freedom from discomfort*, by providing an appropriate environment including shelter and a comfortable resting area. As yet, however, the Zoo Licensing Act 1981 does not explicitly prohibit these activities, and the animal welfare group CAPS has put forward a proposal to amend this Act to prohibit discipline by means of deprivation of food, water or rest (CAPS 2001).

Frequent use of the ankus, and other implements such as sticks, during breaking also compromise another two freedoms: *freedom from pain, injury or disease*, by prevention or rapid diagnosis and treatment; and *freedom from fear and distress*, by ensuring conditions and treatment which avoid mental suffering. Evidence given by experts involved in the Tuli elephant case leave little doubt that these elephants experienced a significant amount of pain and distress during the breaking procedure carried out by Asian mahouts. For instance, the elephant expert Joyce Poole (2001) states in her affidavit that: “The traditional "spirit breaking" method of taming elephants is by its very nature and definition cruel and inhuman. This method may have been used for centuries in Asia to train and dominate captive elephants, but as we approach the new millennium it is totally unacceptable and unethical”. This treatment, if it had occurred in the U.K., would be subject to review under the Protection of Animals Act 1911 which states that “no person shall cruelly beat or ill-treat an animal”.

Psychological consequences (possibly long-term)

The breaking process involves repeated exposure to aversives (either physical punishment or forced handling) that cannot be escaped and which the elephant has no control over. The end result is an elephant that no longer tries to escape or retaliate against its handlers or in any way try to resist being handled. Both the process and endpoint of breaking are comparable to those involved in learned helplessness (Job 1987; Mazur 1998). This state can be induced in laboratory animals. For instance, rats repeatedly exposed to inescapable electric shocks will cease to try to escape and simply sit motionless when they are shocked (Jackson *et al.* 1980). As similar state is seen in animals that are repeatedly defeated during confrontations, with the result that the defeated animal will rapidly learn to avoid or placate their adversary, and minimise the attention drawn to themselves in order to minimise the chances of having a repeat performance (Dimond 1970). Learned helplessness is a debilitating condition that has been likened to depression in humans (Seligman 1975). Animals and humans suffering from this condition develop the expectation that their behaviour has no effect on their environment, i.e. they develop a sense of hopelessness, which is generalised to a wide-range of situations (Overmier & Seligman 1967; Maier & Seligman 1976).

This is of concern from a welfare point of view, as animals and humans that have developed this condition show a range of impairments, including behavioural depression and emotional problems, and can even lead to death (Jones 1987). There is also evidence that helpless animals are poorer at learning tasks (e.g. Kendrick 1992). For example, exposing rats to inescapable shocks later reduced their ability to learn which of two arms of a maze allowed them to escape (Jackson *et al.* 1980). Animal that have experienced repeated social defeat may also experience growth retardation (e.g. rodents: Koolhaas *et al.* 1997) and display long term behavioural and physiological changes that resemble the symptoms of human psychopathologies, such as depression and anxiety (Ruis *et al.* 2001).

The effects of physical punishment and negative reinforcement: acute

It is clear that elephants can feel pain, as do other mammals (reviewed by Short & van Poznak 1992). For example, elephants possess pain receptors (nociceptors) close to the skin's surface (Shoshani *et* al. 2000), and have morphine-like substances in their brain that act like natural painkillers (Cheng & Yamashiro 1991). The question is, however, how much pain does an elephant experience when it is subject to physical punishment, and does this have a detrimental impact on their welfare? The impact on welfare potentially involves two attributes: a) the severity of the individual event; and b) the predictability and frequency of these events. These are considered in the following sections.

Hitting with the ankus or other implements

During elephant training, the ankus is used on some of the most sensitive parts of the body such as the trunk, inside of the elbows, backs of the legs and behind the ears (CAPS 2000). In cases involving severe physical punishment, such as when an elephant is hit hard with an ankus, stick or metal bar, there is no doubt that this causes pain, as highlighted by various experts during legal cases. For example, when the welfare scientist Professor Donald Broom was called in to comment on the welfare of an elephant caught on tape being beaten with an iron bar at Chipperfield's circus, he concluded from the behaviour of the elephant that it was feeling pain and suffering (Anon. 2001). The handler in question, Stephen Gills, was later charged with causing unnecessary suffering to the elephant under the Protection of Animals Act 1911 and imprisoned.

Behavioural responses to pain include vocalisation (Association of Veterinary Teachers and Research Workers 1989). These are also used by scientists to assess the degree to which stimuli are aversive and to judge the general welfare of animals (e.g. Broom 1986; Broom & Johnson 1993). Footage of the Tuli elephants and the National Geographic coverage of breaking show the elephants emitting loud, high pitched 'screams' in response to being hit by the trainers (Carte Blanche 1998). This indicates that these elephants were indeed experiencing pain and/or fear when they were hit.

There remains the question of whether less severe physical punishment, such as a softer blow with an ankus, which most traditional handlers admit to using, would inflict pain or cause little more than a mild sensation. There is no question that they find this aversive, as this underlies the very effectiveness of physical punishment. There is evidence that hitting induces fear in other species, shown by an increase in flight distance (e.g. cows: Breuer 1997; Munksgaard *et al*. 1997; Rushen 1999a; pigs: Gonyou *et al.* 1986; Hemsworth & Barnett 1991), and increase in defecation and urination whilst being hit (cows: Munksgaard *et al.* 1997). However, the acute effect that this has on elephant welfare has not been documented.

Aversive handling, such as hitting and goad use, is known to cause various welfare problems in a range of farm and laboratory species, reviewed by Hemsworth (1993) and Seabrook and Bartle (1992). These include a reduction in growth rate (e.g. Gonyou *et al.* 1986; Hemsworth *et al.* 1989; Breuer *et al.* 2000) and reproductive success (Hixon *et al.* 1981), for instance by reducing conception rates (e.g. Stoebel & Moberg 1982), litter size and mortality (Hemsworth 1993). These effects are thought to be the result of chronic stress (Hemsworth *et al.* 1981; 1986; and 1987). This is supported by observations of enhanced levels of plasma cortisol (a hormone associated with stress) following aversive handling (Hemsworth *et al.* 1991), and also in the presence of people who have handled them aversively (Hemsworth *et al.* 1981; 1986; 1987; 1989; and 1991). This elevation can reach chronic levels that could potentially interfere with growth (e.g. Paterson & Pearce 1992). Furthermore, even mildly aversive stimuli can have long-term effects if they are sustained, frequent and/or unpredictable (e.g. Cremaschi *et al.* 2000; Silberman *et al.* 2002), which is true of the frequent taps and prods with an ankus handlers used to 'cue' elephants.

Electric goads

The prods kept in zoos and safari parks are the same type as those used on farms. The effect prods have on elephants has not been subject to study, but there has been extensive research on the effect of electric goads on livestock, from which we can draw inferences.

The degree of pain felt by an animal when shocked is dependent on the intensity of the current. Electric prods are designed in such a way that they deliver virtually no amperage, which causes burns and injury, but instead store a high voltage charge. Despite the lack of physical damage, it is clear from research on a range of studies that the electric shock delivered by prods is highly aversive. This has been demonstrated with aversion learning techniques, which allow scientists to measure whether, and how much, animals find certain stimuli aversive. For example, pigs that were given one experience with an electric prod (two brief shocks) took significantly longer to enter a crate than those that were not shocked (Jongman *et al.* 2000). Pigs found this more noxious than a crate full of carbon monoxide, which itself is known to be highly aversive (Raj & Gregory 1995), leading Jongman *et al.* (2000) to conclude that electric prods represent a "welfare concern".

The application of electricity to the skin also causes an increase in heart rate due to activation of the autonomic nervous system, which affects sensory and motor functioning (Eckert 1988). Activation of this system is normally harmless and decreases to resting levels once stimulation has stopped, but it can be very dangerous if the shock is applied close to any vital organs causing an increased risk of heart flutters, breathing difficulties or stroke (Schwizgebel 1996). However, recommendations from the manufacturers of these products state that they should only be used on the muscle of the hind limb, as do the laws governing their use with livestock in this country (see Box 7).

Livestock that have been exposed to electric prods also show symptoms of stress. For instance, pigs that have been subjected to electrical stimulation show significant stress-responses (Veum *et al.* 1979; Becker *et al.* 1985), although, this study used small electrical doses over a relatively long period (4-6min) rather than the brief discharges from a cattle prod. However, a study by Zanella (2002) found that pigs loaded onto a trailer using an electric prod has significantly higher salivary cortisol, heart rates and rectal temperatures (all stress indicators, see Chapter 1) than pigs loaded with a hurdle. Pedersen *et al.* (1998) conducted a study on pigs using brief electric shocks and found sustained elevated cortisol levels that were significantly higher than in individuals that received gentle or minimal handling. The use of electric prods, along with other handling stresses, have also been reported to cause a reduction in conception rates: an indicator of chronic stress (Blecha *et al.* 1984; Broom & Johnson 1993). No such studies have yet been done on elephants.

Electric prods are considered to be the last resort by some who work with livestock (e.g. Grandin 2001), and some organisations have banned their use altogether (e.g. pigs: Assured British Meat 1999). In addition, some organisations have already banned the use of electric prods and collars for training dogs and circus animals due to concerns for the welfare of the animals involved (e.g. Anon. 2000; NCCAW 2001) and are discouraged by many handlers (e.g. Messent 1979).

The effects of physical punishment and negative reinforcement: chronic

Punishment is known to have several side effects. For instance, animals may show a similar emotional reaction in the absence of punishment when they are placed in the same situation (e.g. Kazdin 1975). Studies have shown that animals may react to the location where the aversive experience took place. For example, cattle subjected to electric prods were found to be less willing to move along the raceway where they have previously been shocked (Goonewardene *et al.* 1999; Pajor *et al.* 2000). Alternatively, animals can learn to associate aversive treatments with people in general or a specific handler (Hemsworth *et al.* 1994b; Rushen *et al.* 1999b). Generalised fear responses to people have been demonstrated in poultry (Barnett *et al.* 1993; Jones 1994), pigs (Paterson & Pearce 1992; Hemsworth *et al.* 1994b; Hemsworth *et al.* 1996a; Hemsworth *et al.* 1996b), and dairy cattle (Rushen *et al.* 1999a). For instance, pigs that had been shocked with electric prods had significantly elevated corticosteroids when approached by humans, and were also more hesitant to approach and interact with them, compared to pigs that had no experience with the prods (Hemsworth *et al.* 1987). Animals appear to be capable of discriminating between individual handlers (e.g. poultry: Gray & Howard 1957; Rovee-Collier *et al.* 1983; pigs: Tanida & Nagano 1995; Taylor & Davis 1998; Koba & Tanida 2001; cows: Rybarczyk *et al.* 2001), and hence show specific responses to people based on previous encounters with them. Cows that had previously been mistreated showed an elevation in heart rate when they were close to the handler that had inflicted this treatment (Rushen *et al.* 1999a), calves and dairy cows learn to avoid specific handlers as a result of aversive treatment (de Passillé *et al.* 1996; Munksgaard *et al.* 1997; Rushen *et al.* 1999a).

Thus, the use of physical punishment on elephants could lead to an association between the punishment and either the location or the punisher, although this has yet to be subject to study. The elephant may then experience fear when they are placed in the same location (i.e. the indoor or outdoor enclosure) or the handler. Given the fact that they will be in almost constant contact with both, this could constitute a welfare problem in itself. These 'fear memories' are known to be very difficult to eradicate, although the response can be suppressed by learning (Ledoux 1994), because the experience builds a 'subcortical circuit' in the brain, allowing the animal to make a rapid escape response in similar, dangerous situations (Ledoux 1994). The long-term effects of location and/or cues associated with aversive (even mild) stimuli have not been researched in elephants. However, it could play a role in the various signs of poor welfare zoo elephants display (see Chapters 7 to 10), and anecdotal evidence suggests that elephants do remember people who have treated them badly in the past (e.g. Lipman 2000).

Another well-known side effect of physical punishment is aggression, particularly when the recipient experiences intense pain (e.g. Kazdin 1975). Painful stimuli have been shown to induce aggression in humans and other animals, directed towards the person who is delivering the stimuli (e.g. Kazdin 1975; Berkowitz 1993; Polsky 1994; Schwizgebel 1996; Sullivan 2001). Anecdotally, for elephants, cruel training and taming by inexperienced people, has probably always been a major reason for accidents in elephant keeping (Schmid 1998). For example, in extensive systems, Hart (1994) reports that eight out of 17 drivers claimed that their elephants sometimes "got angry with them", and that primarily "it was provoked ... by beating". Elephants in intensive timber camps tend to be severely punished for any attacks or aggressive behaviour. This allegedly causes an increase in their "latent willingness to attack," particularly in musth bulls (Kurt 1995). Further possible causal factors in aggression directed towards handlers are discussed in Chapter 10.

Furthermore, the use of punishment during may suppress reproduction in both males and females. For example, Kurt (1992, cited in Kurt & Hartl 1995) suggests that the use of physical punishment can lead to a male refusing to mate. Hildebrandt *et al*. (2000) also reports that males 'dominated' by their handler, other female elephants or other males had lower sperm quality compared to those that were not. These issues are discussed further in Chapter 9.

Transient relationships between handlers and elephants

Traditional training relies heavily on a strong relationship being built between handler and elephant, the basic premise being that the handlers become the dominant members of the group. There are two main reasons why this may be of concern given the situation in zoos. First of all, handlers only have contact with the elephants during working hours and so the 'dominant herd members' disappear from the group on a regular basis. If, as suggested by anecdotal evidence from handlers, the elephants look to their handlers for security, such an attachment to humans may actually be detrimental to the elephants considering the large amount of time when the handlers are not present. Secondly, due to the recent rise in staff turnover in elephant departments (e.g. Ruhter & Olsen 1993) relationships between handler and elephant are often short-lived and transient. Such regular changes in the 'social structure' of the herd may be stressful for the elephants (discussed in Chapter 5). As yet, whether elephants do in fact view their handlers as a member of the group has yet to be studied, although anecdotal evidence suggests this may be the case (see '*Potentially enhanced herd size*' section), as does the effect of separation.

Beneficial effects of preventative health care and veterinary diagnosis

In traditional free contact systems, handlers are able to carry out regular preventative health care measures such as foot trimming and dental examinations, and treat minor veterinary problems such as abscesses and skin problems (e.g. Fowler 1978; Molter 1980; Schmidt 1982; Poole 1995; Koehl 2000). The regular physical contact also enables handlers to identify any health problems early on. This is obviously beneficial for the health of zoo elephants and also reduces the need for anaesthesia, which can be a risky operation (see Chapter 8). Yet, it also raises the question of why this degree of intervention is necessary for elephants but not other large mammals. The degree to which these benefits can also be achieved in other systems is discussed later in this chapter.

Potentially enhanced herd size

Another potential benefit of traditional training involves the position of handlers in the social system of the elephant group. If handlers are viewed by the elephants as another member of the group, the close interaction involved in traditional training may offset the problems of small social grouping in zoos (see Chapter 6) in that the size of the social group may effectively be the sum of elephants and handlers. There is some anecdotal evidence that elephants do view their handlers as another member of the group. For instance, the greeting ceremony between elephants, placing the trunk near or in the mouth of the elephant being greeted (Moss 1988), is mirrored in the greeting extended to their handlers: touching the handler's mouth with their trunk (Guerrero 1995). Furthermore, handlers state that in a free contact system, "...elephants look to the handlers for security..." (E. M A., 1992, cited in Desmond & Laule 1993), as elephants would do in the wild, particularly calves seeking comfort from their mothers (e.g. Moss 1988). Whether elephants actually do view their handlers as part of their social group has yet to be studied and this potential benefit is obviously highly dependent on this information.

Physical benefits of trained behaviours

As discussed in Chapter 4, zoo elephants often do not get enough exercise leading to excessive weight gain and thus exacerbating foot and joint problems (see Chapter 8) and possibly impairing reproductive success (see Chapter 9). One of the suggested benefits of traditional elephant training is that along with the regular performance of trained behaviours, elephants can be taken from walks outside their enclosure with the handlers and thus gain adequate exercise and improved health (Molter 1980; Dudley 1986; Sampson 2001; Schwammer 2001). A study by Kurt and Kumarasinghe (1998), reviewed in Chapter 4, revealed that zoo elephant that were trained regularly had significantly lower body weights to those that were not. This shows that training does improve the health of elephants by reducing excessive body weight, which is a significant problem in zoo elephants, although trained elephants were still significantly heavier than conspecifics in the wild and circuses. It was not specified whether these trained individuals were taken for walks out of their enclosure, but this appears to occur in only a handful of zoos. In addition, a study by Reimers *et al.* (2001) demonstrated that with suitable modification of the enclosure and husbandry, including the use of environmental enrichments, African zoo elephants may travel up to 5km per day *within* their enclosure, which although still short of what occurs in the wild, is comparable to that seen in wild Asian elephants (see Chapter 4).

Psychological benefits of trained behaviours

Training is said to a be a positive, enriching experience, through interaction with the handler and mental stimulation (Hediger 1955; Schmidt & Markowitz 1977; Molter 1980; Dudley 1986; Winhall 1998; Koehl 2000). Training in free contact systems can occupy a considerable portion of time, although this varies between facilities (see '*Traditional elephant training*' section). This is said to be one of the benefits of this system as it acts as a form of occupational therapy for the elephants (e.g. Koehl 2000). However, in some facilities, the elephants are made to perform the same behaviours time and time again, particularly those that participate in shows. This arguably reduces any potential enriching experience of training. Studies on other species have demonstrated that positive experiences with handlers can be very beneficial for the animal, not only reducing stress during novel procedures (e.g. Grandin 1989) but also been associated with lower levels of stereotypic behaviour (Mellen 1989). However, contact with humans that have previously handled the animal adversely, for instance by hitting and shouting at it, can have the opposite effect (e.g. Hemsworth *et al.* 1981; 1986; 1991).

A further possible disadvantage of traditional training is the degree of training which has led to the criticism that animals in this system have little time to 'be elephants'. As yet, the behaviour repertoire of elephants held in different systems has not been subject to study, and so this is impossible to assess at the present time.

Intervention in aggressive interactions

Free contact is said to allow handlers to intervene when fights break out between individuals, thus reducing any injuries that may occur. However, given the risks involved some facilities do not allow this (Desmond & Laule 1993; Schmid 1998).

The performance of 'power behaviours'

Behaviours that require a great deal of physical effort, such as headstands, hind-leg stands and sitting, are trained in some zoos. These have been terms 'power behaviours'. Although these could be trained in other systems, such as protected contact, they shall be considered here as they are most common in traditional systems.

One of the arguments for the performance of these behaviours is that some have been observed in wild elephants. It is true that wild Asian and African elephants have been seen to stand on their hind-legs to reach upper branches and leaves (Shoshani 2000). However, this is by no means a regular occurrence (Kuntze 1989) and is this very different to repeat performances in a daily show, for instance, which is very unnatural. As put by Mellen & Ellis (1996):

> "A good rule of thumb is to consider how often per day an elephant might exhibit a particular behavior in the wild; that number is a reasonable guideline for requiring that behavior in any one day (M. Schmidt, pers. comm.)."

A further difference is that elephants in the wild perform these behaviours when they want or need to, and not on command. There is thus the danger that elephants in zoos may be made to perform behaviours that may cause them discomfort or pain, and possibly cause physical damage.

There is evidence that the performance of these behaviours can physically damage the elephant, particularly if these are trained at an early age (Lindau 1970). Kuntze (1989) studied many circus elephants and concluded that some of the ailments diagnosed were the direct result of performing unnatural behaviours that required "static straining or over-exertion of individual parts of the body". He stressed that elephants are physiologically designed for dynamic movement, as opposed to the static straining that occurs when they have to remain in a physically demanding position for some time, such as when doing a hind-leg stand, can cause several serious health problems. These include damage to the joints including swelling of the joints (*bursitis praepatellaris*) and calloused elbows (*tyloma olecran*) (Kuntze 1989). Lindau (1970) also considered the common development of lameness in circus elephants a result of premature wear and tear of the joints, tendons, and muscles of the legs during tricks such as standing on one leg and mounting.

In addition, the excessive pressure placed on the diaphragm during sitting can cause hernias (*hernia perinealis*), in which the muscle wall ruptures causing internal organs to protrude through the opening (Kuntze 1989). This is a serious condition that can cause lead to death if the prolapsed inner organs (e.g. intestine, bladder, uterus) become strangulated and necrotic (Kuntze 1989). This internal pressure caused by these behaviours is a well-known fact among circus trainers who routinely command their elephants to defecate before entering the ring to avoid it occurring while performing (Kuntze 1989). Kuntze (1989) notes that hernias are rare in large domestic animals such as cattle. Lindau (1970) also notes that elephant trainers anecdotally confirm his belief that the performance of these behaviours can cause lameness in circus elephants, particularly standing on the front or back legs only, and this is particularly dangerous for young elephants.

There are currently no standards or legislation in Europe that cover which behaviours are acceptable to train. However, in India making an elephant stand on its hind legs, or on a spherical object, is prohibited in India according to the Prevention of Cruelty to Animals Act, 1960" Act (PCA Act) (Barua & Bist 1996).

Alternatives to traditional elephant training and their effect on the welfare of zoo elephants

In recent years, there has been a move away from the use of physical punishment in animal training in general and many handlers now use other methods (e.g. Woodhouse 1980; Desmond & Laule 1991; Tellington-Jones 1992; Pryor 1999; Davis 2001). Although there is still opposition from traditionalists, these methods are beginning to become generally accepted amongst animal handlers. The situation is similar with elephants, though perhaps at an earlier stage of development than for example dog or horse training, as most traditional elephant trainers are opposed to the use of alternative techniques. The sections that follow summarise the general principle behind each alternative technique, and highlight the main differences compared to traditional training.

Protected contact training

Until recently, all handlers trained elephants with traditional methods. Around ten years ago, however, an alternative system was formulated by Tim Desmond and Gail Laule of Active Environments Inc. in response to a request from the San Diego Zoological Society (Desmond & Laule 1991). The requirements were that no punishment was used, handler safety was ensured and necessary husbandry behaviours could be trained and carried out without the use of anaesthesia or restraint (Desmond & Laule 1991). The result was the “protected contact handling system”, defined by the AZA as “handling of an elephant when the handler and the elephant do not share the same unrestricted space. This includes confined contact which is the “handling of an elephant through a protective barrier where the elephant is spatially confined, as in an elephant restraining chute (ERC)” (AZA 2001).

In protected contact, the handler can physically interact with the elephant through a protective barrier of some type, while the elephant is not spatially confined (except in confined contact) and can leave the work area when they so wish (Otten 1994). The developers of the system have, however, given a more detailed definition: “protected contact is a system for managing elephants that uses positive reinforcement training as a primary method to modify behavior; directing the positioning and movement of the elephant is achieved through the use of targets. Keeper safety is achieved by elephant and keeper positioning relative to each other and to a barrier, which typically separates human and animal spaces. Trainers function outside the elephant social hierarchy and do not attempt to establish a position of social dominance". This method is now recommended by the AZA who "philosophically believe the future management of captive elephants should be based on methods associated with protected contact" (Wylie 1993, cited in Priest 1994). This system is used with at least some elephants in 21.9% of facilities in Europe that house female and young male Asians, and 35.5% that hold adult bulls (Griede 2000, see Table 7). It is the sole handling system in just 1.6% of zoos for training females and young males, and in 9.7% of zoos for training bulls.

The training methods used in this system thus differ to traditional methods in that no punishment or negative reinforcement is used (with the exception of "time-out", see below) and participation of the elephant is entirely voluntary (Desmond & Laule 1991). All the behaviours necessary for the maintenance of elephants can be trained in this system using operant conditioning (see section '*Operant (instrumental) conditioning*') similar to those used to train marine mammals. In protected contact systems, no ankus is used (but see later in this section). Instead, the main training tools are targets and a whistle (the 'bridge') and food rewards (see section '*Operant (instrumental) conditioning'*). The basic idea is that the elephant orients and moves towards the target, and this response is positively reinforced with a reward such as food (Desmond & Laule 1991; Laule & Whittaker 2001). The whistle is used to bridge the gap between the performance of the correct response and provision of the reward, which is crucial if the elephant is to know exactly what movement is being reinforced (Domjan & Burkhard 1986; Pryor 1999). Repeated pairings of the whistle and reward build up an association between the two until the whistle alone acts as a conditioned reinforcer. The only punishment used in protected contact is 'time-out' where the handler withdraws their attention for a short time, or in the most severe case the training session is ended, if the elephant is not co-operating or displaying unwanted behaviours such as aggression (Desmond & Laule 1991). However, participation is completely voluntary and elephants can simply walk away if they want to (though see later in this section). For this reason, some prefer to call it voluntary management (Kalk & Wilgenkamp 2001).

Training progresses in several stages. Firstly, the elephant may have to be habituated to the target so that it will approach and touch it. This process is particularly necessary with elephants that have undergone traditional training, where behaviours are trained using the ankus as negative reinforcement, and later as a cue. In traditional training, behaviours are trained by teaching the elephant to move *away* from the ankus (see section '*Traditional elephant training*'). In target training, the elephant is required to move *towards* the target and it can take some time for individuals to do so, particularly if they have had experience with more extreme methods of punishment such as electric prods (Desmond & Laule 1991).

Once the elephant has been habituated to the target, rewarding movements that approximate the required response (successive approximation) can shape the required behaviour. For instance, in the initial stages the elephant may be rewarded for any movement towards the target. This continues for some time so that the elephant learns the association between the movement and the reward. The criterion is then increased so that the elephant must move slightly closer to obtain the reward; again this continues for some time, and once successful the criterion is raised, etc. Eventually, the elephant will have been trained to walk up to the target, and can thus be positioned anywhere around the enclosure. Other targets are used to position specific parts of the body, and thus train actions such as leg and trunk lefts, ear presentation and so on. Combining the two can therefore be used to gain access to all parts of the elephant's body and carry out the necessary maintenance procedures, such as washing, foot care and blood draws (Desmond & Laule 1991).

Handlers must receive proper training in these techniques, including the theory behind operant conditioning, so that they can use them correctly (see later in this section). In addition, existing enclosures usually have to be modified to facilitate these procedures and ensure handlers are safe while working. For instance, all gates must be able to be opened from the outside and holes may be cut through the bars to allow access to feet and ears, etc. This helps ensure that handlers are in a position where they cannot be harmed by the elephants, which is aided by handlers working in pairs (a requirement in this system) so that one can constantly watch the animal while the other does the necessary work (Desmond & Laule 1991).

Training using this method has achieved swift results when done correctly. For example, Desmond & Laule (1991) report that a female Asian elephant, which was previously trained in a free contact system, took only six training sessions to enter a restraint chute. However, they had to adapt their methods to each individual in order to achieve this sort of result, in this case by increasing the proximity and the level of physical interaction between themselves and the elephant. In addition, these methods have been used to successfully train elephants that previously had no training or physical contact with handlers due to their aggressive nature, even with bulls in musth (Desmond & Laule 1991).

It has come to light, however, that not all facilities that claim to use protected contact are following the most basic recommendations of Desmond & Laule (1993) in three main ways: a) use of the ankus; b) handler training; and c) voluntary participation by the elephants. Firstly, facilities that have changed over from traditional training may continue to use the ankus as a cue in protected contact. The reasoning behind this appears to be that it is quicker to carry on with the old training method than starting from scratch with target training developed for protected contact systems. For instance, Iain Valentine, Director of Blackpool Zoo, U.K., claims that "the quickest way in a PC [protected contact] programme is the use to use the hook" (Iain Valentine, pers. comm).

Furthermore, in some facilities that claim to be using protected contact, handlers have simply moved behind a barrier but still give commands using the same dominance technique as in traditional training, using the ankus as a cue (Desmond & Laule 1993; Buckley 2001; Laule & Whittaker 2001). It also appears that traditional handlers are not willing to "drop their standards" when it comes to obedience (Iain Valentine, pers. comm). Laule, who helped develop this system (Desmond & Laule 1991), considers the use of the hook in protected contact as "totally unacceptable" (pers. comm), and that systems which continue to use dominance and the ankus are not using true protected contact (Laule & Whittaker 2001). The reason that such a practice could cause problems is that "it can create the perception that the trainer is attempting to dominate the animal [as it is used in traditional training] when the trainer is no longer in a position to back it up. This can lead to challenging and aggressive behaviour by the elephant" (Desmond & Laule 1993).

Secondly, another source of problems is that many handlers do not get the necessary training in behaviour theory and operant conditioning principles, as is essential for these methods to be used effectively. Notably, in some facilities in the U.S.A. handlers are required to take written exams in these subjects (Priest 1994), but this is not the case in the U.K. or the rest of Europe. Desmond & Laule (2001) stress that "incompetent and inconsistent use of positive reinforcement training can create a frustrated, confused animal".

Thirdly, another of the main principles of protected contact is that participation in the training session is voluntary. However, some facilities will attempt to encourage participation by conducting training sessions in a specific area away from the rest of the group, which lacks as many distracting stimuli as possible (Scott Blais, pers. comm.). Thus, the elephant may be given the choice of either participating in the training session or doing nothing. This is obviously very different to the situation when an elephant is asked to participate in a training session while it is free to interact with other group members, wallow or carry out some other activity. This former situation obviously removes much of the voluntary nature of the session and is another example of how the basic principles of protected contact are being violated in some facilities.

Thus, much of the debate surrounding what method of handling provides the greatest benefit to the elephant is clouded by the fact that facilities claiming to use protected contact may in fact be using an amalgamation of this and traditional training. Thus, when we consider the welfare pros and cons of this method in the sections that follow we use 'protected contact' to refer to the system that was designed by Desmond & Laule (1991).

A major difference between traditional and protected contact training is that the latter does not require the domination of the handler over the elephants. Thus the process of breaking is no longer deemed necessary (see '*Breaking*' section). Similarly, protected contact training does not involve the use of physical punishment and so all the welfare concerns regarding the use of excessive force, such as beating with the ankus and the use of electric prods, are also not applicable.

Degree of preventative health care

Concern has been voiced over the health of elephants managed in protected contact systems. For instance, foot health, which is a major problem in zoo elephants (see Chapter 8), is said to be poorer in protected contact systems (e.g. Molter 1980; Priest 1994; Koehl 2000; Schwammer 2001) but others disagree (e.g. Roocroft & Oosterhuis 2001; West 2001). Elephants given protected contact training can, and are, trained to present their feet for trimming and veterinary treatment, and given adequate training and enclosure design, a high standard of foot care can be achieved (e.g. Gibson & Flanagan 2001; Kalk & Wilgenkamp 2001; Kam 2001). The general consensus of specialists at a recent conference on elephant foot care was that this system could provide the appropriate foot care, albeit requiring more time and specialised facilities (Fowler 2001). Skin care has also been voiced as an area of concern in protected contact systems (Molter 1980; Koehl 2000), although again others disagree (e.g. Roocroft & Oosterhuis 2001). Given the necessary enclosure design, handlers are still able to wash and scrub elephants (Desmond & Laule 1991), and access to elephants can be achieved 80% to 90% of the time with repeated attempts (Desmond & Laule 1993). More importantly, as discussed in Chapter 4, an enclosure that includes pools, wallows, scratching posts of appropriate textures and at varying angles and an opportunity to dust-bathe is very important for the maintenance and health of elephants' skin in captivity. The provision of such facilities reduces the need the extensive manual washing and scrubbing that generally occurs in traditional systems, and are included in the AZA and EAZA standards (EAZA ; AZA 2001, see Chapter 4).

Degree of physical benefits of trained behaviours

It has also been suggested that elephants in protected contact do not gain the benefit of physical exercise through trained behaviours and walks outside the enclosures that can be achieved in free contact systems. As already mentioned, training itself does appear to have beneficial consequences in terms of reducing body weight (see Chapter 4), but the degree to which this can be achieved in free contact versus protected contact systems has not been compared. Elephants in protected contact systems can be trained to perform behaviours that provide exercise on a regular basis, as they can in free contact systems (Desmond & Laule 1991). Although they cannot be removed from their enclosure, as discussed in the previous section, enclosure design and husbandry can have a great effect on the amount of exercise gained by zoo elephants within their enclosure (Reimers *et al.* 2001).

Degree of psychological benefits of trained behaviours

There have been concerns that managing elephants behind a barrier, such as in protected contact, removes a great deal of the interaction between handler and elephants and that the loss of this arguably enriching experience is detrimental to elephant welfare (Desmond & Laule 1991; Laule & Whittaker 2001). For this reason, many refer to the system as 'limited contact' or 'segregated contact' (Laule 1993). Positive experiences with handlers can be very beneficial (e.g. Grandin 1989; Mellen 1989). The developers of protected contact do stress the importance of physical interaction between handlers and the elephants, which can still occur in protected contact, albeit through a barrier (Desmond & Laule 1991; Desmond & Laule 2001). In fact, given that the relationship between handler and elephant is no longer based on domination and the elephant does not have to comply to all commands, the relationship is said to be more enriching than in traditional systems, when done correctly (Desmond & Laule 2001), although no data exist to test this. However, the AZA standards state that handlers should aim to achieve close to 100% compliance, which appears contradictory to this basic principle of protected contact (AZA 2001). Furthermore, elephants that have been changed from traditional training to protected contact have been observed to become more socially interactive with other elephants in the group (Desmond & Laule 1994).

In protected contact, elephants get to choose whether they wish to participate in a training session (elephants actively participated in 99% of 365 training sessions: Laule & Desmond 1992), they are also able to display a greater repertoire of behaviours and 'experiment' with different actions without being punished for it, as they would in traditional training. Thus skilled trainers will reward the animal not just for performing the specified action, "but for more subtle and subjective actions like 'problem solving' a task, offering 'creative solutions', and 'trying' hard" (Desmond & Laule 1993). Elephants in protected contact can still participate in shows, and Priest (1994) reports that at that time, none of the elephants at San Diego Zoo had refused to participate in the show. Positive reinforcement training has been shown to have beneficial consequences in a range of species, such as a reduction in the frequency of stereotypic behaviours, an increase in positive social interactions within the group and an increase in activity (e.g. Cox 1987; Desmond & Laule 1991; Bloomsmith 1992; Laule 1993). In addition, in protected contact training, animals gain more control and choice over events (e.g. Mineka *et al.* 1986). Furthermore, in protected contact, the beneficial enriching experience of training can also be gained by elephants that would not receive traditional training, such as dangerous animals and musth bulls (Priest 1994).

Possible improvements in behaviour

Protected contact training is reported to lead to a dramatic reduction in aggression in some elephants (e.g. Maddox 1992). For instance, a study carried out by Desmond & Laule (1991) found that the aggression of an African bull elephant, considered to be very dangerous and thus kept in a no contact situation, almost completely disappeared after it was trained in a protected contact system. This was attributed to the handlers ignoring any aggressive behaviour and rewarding gentle, non-aggressive behaviour. This elephant was therefore in a position to gain the numerous benefits attributable to training, including essential veterinary treatment such as foot care. Physical intervention is no longer possible in protected contact, but using training techniques such as those described above and "cooperative feeding", aggression problems can be reduced, as shown in various species (Desmond *et al.* 1987; Bloomsmith *et al.* 1992).

Potential disadvantages of introducing a barrier between the handler and elephant

What also appears to be in question is the effect on elephant welfare when management changes from free contact to protected contact due to removal of the handler from the 'social group'. As reviewed in the '*Traditional elephant training*' section, the handler aims to be integrated into the herd in free contact systems. Under this premise, physical removal of the handler would be equivalent to placing a group member behind a barrier and thus restricting physical interaction. Guerrero (1995), when considering the benefits of both systems, notes that some elephants appear to find this particularly difficult. Some individuals moved to protected contact attempt to greet their handlers, and continually try to solicit their attention (Guerrero 1995). Physical contact certainly plays an important role in the maintenance of social bonds in the wild (e.g. Moss 1988). These problems appear to be largely dependent on experience, as they do not occur in elephants that have not experienced free contact previously (Guerrero 1995). Furthermore, Desmond & Laule (2001) recommend that when changing over gradually from free to protected contact, the elephants should be trained by a *different* set of staff in the beginning. It is only when the elephants are competent in basic procedures, and have hence learned the new set of rules, that the original staff then start to work with them in a protected contact situation.

Passive Control

Another handling system has been developed in recent years by Carol Buckley and Scott Blais who run the Elephant Sanctuary: an 800 acre facility in Tennessee, U.S.A.., founded in 1995 that houses retired female elephants from zoos and circuses (Buckley 2001). Both Buckley and Blais come from a background of traditional elephant training and formulated this system over many years (Buckley 2001). Instead of attempting to dominate the elephants as in traditional training, handlers in this facility build up a social bond with the elephants and become "good providers" and "an accepted and bonded member of the herd" (pers. comm., Carol Buckley). No punishment or negative reinforcement is used, as in traditional training. Nor do handlers remove their attention (time-out) when an elephant fails to respond or exhibits unwanted behaviour such as aggression (see previous section) as in protected contact systems. Instead, with passive control elephants are "asked to comply", never given a command, and are reinforced for co-operating with positive reinforcement such as food rewards, physical interaction and verbal praise (Buckley 2001). The only behaviours that are trained are those required to undertake basic maintenance and veterinary procedures. What also makes this method unique is that it is used in both protected contact and free contact systems, and thus refers to the training method rather than the physical environment.

When an elephant arrives at the sanctuary it is initially managed with no contact and passive control. With time, and depending on how the elephant responds to staff, it may be moved to protected contact, and then free contact. Emphasis is placed on the individual elephant and how they respond to each individual handler. For instance, new staff members are initially not allowed to interact with the elephants at all, so that the elephants can slowly become familiar with their presence. With time, the handler is then involved in the management of the elephants, but no contact is allowed and the handler cannot communicate with the elephants either physically or verbally. The principle behind this is that it is up to the elephant to decide when they wish to interact with the handler, not the other way round. If the behaviour indicates that they do wish to interact, for instance by attempting to initiate contact, the handler may then do this in a protected contact situation. The handler may then move in with the elephant to a free contact situation if this is deemed appropriate and safe by the senior handlers (Blais and Buckley). The handler may become involved in training once a strong relationship has been built up with the elephant. This involves the same target training as used in protected contact (see previous section), but the handlers do not use any punishment, even 'time-out'. Instead, the elephants are rewarded for the correct response with food rewards, praise and physical interaction, and training sessions tend to end when the elephant has responded well, lost interest or no longer wishes to participate.

As with other elephant training, this requires a certain degree of skill to detect the nuances of behaviour of individual elephants, which is particularly important when the handler moves to free contact handling. Progression to the different stages differs with each individual elephant, depending on how they react to each handler. Thus, a handler may be able to work in free contact with one elephant but not interact with another at all depending on each individual relationship (Scott Blais, pers. comm).

Whether passive control is possible in a zoo setting, and hence a viable alternative to other training methods, is debatable. The Elephant Sanctuary differs in many respects to a typical zoo environment. The elephants are free to roam over a very large area (222 acres) of natural grassland and woodland. This almost completely removes the need for foot and skin care once the elephants have been there for some time (see Chapters 4 & 8). In addition, the elephants decide when and what they do, for instance they move to the indoor enclosure when they choose to. This is very different to the zoo setting, where there is only a limited period of time that staff are present (but see below). Finally, there are presently only four staff members and at least one member is there at all times. They therefore have the time to build up a strong relationship with each individual elephant, as opposed to many facilities that have a very high staff turnover (Molter 1980; Ruhter & Olsen 1993). Finally, only female elephants are held, and therefore there are no problems associated with housing adult, particularly musth, bulls.

Although this system has not yet been attempted in a more conventional captive setting, the founders of passive control, Buckley and Blais, are convinced that it is possible given suitable modifications, for instance by allowing flexibility in the strict schedule and by modifying enclosure design. However, Gail Laule, one of the founders of the protected contact system, believes that it would be impossible to replicate this in a zoo setting (pers. comm). Protected contact as designed by Laule and Desmond (i.e. without the use of dominance and the hook) is very similar to passive control in a protected contact system, and thus the various pros and cons of this system also apply (see following section). But the movement to free contact without the use of domination is in question. This is discussed further in the section '*Comparison of different methods in terms of welfare*'.

In theory, passive control methods provide the best of both worlds. Handlers are able to maintain a strong physical relationship with their elephants without the need for breaking, domination and physical punishment, and thus the various associated welfare concerns. Elephants can be trained to allow basic maintenance and veterinary procedures to be carried out, and so foot health, skin care, etc. is not a problem. The various benefits of a positive relationship between animal and handler and training can therefore be reaped (reviewed in the previous two sections). Handlers at the sanctuary have reported various improvements in health and behaviour of the elephants held there, including a reduction in aggression, great improvement in foot health and exhibition of social behaviour akin to that seen in wild elephants (Buckley 2001). Importantly, this system provides elephants with choices regarding how and where they spend their time, and thus affords them at least some control over their environment: an aspect which is generally lacking in many traditional and protected contact systems. A lack of environmental control can cause a range of behavioural and physiological problems (e.g. Weiss 1972, Overmeir *et al.* 1980), and thus may be a potential welfare problem in these systems that do provide this. However, as reviewed in the '*Passive control*' section, this is confounded by the many differences that distinguish The Elephant Sanctuary from traditional zoos, such as the huge amount of space available. As this method has never been used in such a zoo setting, it is therefore impossible at this stage to judge whether passive control is a viable alternative to traditional and protected contact training.

No contact

No contact, or hands-off, management is defined by the AZA as "handling of an elephant with no contact made unless the elephant is chemically sedated" (AZA 2001). In this sense, this system involves treating elephants like any other large, potentially dangerous animal, but see the requirements of the AZA below. This system is often used with individual elephants that are considered to be too aggressive to be handled, although many have now been moved to protect contact management (see '*Protected contact*' section). For instance, no contact is used in combination with other handling systems in 20.3% of facilities with Asian females and pre-pubescent males, and 25.8% with Asian bulls (Griede 2000, see Table 7). There are also some facilities that house the entire group hands off (e.g. Ramat Gan, Israel and Parque de la Naturaleza de Cabarceno, Spain) and no contact is the sole handling system in 10.9% of zoos with Asian females and young males, and 38.7% with adult bulls. Elephants managed in this way are not trained to respond to commands. The AZA do not recommend that this is main form of management (Otten 1994), and in their standards they state that all elephants must be trained to "permit a complete body daily exam (include feet, eyes, ears, open mouth and tongue, teeth and tusks) for any sign of abnormalities", "to accept injections, oral medications, insertion of ear or leg vein catheters, treatment of wounds, enemas, and urogentical examinations" and "to accept regular collection of blood, urine, feces, saliva, semen skin biopsy, and temporal gland secretion (AZA 2001). Little research has been done on elephants managed in this way, but the possible pros and cons are discussed in the following section.

As with the other systems there are numerous benefits and disadvantages of no contact relating to the absence of training. Firstly, as with protected contact, welfare concerns about the use of physical punishment and deprivation are not applicable, the process of breaking is not required, and there is no question of dominance or control. Conversely, there are various objections to hands-off management because of the lack of training. Handlers are not able to perform routine foot or skin care, unless anaesthetic is used, and Schmid (1998) states that this will be necessary in this system. This carries serious risks (see Chapter 8), and measures that reduce this risk (e.g. the use of ropes and controlled lying down) are not possible with elephants kept in no contact (Bush 1996; Schmid 1998). There have therefore been claims that elephants in these systems have more foot problems than trained elephants. No data are available to determine whether this is actually the case. However, as mentioned in the previous section, this is also influenced by enclosure design. For example, hygienic conditions, the use of natural substrates, access to a pool, mud wallow, dust baths and scratching posts are all linked to improved foot and skin health (see Chapter 8). Thus, the condition of elephant's feet in this system will be at least partly be dependent on whether or not these facilities are available.

As with protected contact, elephants kept hands-off are reported to get less exercise compared to those in traditional systems. They do not participate in training sessions or shows, and they cannot be taken out of the enclosure for walks. However, as discussed in the previous section, adequate enclosure design and husbandry can ensure sufficient exercise is achieved (e.g. Reimers *et al.* 2001).

The potentially enriching quality of training is no longer applicable in this system. Positive reinforcement training has been shown to be an enriching experience for many species held in zoos with numerous beneficial welfare consequences (e.g. Cox 1987; Desmond & Laule 1991; Bloomsmith 1992; Laule 1993). It is therefore recommended that this is compensated for by using other environmental enrichments (Schmid 1998), such as scatter feeding, hiding food, adding toys and scents to the enclosure (Green 1989, Leach *et al.* 1998, Gilbert & Hare 1994, see Chapter 4;). Adequate social grouping is possibly the most effective environmental enrichment, particularly for highly social elephants (e.g. Rees 2000). Environmental enrichments can have several beneficial consequences, such as increased activity and reduced abnormal behaviour (e.g. Shepherdson *et al.* 1990; Carlstead *et al.* 1991; Forthman *et al.* 1992).

Handlers of elephants in no contact systems are not able to intervene when aggression breaks out in the herd, either physically or by reducing aggression through training (Desmond *et al.* 1987; Schmid 1998) as in traditional and protected contact systems (see previous section). Therefore, as Schmid (1998) points out, it is essential that a no contact group consists of “well-socialised” compatible individuals where aggression is not a problem.

In contrast, there are several benefits of a no contact system, providing that the conditions already mentioned are met, i.e. the use of environmental enrichments, provision of substrates for foot and skin care (available both indoors and outdoors) and a compatible social group (Schmid 1998). Firstly, elephants kept in this way can have ‘nearly natural’ conditions (Schmid 1998), particularly if they are kept in a more natural social group containing a range of age classes, ideally a family group (see Chapter 6). This, along with the provision of enrichments would facilitate the performance of more species-typical behaviour compared to trained elephants, although this has yet to be tested. However, Schmid (1998) points out that facilities rarely provide the necessary preconditions to yield these benefits, although this could be due to the lack of experience as it is a relatively new system.

Table 15. Summary of the key features of different training methods

The table below is based on a table published by Schmid (1998), although we have mainly used only those sections that relate to the welfare of the elephants. We have also added factors reviewed in this chapter. Boxes marked with an '✓' indicate that the characteristic is applicable, or is possible, those marked with an '×' indicate that the characteristic is unnecessary or impossible using that method, and '✓×' denotes that the characteristic may or may not occur, depending on management within individual zoos and/or enclosure design. Some characteristics are highly dependent on factors other than training method, such as enclosure design or group composition, and these are marked with an '*'. †In Schmid's table, only free contact provided sufficient movement, but we disagree for reasons stated in the text.

Characteristics	Traditional training/free contact	Protected contact training	Passive control (free & protected contact)	No contact/ hands-off
Training	✓	✓	✓	×
- breaking	✓	×	×	×
- social domination by the handler	✓	×	×	n/a
- use of physical punishment	✓	×	×	n/a
- compliance mandatory	✓	×	×	n/a
- possible with all elephants (e.g. aggressive individuals)?	×	✓	✓	✓
- performance of power behaviours	✓	×	×	n/a
Physical interaction with handler	✓	✓	✓	×
Intervention in social conflicts	✓	✓	✓	×
Nearly natural social group*	×	✓	✓	✓
Associated with species-typical behaviour*	✓×	✓	✓	✓
Chaining	✓	✓×	×	×
Adequate foot and skin care	✓	✓	✓	✓×*
Treatment without anaesthesia	✓	✓	✓	×
Sufficient exercise*†	×	✓×	✓×	✓×
High risk of accidents	✓	×	unknown	×

Summary

- Several handling systems for zoo elephants are in use, which dictate what type of training is used: traditional training is used in free contact systems; protected contact training is used in protected contact systems; passive control is used in both free and protected contact systems; and no training is used in no contact systems.
- Traditional elephant training (as used by mahouts and many zoos) is based on a system of dominance, the principle being that the handler becomes the dominant member of the herd and thus maintains control of the subordinate elephants. It allows free contact between handlers and the elephants. Training uses negative reinforcement (pain/discomfort) and punishment, as well as positive reinforcement, and elephants must comply with commands. This is the only system where 'power behaviours' are trained. Elephants can be taken for walks around the zoo with their handlers.
- A critical examination of the underlying principle of traditional training, i.e. dominance, suggests that elephants are unlikely to view their handlers as high ranking members of the herd. In traditional systems in Asia, dominance is said to be established once the elephant has been 'broken'. Breaking involves severe physical restriction, deprivation of food, water and sleep, the use of, sometimes severe, physical punishment, and rewards such as affection and food. Captive-born timber elephants are subject to less severe breaking involving physical restriction, but published details are not available concerning what occurs in zoos and procedures are not monitored. There is no equivalent of breaking in the natural social system of the elephant, where dominance is primarily determined by size; disputes are resolved through threats, displays and displacement and rarely physical aggression; and the hierarchy is said to resemble a 'democracy'. A further contrast is that matriarchs are with the herd almost constantly throughout their lives, compared to zoos where handers are present only during working hours and where staff can change regularly. The resultant obedience of the elephant is thus more likely to be due to a combination of conditioning, habituation, fear and learned helplessness, rather than an acceptance of a subordinate position in a social system that includes the handler.
- The methods handlers use to maintain 'dominance' in traditional systems involve psychological means, physical restriction with ropes and chains, and physical punishment. Handlers may also take steps to 're-establish dominance' if an elephant is disobedient. This 'discipline' may involve physical restraint and severe physical punishment. Again, it is highly unlikely that handlers are 'maintaining' or 're-establishing dominance', but are instead simply strengthening the conditioning achieved during breaking or training.
- Reports of elephants physically attacking, and in some cases killing, their handler may relate to the methods used during training. For instance, the use of physical punishment has been suggested to cause the build up of 'resentment'. Another possible risk factor is high staff turnover.
- The methods used to 'maintain dominance' are also used to train behaviours and the ankus, or elephant hook, is the basic tool used. Following initial training, however, the ankus is mainly used simply as a cue. The degree to which aversive techniques are used varies between facilities and some are known to use the electric prod as a training tool. Use is often at the discretion of an individual handler and not monitored in any way.
- The process of breaking has severe welfare implications for elephants due to the apparently common use, at least in Asia, of severe physical restriction, deprivation of food, water and sleep, and the use of severe physical punishment.
- Physical punishment such as repeated beating with an elephant hook potentially compromises the welfare of elephants, although the threshold is uncertain. Use of the electric prod on livestock has been shown to be stressful and highly aversive, and its use

is under strict control with these species. Rough handling could also lead to chronic stress (e.g. as seen in pigs), possibly because of repetition and associations between pain and particular people and/or locations.

- Traditionally trained elephants commonly perform 'power behaviours' such as standing on the hind-legs and sitting. Although similar behaviours are occasionally seen in wild elephants (e.g. standing on hind-legs to reach upper branches), repeated performance, at least in circuses, is associated with several health problems. These include hernias, swelling of the joints and other premature wear and tear of the joints, tendons and muscles of the legs.
- There are no good data on the welfare consequences of different training regimes. However, bulls that have been identified as 'subordinate' to keepers (or female elephants) may have lower sperm quality and lower testosterone levels. On the other hand, regularly trained elephants have lower weights compared to those that are not trained (see Chapter 4).
- In protected contact elephants are separated from the handler by a barrier at all times, behaviours are trained using positive and negative reinforcement, and punishment (time-out) with the help of targets. Compliance is not mandatory and so this training method is sometimes called voluntary management.
- Comparison of protected contact with traditional training indicate that: i) breaking is not required and physical punishment is not used in the former system; ii) experts state that foot and skin care can apparently be adequately achieved; iii) sufficient exercise can be achieved given adequate enclosure design and husbandry; iv) the loss of close physical contact with the handler, and the removal of the handler from within the social group may be stressful for elephants changing over from free (traditional) to protected contact, but this may be minimised with the appropriate procedure; v) elephants in protected contact can benefit from the enriching qualities of training more than traditionally trained elephants, as the latter must comply with commands; and vi) aggressive behaviour can be reduced through training in protected contact.
- Passive control has only recently been developed and is only used in handful of facilities. In this system, no dominance or physical punishment is used and compliance is entirely voluntary. Similar operant conditioning techniques to those used in protected contact are used, but no negative reinforcement is used. Passive control can be used to work with elephants in both protected and free contact systems. Due to the fact that the facilities that use this technique are sanctuaries, and thus differ in several respects from zoos, and it has yet to be tried in a zoo setting, its use as a viable alternative to other zoo elephant training techniques is currently questionable.
- Comparison of passive control with protected contact and traditional training suggests that this method may provide the greatest welfare benefits to the elephants. As well as all of the above attributable to protected contact training, elephants can maintain a close physical interaction with their handlers (if they so wish). However, the method remains unproven in a zoo setting and so cannot currently be considered a viable alternative to other training methods, particularly given handler safety concerns.
- No contact (hands off) management involves no training at all and is comparable to the management of other zoo animals. Elephants must therefore be anaesthetised in order to receive any handling or veterinary treatment. It is thus important that elephants kept in this way have high quality facilities to minimise the need for human intervention.
- No contact (hands off) management is potentially capable of providing the most natural environment for zoo elephants. However, these benefits are wholly dependent on adequate enclosure size, design and social grouping. These are rarely found in European zoos (see Chapters 4 & 6) and given that maintenance procedures such as foot care would have to be carried out under general anaesthetic, which carries significant risks, it is unlikely that this method would be beneficial in most existing facilities.

Chapter

7

Mortality rate

The level of premature mortality found in a population is a clear indicator of welfare (see Chapter 1). In this chapter, we first discuss longevity in the wild in extensive systems in Asia, and in zoos. We then quantify age-specific mortality rates for Asian and African elephants in European zoos using life table analysis. These data are then compared with mortality data for several wild populations.

Longevity

Most species have a greater life expectancy in captivity compared to their wild counterparts, due to the reduced risks of disease, predation, starvation and competition (e.g. Conway 1986; Mallinson & Barker 1998). In contrast, estimates for elephants suggest that they live longer in the wild than in zoos. For instance, Moss (1988) estimates that African elephants live for up to 65 years in the wild. Similar longevity estimates exist for Asian elephants, most referring to those held in timber camps, where 10% to 22.5% reach 60 years or over (Schmidt & Mar 1996, cited in Schmid 1998; Gale 1974) and individuals as old as 79 have been reported (Sukumar 1989). In contrast, data from the studbooks reveal that out of 517 Asian and 238 African zoo elephants of a known age (dead and alive), none have lived to 60 years, and the maximum recorded age is 56 in Asians and 50 in Africans.

Furthermore, the mean life expectancy (i.e. the mean age at death) of elephants in European zoos is just 15 years in Asians and 16 years in Africans, if all deaths are included. Recalculating these figures to exclude very young calves under one year of age (because of the possibility that deaths have very different causes, e.g. stillbirths, infanticide, and rejection) caused a slight increase in life expectancy to 21 years in Asians and 18 in Africans but even when mortality in the first five years were excluded, life expectancy was still only 24 years in Asians and 20 in Africans. In contrast, Schmidt & Mar 1996 (cited in Schmid 1998) report that Burmese working elephants have a mean life expectancy of 30 years (this may include infant deaths). Data on the average life expectancy in wild elephants is difficult to find. Calculations using data provided by Laws (1975) reveal a similar life expectancy for wild African elephants when all the data are included (14.1 years cf. 16 years in zoos), and also when deaths under one year are excluded (21.8 years cf. 21 years). However, excluding individuals that died before reaching five years of age reveals a far longer life expectancy in wild Africans (34.0 years) compared to those held in European zoos (24 years), reflecting the unusually high infant mortality in Laws' (1975) study compared to other estimates for wild populations (see the following section).

Analysis of the EEP studbook data revealed that female Asian elephants born in zoos have an average life expectancy of 15.4 years (range 4.5 - 37.9 years) compared to the average 25.1 year (4.3 – 49.5 year) life span of those imported from the wild (see Figure 10). A similar result was found in male Asian elephants. On average, captive-born males lived to be 19.1 years of age (4.3 - 40.8), whereas wild-caught males reached 26.9 years (11.7 – 49.8 years). A General Linear Model, including sex as a factor, revealed that longevity (which was log-transformed to meet the assumptions of the model) was significantly affected by source ($F_{1,\ 109} = 9.82$, $p < 0.01$), such that captive-born elephants die significantly younger than those caught from the wild. The age at which wild-caught elephants were imported did not affect life expectancy ($F_{1,\ 109} = 0.07$, $p > 0.05$). There were no significant interactions between these variables, including sex, showing that this effect was true for both males and females. These data exclude elephants that died at three years of age or younger, which is the average age at which Asian elephants were imported (both males and females). This was to exclude the possibility that they had already undergone the usual juvenile peak in mortality (see next section) before being imported, and the age at import was further controlled for by inclusion in the analysis. Insufficient data were available to analyse data for African elephants.

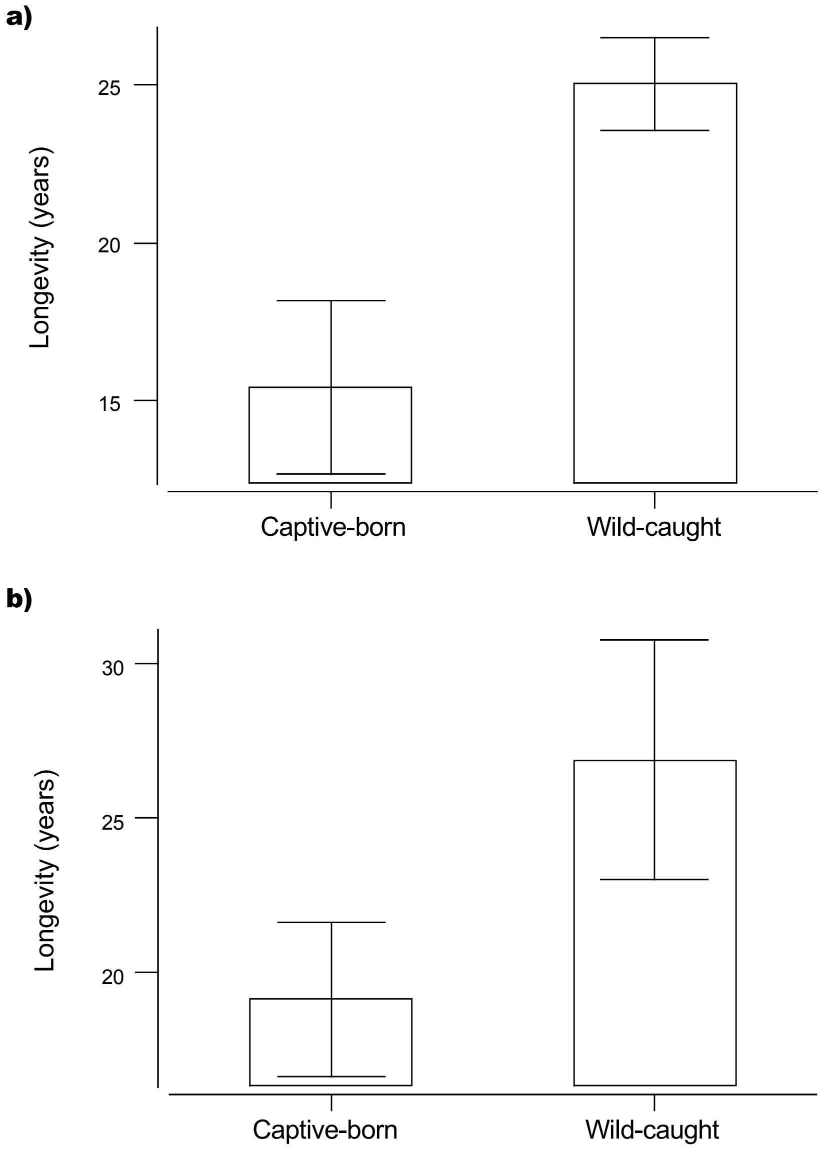

Figure 10. Longevity of captive-born and wild-caught a) female and b) male Asian elephants in European zoos

Data from the EEP studbook showed that captive-born elephants have a significantly lower life expectancy compared to those caught from the wild. These data exclude deaths of three years (the average age at importation of wild-caught elephants) and under.

A further possible risk factor that could affect female longevity is whether or not an individual has borne calves (see Chapter 9). A similar analysis to that described above was conducted on the

EEP data, but revealing no significant effect in Asian zoo elephants ($F_{1,68} = 0.07$, $p > 0.05$). Again, there was insufficient data to perform this analysis for African elephants.

Although these data are intriguing, life expectancy estimates do not provide a great deal of information, and they can be greatly affected by high mortality within specific age groups (Caughley 1977). For this reason, mortality was calculated for each age interval (age-specific mortality) in the following section to determine whether zoo elephants really do have high mortality, and also to identify whether some age groups are more affected than others.

Age-specific mortality

In this section, studbook data were used to construct life tables for Asian and African elephants in European zoos, and hence estimate mortality for each age interval. These data are then statistically compared to the age-specific mortality rates reported for elephants living in extensive systems (timber camps) and in the wild.

Life table analysis: methods

General methods and calculations for zoo elephants

Several types of data can be used to construct life tables. These are discussed in detail by Caughley (1977) but the main methods used in this chapter, and in the studies that will be used for comparison, will be briefly summarised here. Firstly, information on the age distribution of the living population can be used to calculate the proportion of animals dying within each age class. This method is used by 'DEMOG', a computer program used to calculate various demographic parameters for zoo populations (written by J. Ballou, National Zoological Park, Washington D.C.), which was used to estimate mortality in the current elephant population in European zoos (see below). Secondly, one can record the age at death for a group of identifiable animals born over a range of seasons or years. This was the method employed to calculate life table parameters for zoo elephants in Europe, using data on the age at death from studbooks, to compare with populations in extensive systems (reported by Mar 2001) and in the wild (see below). Thirdly, the age of animal's remains such as jawbones that are found can be estimated and tallied to provide a frequency distribution of deaths, and used to construct a life table. This method has been used by various authors to calculate life tables for wild elephant populations, including the studies that will be used for comparison with zoo elephant mortality.

To calculate mortality in zoo elephants the first two data types mentioned above were used, the third having been used by other authors to calculate mortality in wild elephants. First, data from the electronic version of the EEP studbooks, stored on the computer program software 'SPARKS' (Single Population Analysis & Records Keeping System, developed by the International Species Information System, ISIS), were analysed using 'DEMOG' to estimate mortality within each age class for males and females separately. This method uses the age of the current population to estimate the proportion of animals that die within each age class. Data on 333 (62 male, 271 female) Asian and 191 (41 male, 150 female) African elephants, accurate up to 1st Oct 2001, were used to calculate age-specific mortality for each age interval, 0-1 years, 1-2 years, 2-3 years, etc. Following the methodology of Wiese (2000) and Olson & Wiese (2000), age-specific mortality within the first year (age class 0-1) was calculated using only data for individuals that were born in European zoos, as first year mortality is not known for imported animals. Second, to facilitate comparison, life tables were constructed for the zoo population using information on just the number of elephants dying within each age class, as this was the method used to calculate mortality in extensive and wild elephant populations. Data on the age at which individuals had died were taken from the studbooks and used to construct a life table in an Excel spreadsheet using formulae from Caughley (1977).

The number of elephants dying in each age interval *x* to *x*+1 ($f'x$) were used to calculate the following:

d_x: proportion of individuals dying *during* the age interval *x* to *x*+1, calculated as $f'_x / \sum f'_x$;

l_x: proportion of individuals surviving at the start of each age interval, calculated as $1 - \sum_{0}^{x-1} d_x$;

qx: infinite rate of mortality during the age interval x to x+1, i.e. age-specific mortality, calculated as dx /lx .

Data were available for a total of 194 (60.132.2) Asian elephants and 42 (15.27.0) African elephants that died at a known age. Age-specific mortality was calculated across three-year intervals, excluding the first age class (0, 1-3, 4-6, 7-9, etc), to smooth out fluctuations caused by small sample sizes (the age class '0' includes all deaths that occurred before one year, i.e. up to 0.99 years). This was done by summing d_x values across the three age classes and dividing this by the sum of all three l_x values (Caughley 1977). Again, first year mortality was calculated excluding imported elephants. This had little effect on the sample size and brought the number of elephants used to calculate the life tables to 193 (60.131.2) Asian and 41 (14.27) African elephants. Life tables were constructed for each species for the sexes combined, and also for males and female separately.

Data from extensive husbandry systems

Zoo data were compared to mortality in Asian elephants living in extensive systems (timber camps) using data provided by Mar (2001). She had access to records for approximately

9600 elephants, collected from elephant logbooks and annual reports of the Burma Timber Enterprise of the Union of Burma, from 1875 to 1999. These records contained much the same information as those kept by zoos and so the quality of mortality data should be directly comparable to that of the zoo elephants. Mar constructed a life table for males and females combined. Mortality (q_x) was calculated for each year of age (0, 1, 2, etc) up to 45 years (again, ‘0’ includes all deaths that occurred up to 0.99 years), after which the remaining deaths were pooled. The data provided by Mar allowed us to recalculate mortality, using the formulae given in the previous section, for the age intervals used for the zoo elephants (see previous page) to allow direct comparison of mortality. As discussed in Chapter 3, African elephants are not commonly kept in extensive systems and so comparable data were not available for this species.

Data from the wild

Mortality in wild Asian elephants was taken from Sukumar (1989). He used several methods to estimate mortality, but the most accurate and comparable results were given in the form of life tables that were constructed using ages at death. A sample of 90 dead female elephants from the Nilgiri-Eastern Ghats region of southern India, collected between 1977 and 1983, were used. Similar calculations were not possible for males, as they did not have a stable age distribution, due to poaching and shooting, which violates one of the assumptions of this method. Elephants were aged according to body measurements, but due to the limitations of this method and the inability of distinguishing between elephants over 20 years of age, mortality could only be estimated for the following broad age classes: 0, 0-5, 5-10, 10-15, 15-20, and 20-70 (deaths at 0.99 years and under are included in ‘0’). These mortality estimates are likely to be less accurate than those for zoo elephants because the remains of some animals will not be found in the wild, particularly those of young elephants which are more likely to go unnoticed or removed by scavengers (Laws 1969a; Jachmann 1986; Sukumar 1989). These data are therefore unlikely to represent absolute age-specific mortality rates, but they are nevertheless useful as estimates to compare with mortality in zoo populations.

Mortality rates of African elephants in zoos were compared to those of wild populations in a similar manner. This species has been studied far more extensively in the wild than the Asian elephant, and this is reflected in the greater availability of mortality estimates. During a search of the literature, several studies were found which quantified age-specific mortality for a range of age classes, namely Laws (1969a), Corfield (1973), Jachmann (1986), and Whitehouse & Hall-Martin (2000). In addition, a long-term study by Douglas-Hamilton (1972) published in his Ph.D. thesis consulted, as several authors referred this to. The most detailed data, in terms of the number of age-classes provided, were found in Laws (1969a), Jachmann (1986) and Whitehouse & Hall-Martin (2000), which were collected from well-studied populations over several years. Data in Douglas-Hamilton in contrast only gave detailed mortality up to the age of “ten and over”; while Corfield’s data were collected during a period of drought when mortality was unusually high. For these reasons, mortality data for zoo elephants were just compared to each of the mortality data sets from Laws (1969a), Jachmann (1986) and Whitehouse & Hall-Martin (2000). By using all three data sets, this reduces the chance of erroneous results, for instance if mortality is unusually high or low in one population.

Laws (1969a) reports the age-specific mortality of elephants living in Tsavo National Park, Kenya, derived from 571 lower jaws of elephants that died of natural causes, collected from ten different populations within the park between 1961 and 1967. The age classes used by Laws were 0-1, 1-5, 6-10 etc, up to age 60. Due to the small number of deaths in zoo elephants in the older age groups, the last four age classes were condensed (41-60) to smooth the data. Jachmann (1986) also used collections of 127 lower jaws, covering six years, to estimate mortality in the Kasungu National Park population in Malawi. The age classes used to calculate mortality were 0 (i.e. deaths up to 0.99 years of age), 1-10, 11-20, 21-30 etc up to 60 years of age. Finally, Whitehouse & Hall-Martin (2000) report the age-specific mortality for the Addo Elephant National Park population in South Africa. They used data on the total number of elephants entering, and dying within, each age class between 1976 and 1998. A total of 53 deaths, recorded between 1977 and 1998, were used to estimate mortality in this population. As already mentioned, estimates of mortality from the wild may underestimate actual figures, particularly for calves, and this should be borne in mind. This will be discussed more fully in the following section.

Comparisons

Mortality rates of zoo and extensively kept elephants were compared using by a 2 x 2 Chi-squared analyses. The variables used were husbandry system (zoo vs. extensive systems) and the number dying and surviving within each system. A separate analysis was done for three age groups, which were infants (0-1 years), juveniles (1-15 years) and adults (15-45 years). Elephants that died at exactly 1 or 15 years of age were included in the younger age category. Observed values were the sum of all individuals that died within each age group, and the number surviving at the end of each age group. This method could not be used to compare mortality in zoo and wild elephants, as the authors did not provide the raw data on the number dying within each age class. Instead, these were compared using Wilcoxon’s signed rank test. For this analysis, the last age class was excluded because this includes the deaths of all remaining individuals, which would confound analyses. In addition, some analyses investigated whether mortality had changed significantly over the years, and a Pearson’s correlation was used for this purpose, as data did not meet the assumptions of parametric tests.

Overall mortality: results for zoo elephants

Asian elephants

Data were first analysed to give an overall picture of how age and sex affect mortality in zoo elephants. Analysis of the data from SPARKS revealed no significant difference in mortality (q_x) between male and female Asian elephants in European zoos ($F_{1,61} = 0.08$, $p < 0.05$, see Figure 11a). Data for males were far more limited and this is reflected in the many 'zero' data points see Figure 11a (rather than indicating zero mortality), but on the whole the data show the same general pattern as female mortality. Mortality is relatively high for infants under one years of age, in females (13%) and even more so for males (26%). After this, mortality drops sharply for both sexes. Mortality then remains under 3% in females and under 7% in males until around 30 years of age, when various large peaks and troughs appear. The uneven nature of the mortality curve (see Figure 11a) is due to the sample size being relatively small for this type of analysis.

This pattern is similar to data published by Wiese (2000) for female Asian elephants in North American zoos. Infant mortality, however, is far higher in the North American population (30.70% for all institutions or 39.44% for AZA member institutions only) and subsequently, mortality for higher age intervals low (1% to 2% between 1-30 years).

African elephants

Fewer data are available for African elephants due to the comparatively small number held in European zoos (see Chapter 3), and this is particularly true for males. This lack of data limits interpretation of the results presented here and it is unlikely that data reflect the true pattern of mortality in this species. The results are still of some interest from a welfare point of view to estimate how mortality differs in elephants in zoos and in the wild, but interpretation should be subject to some caution.

No significant difference in age-specific mortality was found between male and female African zoo elephants ($F_{1,51} = 0.46$, $p > 0.05$, see Figure 11b). However, in contrast to the Asian elephant, only a small peak in infant mortality was found (8% males, 7% females). Mortality then remains under 3% in females and under 7% in males until around 20 years of age, when various large peaks and troughs appear. After this, mortality drops to less than 3% until 23 years of age, when mortality rises in a series of peaks. Males have slightly higher mortality, but it remains under 10% until 22 years of age when it rises rapidly in several peaks until 28 years, which represents the maximum age present. Again, the very uneven nature of the mortality curve is due to the relatively small sample size for this species.

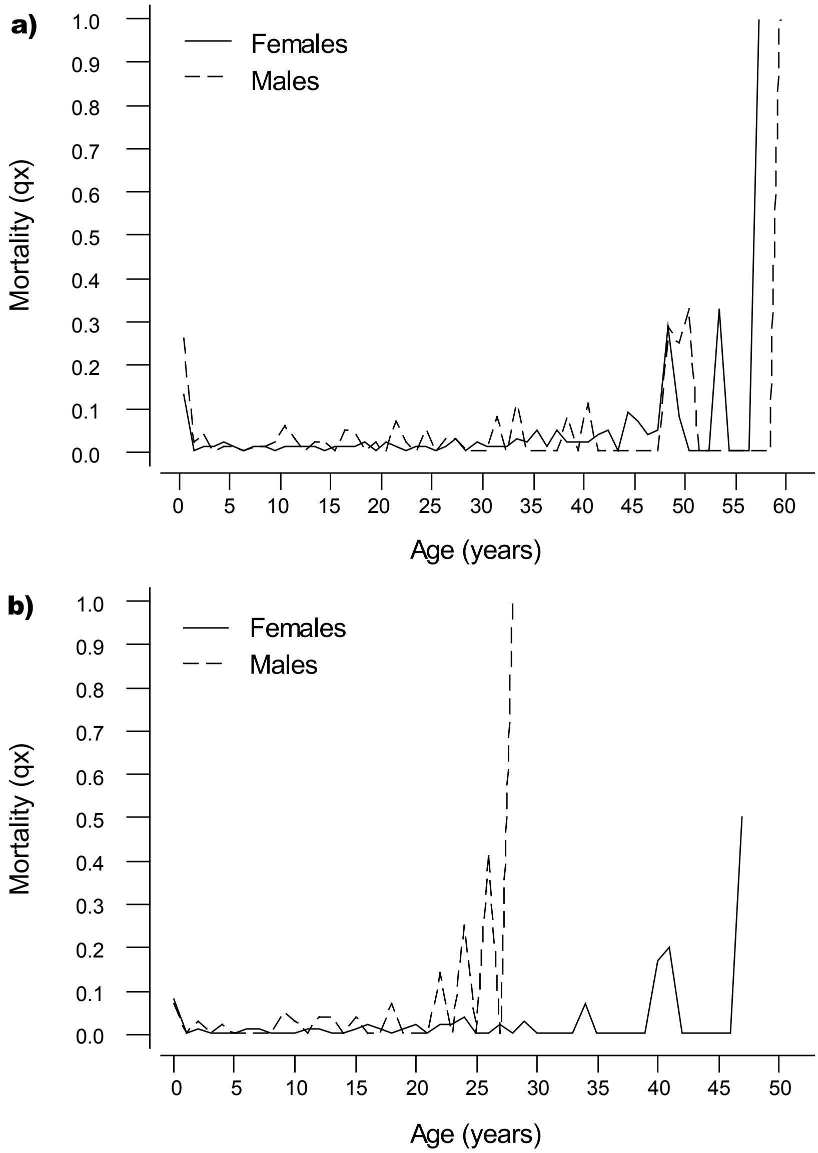

Figure 11. Age-specific mortality of a) Asian and b) African male and female elephants in European zoos

Mortality curve for male and female African elephants calculated using the program DEMOG from SPARKS data. Qx represents the proportion of elephants that die at age x. No difference was found between the sexes.

Mortality in zoo Asian elephants from different sources

We presented data at the beginning of this chapter showing that captive-born Asian elephants have a lower life expectancy compared to wild-caught individuals. In order to test this further, age-specific mortality was calculated for Asian elephants (sample size precluded analysis of African elephant data), males and females combined, that had been born in captivity and those caught from the wild. Chi-squared analyses showed that Asian zoo elephants caught from the wild experienced significantly higher mortality than wild-caught individuals when they were juveniles (χ^2 = 6.52, df = 1, p < 0.01), but not when they were adults (χ^2 = 1.49, df = 1, p > 0.05). See Figure 12.

A similar relationship was found by Mar (2001) using the much larger data set for female Asian timber elephants in Burma. Survivorship was lower in captive-born individuals compared to wild-caught elephants, up until approximately 39 years of age after which the opposite was true. The author does not comment on the possible cause for this relationship.

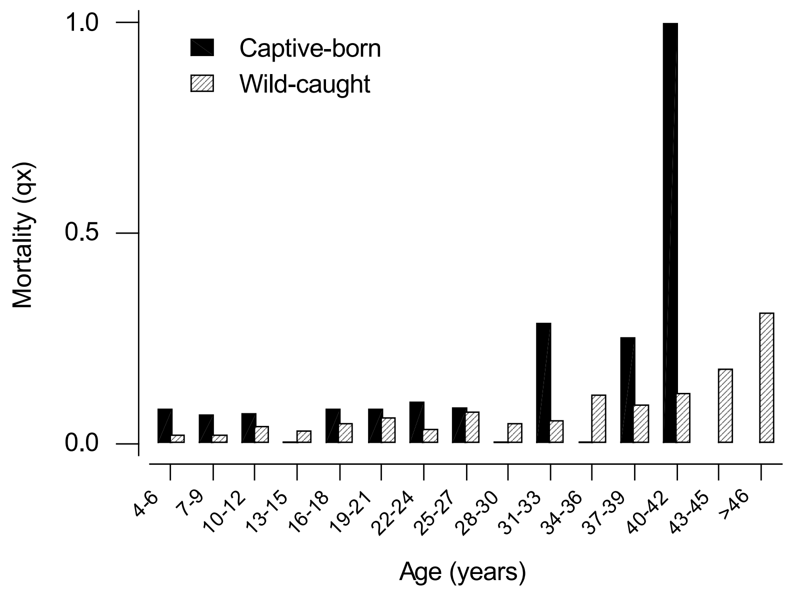

Figure 12. Age-specific mortality of captive-born and wild-caught Asian elephants in European zoos

Data from the EEP studbooks were used to calculate the mortality curve for Asian elephants, both sexes combined, caught from the wild and born in zoos. Deaths under four years of age were excluded, as the average age at which wild-caught individuals were imported was three years. Qx represents the proportion of elephants that die at age x. Mortality was significantly higher in juvenile captive-born individuals, but not adults.

Mortality in zoo Asian elephants compared to elephants in extensive systems

Age-specific mortality in European zoo elephants, using age at death, was compared with mortality of elephants held in extensive systems. Data for males and females were combined to aid comparison with the Asian timber elephant mortality provided by Mar (2001). Mortality was higher in the zoo population for all age classes, with the exception of calves between four and six years of age (see Figure 13). Chi-squared analyses showed that zoo elephants had significantly higher mortality when they were infants (χ^2 = 53.31, df = 1, p < 0.001) and adults (χ^2 = 52.62, df = 1, p < 0.001), but not when they were juveniles (χ^2 = 2.56, df = 1, p > 0.05), compared to extensively held elephants. Mortality in zoo infants (0-1 years) was 165% greater compared to timber elephants (27.4% vs 10.4%). Mortality in timber elephants shows a small peak at around five years of age (see Figure 13), which is suggested by the author to be due to the taming process that occurs at around this age (discussed further in Chapter 7). After 10 years of age, mortality in zoo elephants is between 76% (28-30 years) and 389% (25-27 years) greater than mortality in timber elephants. No data are presented for mortality in timber elephants over 45 years of age as Mar presents a pooled figure, insufficient to calculate mortality across the remaining age classes (see '*Life table analysis*' section).

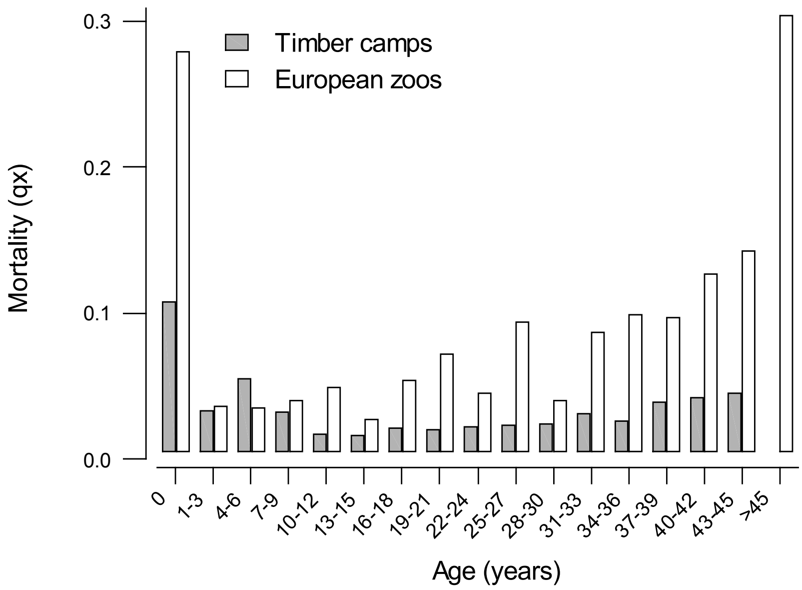

Figure 13. Age-specific mortality of Asian elephants in European zoos and a timber camp

Mortality curve for elephants listed in the 1999 EEP Asian elephant studbook compared to elephants held in a Burmese timber camp (data taken from Mar 2001). Qx represents the proportion of individuals alive at age *x* that die before age *x*+1. Mortality is greater in zoo elephants for almost all age classes. Data for timber elephants over 45 years are missing as mortality was not possible to calculate given the data that were provided.

Mortality in zoo elephants compared to elephants in the wild

Asian elephants

Mortality in female zoo elephants was also compared with mortality in female Asian elephants in the wild reported by Sukumar (1989). Sukumar only reported q_x for five age classes (0-5, 5-10, 10-15, 15-20 and 20-70) thus limiting analysis. Figure 14 shows mortality data for both populations and it can be seen that mortality is greater in zoo elephants for the first three age classes. Again, this was particularly pronounced in calves (0 - 5 years) for which mortality was 58.0% higher in zoo elephants compared to the wild population. However, perhaps unsurprisingly due to the small sample size, there was no significant difference in the mortality of female Asian elephants in zoos and in the wild across all age classes ($T = 3.0$, n = 5, $p > 0.05$).

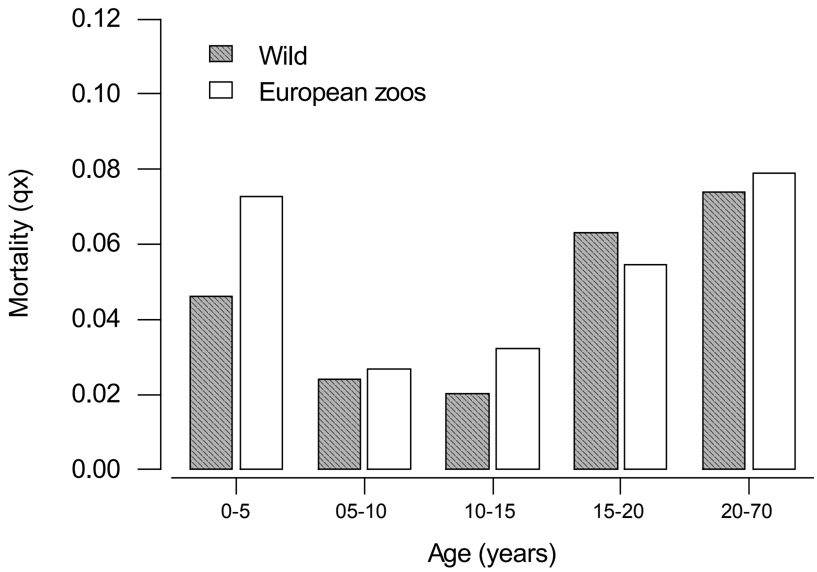

Figure 14. Age-specific mortality of female Asian elephants in European zoos and a wild population

Mortality curve for elephants listed in the 1999 EEP Asian elephant studbook compared to elephants living in the wild in southern India (data were taken from Sukumar 1989). Qx represents the proportion of individuals alive at age *x* that die before age *x*+1. Mortality in zoo females was not significantly different to mortality in wild females.

African elephants

Mortality in African elephants in European zoos was compared with data from wild populations. Three studies that provided good quality data on age-specific mortality in wild elephants were used, to ensure that wild data were representative of the species. These are shown in Figure 15 to give an idea of how the mortality estimates compared between studies. Although mortality was given for specific age classes, it is represented as continuous data in the graph to aid comparison. It can be clearly seen that studies of different wild populations gave quite different mortality estimates. The Tsavo population (Laws 1969a) shows a distinct u-shaped mortality curve with very high mortality in young and old age classes. In contrast, mortality in the Kasungu elephants rises gradually with age and does not show the same peak at either end of the age spectrum (Jachmann 1986). Finally, the Addo elephants do show high mortality in very young and old elephants, but mortality is very low and relatively constant between these age groups (Whitehouse & Harley 2001). Notably, Laws (1975) described the Tsavo population as undergoing a population crash at this time due to very high rates of mortality (particularly calves, as can be seen in Figure 15) and low rates of recruitment caused by habitat loss and the subsequent constriction of their range. These data were included to represent the very upper limit of mortality in the wild for comparison with zoo populations. It also should be noted that these data were calculated for different age classes in each study and this could affect the results, but overall, such a range of mortality curves should be adequate to determine whether mortality in African zoo elephants significantly differs from wild populations in varying states.

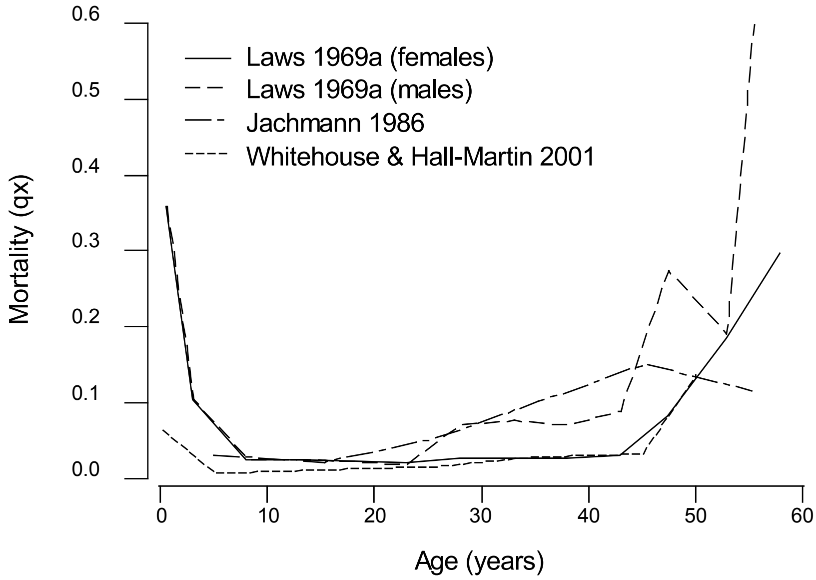

Figure 15. Age-specific mortality of several different wild populations of African elephant

The mortality curves for three different wild African elephant populations are presented to give a rough idea of how estimates compared between studies. Qx represents the proportion of individuals alive at age *x* that die before age *x*+1. To facilitate comparison, data were plotted using the midpoint of the range for the age classes given. For example, mortality for 0-5 years is plotted at 2.5 years.

Firstly, zoo data were compared with mortality for the Tsavo National Park population in Kenya reported by Laws (1969a). Laws presents data for males and females separately, and due to his finding that mortality is higher in adult females than males, data were not combined for comparison with zoo elephants. Mortality was not significantly different from that in zoo elephants in either males (T = 3, n = 7, p > 0.05, see Figure 16a) or females (T = 20, n = 10, p > 0.05, see Figure 16b). Infant mortality was found to be far greater in the wild populations studied by Laws than zoo elephants for both sexes, but as mentioned previously this population was suffering from an unusually high loss of calves which was not sustainable. Similarly high levels of infant mortality (over 30%) have also been reported for elephants in Uganda (Buss & Brooks 1961, cited in Hanks & McIntosh 1973) and Kruger National Park in South Africa (Pienaar *et al.* 1966), although many others report far lower figures for a range of populations (see the following section).

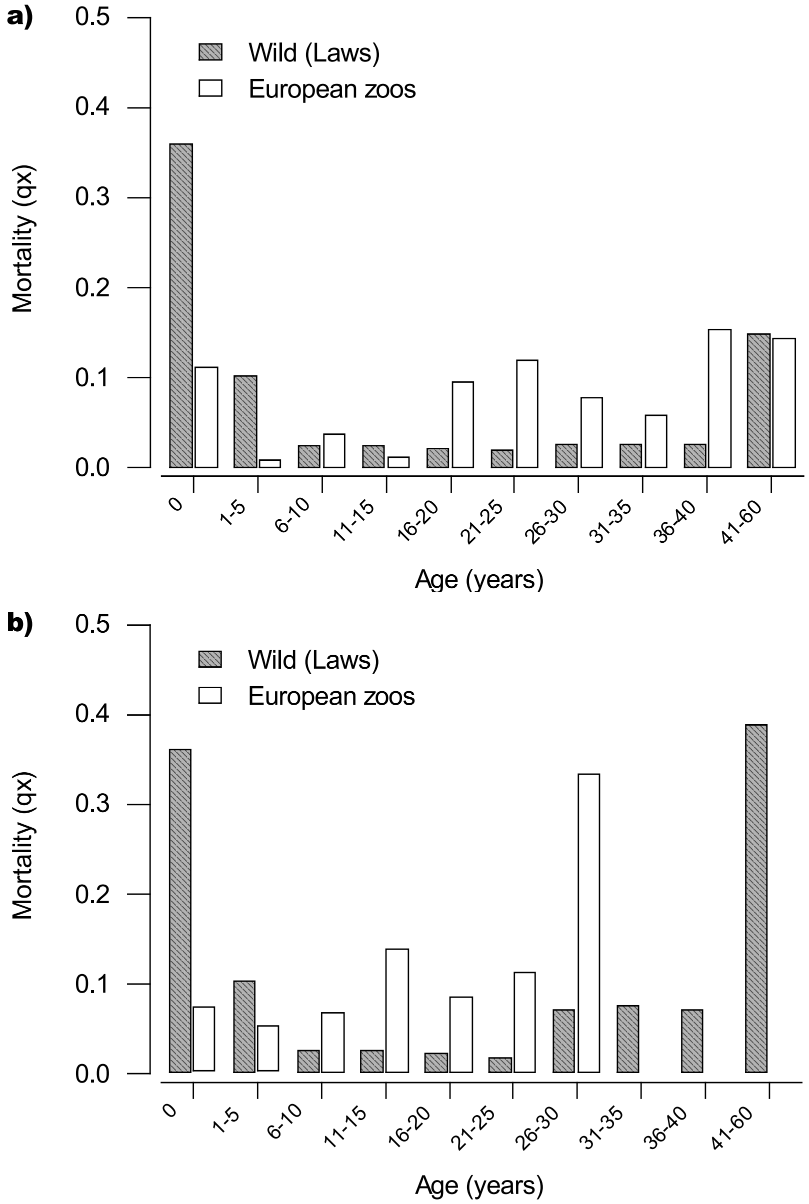

Figure 16. Age-specific mortality of a) female and b) male African elephants in European zoos and a wild population in Kenya

Mortality curve for African elephants, taken from the 2001 EEP studbook compared to elephants living in Tsavo National Park, Kenya (data were taken from Laws 1969a). Qx represents the proportion of individuals alive at age *x* that die before age *x*+1. Mortality was not significantly different in zoo and wild African elephants. Mortality for the last three age classes in the top graph represent missing data rather than zero mortality, as no deaths over 30 were listed in the studbook.

Secondly, African zoo elephant mortality was compared to the Kasungu elephants (Jachmann 1986). These data represent males and females and so zoo data were also pooled for comparison. Figure 17 shows the mortality data for both populations. Mortality is higher in zoo elephants up to the age of 30, and equal or lower in higher age classes. Of all the African zoo elephants that died, none reached over 50 years of age, and so in Figure 17 mortality for this age class is missing, rather than zero, for the last age group. Analysis showed that mortality was not significantly higher in African zoo elephants ($T = 1$, $n = 5$, $p > 0.05$), but this is perhaps not surprising given the small sample size involved.

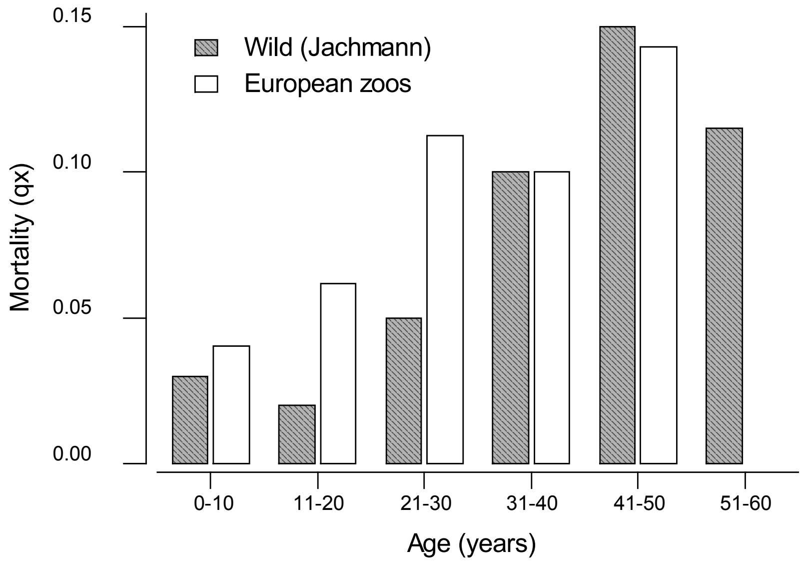

Figure 17. Age-specific mortality of African elephants in European zoos and a wild population in Malawi

Mortality curve for elephants listed in the 2001 EEP African elephant studbook compared to elephants living in Kasungu National Park, Malawi (data were taken from Jachmann 1986). Qx represents the proportion of individuals alive at age *x* that die before age *x*+1. Mortality in these wild African elephants was not significantly different to mortality in zoo elephants. Mortality for the last age class represent missing data rather than zero mortality, as no deaths over 50 were listed in the studbook.

Lastly, data were compared with mortality for the Addo population in South African reported by Whitehouse & Hall Martin (2000). Again, these data represent males and females and so zoo data were pooled for comparison. As can be seen from Figure 18, mortality was far higher in zoo elephants. Compared to the Addo elephants, zoo elephant mortality was 4.2% (0 years old) to 86.7% (20-39 years old) higher, and this proved to be significant ($T = 1$, $n = 6$, $p < 0.05$).

Infant mortality

The results presented in the previous section reveal a peak in mortality in infants (0-1 years) for most populations. Infants are expected to suffer greater losses than older animals due to their vulnerability. However, Asian infants born in zoos were found to have a far lower chance of survival compared to those born in the wild or in extensive facilities (see Figure 13 and Figure 14). The following section examines infant mortality in more detail, using data from the EEP studbooks and reviewing other, previous, studies.

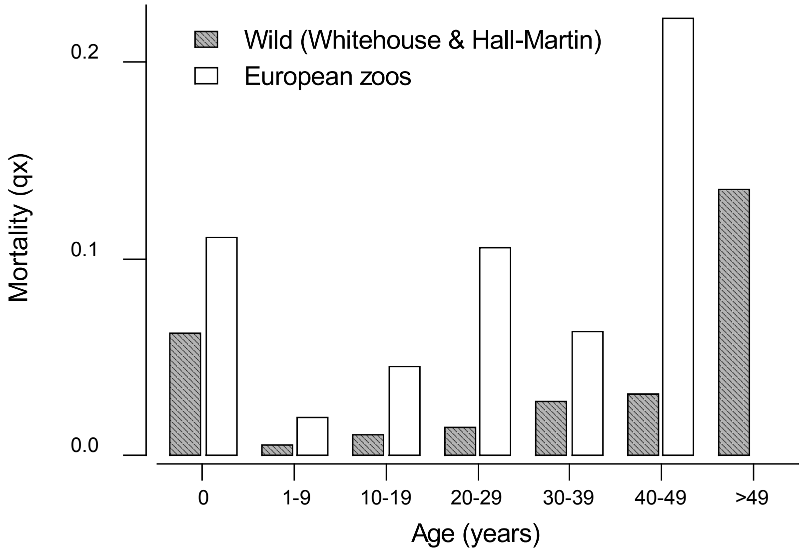

Figure 18. Age-specific mortality of African elephants in European zoos and a wild population in South Africa

Mortality curve for elephants listed in the 2001 EEP African elephant studbook compared to elephants living in Addo Elephant National Park, South Africa (data were taken from Whitehouse & Harley 2001). Qx represents the proportion of individuals alive at age *x* that die before age *x*+1. Mortality in these wild African elephants was significantly lower than mortality in zoo elephants.

The results presented in this chapter reveal that 13% of female and 26% of male Asian calves born in European zoos died within their first year. The latter figure is similar to reports of other authors for zoo elephants in Europe and North American, which range between 25% and 41.2% (see Table 16). In contrast, Mar (2001) reports a mortality rate of only 10.7% for infants born in timber camps in Burma. Infant mortality in zoos is also higher than estimates from the wild in the Asian elephant. Sukumar's (1989) data shows that 21.1% of wild female calves die at five years or less, which compares to 31.3% in females that have been born in zoos. Taylor & Poole (1998) report a far higher mortality rate of 56.5% of this age group in a sample of 20 European and North American zoos and, as in this report, they also found a far lower mortality in extensive systems. They found that mortality (0-5 years) in calves born in two timber camps was only 10% (Tamilnadu Forest Department, India) and 6.36-11.1% (Burma Timber Enterprise), although the latter does not include a stillbirth rate of less than 3%. Similarly, only 9% of calves born in an elephant orphanage (Pinnawela, Sri Lanka) died within the first five years. A similar pattern can be seen when looking at the results from a range of studies on the Asian elephant (see Table 16).

Table 16. Infant mortality in zoos, extensive systems and in the wild

Mortality estimates within the first year of life are presented from various sources for elephants in zoos, extensive systems and wild populations. These figures are presented here simply for comparison with the general findings of this section. Figures represent the percentage of infants between 0 and 1 year of age that died, including stillbirths (see the following chapter for data on stillbirths alone). Data include males and females unless otherwise indicated. The year range of data used to calculate infant mortality in zoo elephants is provided as these differed between papers. The methods used to calculate infant mortality also differ between studies. Some authors constructed life tables, as was done in this report, while others simply calculated mortality as the percentage of calves that died under one year of age ('Deaths/births').

Location	Species	First year mortality (%)	Method	Location and year range	Ref
Zoo	Asian	28.2	Life table	Europe (1902-1999)	1
		†36.4	Deaths/births	Europe (1902-1992)	2
		37	Deaths/births	Europe (1981-1990)	3
		25	Deaths/births	North America (1962-1996)	4
		*30.7	Life table	North America (1959-1999)	5
		41.2	Deaths/births	North America (1980-1996)	6
	African	*44	Life table	North America (1959-1999)	7
		50	Deaths/births	North America (1980-1996)	6
Extensive system	Asian	11.0	Deaths/births	Timber camp, Burma	8
		7	Deaths/births	Timber camp, Burma	9
Wild	Asian	*4.6	Life table	India, females only	10
		7	Deaths/births	Sri Lanka	11
	African	36	Life table	Kenya	12
		24	Life table	Uganda	13
		10.3	Deaths/births	Tanzania	14
		6.2	Life table	South Africa	15

References: 1 - This report (data from EEP studbooks); 2 - (Kurt & Mar 1996); 3 - (Schmid 1998); 4 - (Keele 1996); 5 - (Wiese 2000); 6 - (Ryan & Thompson 2001); 7 - (Olson & Wiese 2000); 8 - (Mar 2001); 9 - (Gale 1974); 10 - (Sukumar 1989); 11 - (Kurt 1974); 12 - (Laws 1969a); 13 - (Laws *et al.* 1975); 14 - (Douglas-Hamilton 1972); 15 - (Whitehouse & Harley 2001).
*Data for females only; †Includes data for some circus elephants.

However, Laws (1969a) reports very high infant mortality in wild African elephants in Tsavo National Park in Kenya (36%), which is around the same as that found in Asian zoo elephants. As mentioned in the previous section, other authors have found high infant mortality in this population. Other studies on wild African elephants have found far lower infant mortality that are closer to that reported in wild Asian elephants, suggesting that the Tsavo populations had an unusually high infant mortality. Laws collected these data during relatively normal years (i.e. not during a drought), showing that infant mortality could potentially be just as high in some wild populations as in zoos. Alternatively, these data may reveal a species difference, as some studies show very high mortality in African elephants in zoos, which is far higher than any reported for Asian elephants (see Table

16). Nevertheless, the results clearly show that elephants maintained in captivity under extensive conditions, for which data are of comparable quality, do experience significantly lower infant mortality compared to zoo elephants.

Changes with time

To determine whether high infant mortality is a historical or current problem, a correlation analysis was carried out on data for Asian elephants, as insufficient data were available to test this in Africans. The year of birth, grouped into ten-year intervals, was used as the independent variable, and the number of calves that died within the first year, as a proportion of all captive births, was the dependent variable. A Pearson's correlation revealed that infant mortality has not changed significantly over the years ($r = 0.068$, $p > 0.05$, $n = 10$, see Figure 19). This analysis also reveals that of the 62 calves born in the past decade, 35.5% died within the first year (see Figure 19), highlighting that this is very much a current problem.

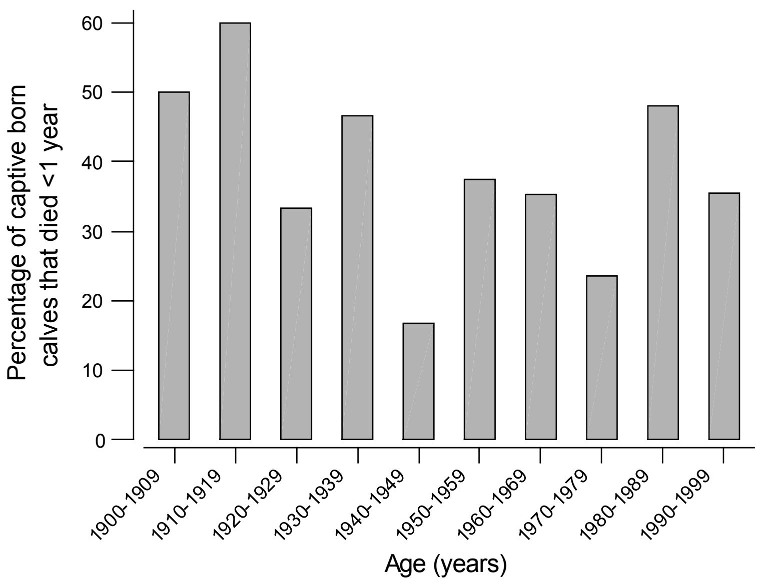

Figure 19. Infant mortality in Asian elephants in European zoos

The number of calves that died before reaching one year of age are shown as a proportion of all births in captivity. Data were taken from the 1999 EEP Asian elephant studbook. No significant change in infant mortality was found over the years.

Sex differences

In Asian elephants, mortality was found to be far higher in male infants compared to females born in European zoos, but this trend does not continue throughout life (see previous section). This pattern is seen in most mammals and birds, and has been noted in wild elephant populations. For example, Sukumar (1989) deduces from counts of elephant carcasses, that mortality in male Asian calves up to five years of age was greater than females by a factor of 1.8. Given that the sex ratio at birth was approximately 1:1, he concluded that this must be due to heavier losses of male calves. Similarly, Lee & Moss (1986) found that male African infants had lower survivorship than females in the first year in Amboseli National Park, Kenya. Thus, this difference in mortality between male and female infants would not appear to be a result of the captive environment.

Discussion

This is the first time elephant mortality in zoo elephants has been compared with populations in extensive systems and the wild. Data from extensive systems came from studbooks and were therefore of comparable quality to zoo data. These comparisons, which highlighted significant differences in mortality, are probably the most accurate, and hence telling, of all those presented in this chapter. Analyses were somewhat more limited when it came to comparisons with wild elephants, due to the small number of age classes and the fact that raw data were not provided by the authors. It is also likely that zoo mortality data were more accurate due to the difficulty in accurately quantifying mortality in the wild. Comparisons were nevertheless revealing, and highlighted several areas of concern, including high infant mortality and curtailed life expectancy in zoo elephants. As with overall mortality, the most valuable comparisons of infant mortality rates were between zoos and extensive systems, due to the quality of the data and the inherent difficulty in quantifying this in the wild. In the chapter that follows, the causes of mortality in infants and older elephants are discussed, with particular reference to the connection between their incidence and aspects of the zoo environment.

Summary

- The mean life expectancy of European zoo elephants is 21 years in Asian and 18 years in African elephants, excluding first year mortality. The former is 9 years fewer than Asian elephants living in extensive systems.
- Factors found to correlate with low life expectancy were age (see below) and source of elephants. Female Asian elephants born in zoos have a significantly lower life expectancy (15.4 years) compared to those that have been caught from the wild and imported (25.1 years). A similar trend was found in male Asians, with captive-born animals surviving to 15.8 years compared to 25.0 years in males caught from the wild. Insufficient data were available to test this in African elephants. Whether elephants had bred or not did not affect longevity.
- Age-specific mortality was also found to be higher in captive-born Asian elephants compared to wild-caught individuals for juvenile animals, but not adults. A similar relationship has been found for elephants in extensive systems in Asia.
- The likelihood that infants born in European zoos will die within their first year is 26% and 13% for Asian male and female calves, respectively, and 8% and 7% for African male and females calves, respectively, according to EEP studbook data. However, data from other studies of the European and North American populations report the higher figure of 33.6% in Asians and 47.0% in Africans (median across studies), for the sexes combined. Analysis revealed that this is a current problem.

- Compared to extensively held elephants, mortality is significantly higher in Asian zoo infants (more than double: 165% higher) and adults (76-389% higher depending on the age range analysed), but not juveniles.
- In Asian elephants, mortality is higher in young European zoo elephants (under 10 years) than in wild populations in India, particularly for calves between 0 and 5 years of age (58% higher). However, this is not statistically significant.
- In African elephants, mortality is significantly higher in European zoo elephants compared to one wild population (Addo Elephant National Park, South Africa), but not when compared to another two wild populations (Tsavo National Park, Kenya and Kasungu National Park, Malawi). Again, analyses were hampered by small sample sizes and so non-significant results were perhaps not surprising. In contrast, were suggestions that infant mortality in one wild population is higher than in zoo calves, however the reliability of such comparisons is uncertain due to the very small sample size for the African zoo calf population.
- However, with this possible exception mortality in the wild was never significantly higher than in zoos, despite this being the norm for other species.

Chapter
8

Causes of mortality and morbidity

In the previous chapter, mortality rates were found to be high in elephants held in European zoos compared to those in extensive systems and some wild populations. Here, the major causes of mortality are quantified, firstly in infants, which in Asian elephants at least, have remarkably high mortality in zoos, and secondly in older elephants. Within these sections, aspects of the captive environment that affect, or could affect the incidence of these causes are discussed. We end by highlighting other problems that are affected by captive management and husbandry, which, although not making a significant contribution to mortality, nevertheless constitute significant health problems in their own right.

Causes of infant mortality

Results presented in the previous chapter show that zoo elephants, or at least Asians, experience high levels of infant mortality, an issue that has already been highlighted by several authors (e.g. Kurt & Mar 1996; Schmid 1998; Taylor & Poole 1998; Wiese 2000). In this section, we investigate the major causes of this (e.g. stillbirths) and go on to examine factors that affect their incidence, concentrating on those that relate to the captive environment.

Two sources of data were available. The African elephant studbook co-ordinator, Dr Amelia Terkel provided recently compiled information on causes of death in this species. However, these data only included information on three infant deaths (under one year of age) and so these were of limited use in this section. (Similar studbook data were unavailable for Asian elephants). Secondly, data compiled by People for the Ethical Treatment of Animals (PETA) were also used to quantify the importance of different causes of mortality. These data, as well as additional information on the current status of the European elephant population, have been published as a report entitled '*Captive Elephants in European Zoo, Safari Parks, and Circuses*' (2000). The authors of this report used information from various sources, including data published in '*Elefanten in Zoo und Circus, Teil 1*' Europe (European Elephant Group, 1993) and data from an ongoing investigation by Mark Stanton in the U.K. They took additional information from newspapers, magazines, scientific journals and annual reports, web sites, and personal communications from "reliable sources". They also resolved discrepancies in the data and missing information by sending people out to various zoos and safari parks in Europe, who made notes on the elephants held at each facility. Their published data refer to elephants registered as dead by January 2000, and go back as early as 1968 (the data of some deaths were unknown but these were not included in the analyses here) and cover zoos, safari parks and circuses, including facilities that do not contribute to the EEP studbooks. We obtained the raw data directly from the compiler of the database, Martin Hutter. Details of the cause of death were known for 30 (15 males, 11 females, 4 unknown sex) Asian and 2 female African zoo infants, although this figure could be larger as the age at death was not known for all individuals. Where available, we also compared particular findings with similar results reported in other publications, including those for other species.

Stillbirths

Data from the PETA database provided information on the number of stillbirths in many European zoos, and the studbooks yielded data on the total number of captive births within most of the zoos in the PETA database (some zoos could not be found in the studbooks). Data were available for 27 facilities that had produced at least one Asian calf, and 12 that had experienced an African birth. Out of 111 Asian births, 17 (15.3%) were recorded as having been stillborn, and as such represented the most common cause of death in infants (56.7% infant deaths). Only one out of 46

African births (2.2%) was stillborn, but the cause of death was only known for two infants, and none of the three African infant deaths recorded by the EEP were noted as being stillborn. Other authors have reported an even greater incidence of stillbirths in Asian elephants. For instance, Schmid (1998) reports that 17.7% of births (n = 141) in European zoos between 1902 and 1996 were stillborn (48% of all deaths in the first year). Taylor & Poole also found a high stillbirth rate of 25% (n = 92) when they sampled 20 European and North American zoos. Similarly high figures have been reported for the North American zoo population alone. Of the 104 calves born between 1962 and 1996, excluding elephants that were suspected to be inbred, 20% were stillborn or died within the first day of birth (Keele 1996). Ryan & Thompson (2001) report data from slightly different years (1980-1996) but reach a similar figure of 23.5% of calves (n = 85) that were stillborn or premature, but report that none of the 18 African captive births in North America were stillborn.

Although far fewer African calves have been born in captivity, the figures presented above could suggest that stillbirths are less frequent in African elephants than Asians. To test whether this was the case, G-tests were performed on the data provided by PETA and Ryan & Thompson (2001) for the European and North American population, respectively. This was used, rather than a Chi-squared, due to the small number of 'observed' African stillbirths. These revealed that the proportion of stillbirths was significantly affected by species for both the European ($G = 5.472$, $df = 1$, $p < 0.05$) and North American populations ($G = 5.771$, $df = 1$, $p < 0.05$). This species difference is an interesting finding that will be investigated later in this section when the possible causes of stillbirths in elephants are considered.

Stillbirths are far more common in Asian zoo elephants compared to those in extensive systems. For instance, Taylor & Poole (1998) surveyed two timber camps in Burma and India and one orphanage in Sri Lanka. Out of the 651 calves born in the timber camps, only 3% or less had been stillborn and none of the 11 calves born at the orphanage were stillborn. Mar (2001) also reports a low incidence of 3.1% of captive births in Asian timber elephants in Burma. Accurately estimating the rate of stillbirths in wild populations is problematic due to the difficulty in tracking individuals, although researchers believe that it is a rare occurrence in wild elephants (Kurt & Mar 1996). Nevertheless, the data shown above clearly shows that the rate of stillbirths is between five and eight times greater in Asian elephants held in European zoos than those in extensive systems in Asian.

As a point of comparison, the incidence of stillbirths in several species of farm animals was taken from the literature. Binns *et al.* (2002) report a mean stillbirth risk of 4% (interquartile range 2-6%) for 105 U.K. sheep flocks, and the highest incidence of 15 to 16% was only found on 1% of farms. A similarly low incidence, of 2.6% (range 0 – 11.5% for herd means) has been reported for beef cattle (Waldner 2001), and around 5% in dairy cattle (Chassagne *et al.* 1999). Fraser *et al.* (1997) summarise the results of several studies of pigs and under standard conditions (farrowing crates), taking the average across study means, 6.3% of piglets were stillborn, and the highest level reported was 15.7%. Therefore, the incidence of stillbirths in Asian zoo elephants is at the upper limit observed in farm animals, and as such would be regarded as very high. The fact that stillbirths are so much more common in zoos elephants than those in extensive systems, strongly suggests that some aspect, or more likely several aspects, of zoo husbandry are responsible. Possible candidates are outlines below.

Excessive body weight

Kurt & Mar (1996) have been the only researchers to investigate this problem in zoo and circus elephants. They found that stillborn calves were significantly heavier (124.6 ± 20.8kg) than live calves (92.0 ± 27.6kg), and they were born after significantly longer gestation periods (644.4 ± 24.7days) than surviving calves (615.5 ± 37.5days). This correlation could also explain the lower incidence of stillbirths in Asian camp elephants. Zoo and circus elephants had heavier calves (105.6 ± 26.6kg) and longer gestation periods (644.4 ± 19.5days) compared to elephants in Asian camps (mean birth weight 74.0 ± 21.6kg; mean gestation period 598.1 ± 51.6days). Interestingly, Kurt & Mar (1996) also found a positive correlation between the relative weight of the mother (body weight/shoulder height), at the beginning of the second year of pregnancy, and the birth weight of their calves. Although the last analysis is based on a small sample size (n = 7), this evidence, when considered alongside data showing that zoo elephants are far heavier than camp elephants (see Chapter 4), suggests that the high rate of stillbirths in zoo elephants may be attributable, at least in part, to dams being overweight.

Age of the mother

Another possible risk factor is the age at which females give birth. Mar's (2001) study of Burma timber elephants revealed a steady increase in the frequency of stillbirths and abortions with dam age, to a peak of 20.83% at 25 to 35 years age, followed by a steady decrease in older elephants (see Figure 20). This was investigated in the European zoo population of Asian elephants (only one stillbirth has been recorded for African elephants) using data provided by PETA and the studbooks (see the beginning of this section for more details of the data-set). Data were only available for 43 births, and as can be seen from Figure 20, the percentage of births that result in a stillborn calf increased with the age of the dam, up to a peak at 20 to 24 years of age, after which the frequency declines again. A One-Way ANOVA revealed that, in Asian zoo elephants, stillborn calves were significantly more likely to be born from older females than surviving calves ($F_{1,72} = 5.99$, $p < 0.05$). No births from dams over 30 years of age were in this data set, but if breeding were not prematurely curtailed in zoo elephants (see Chapter 9), it is possible that the data would follow the same pattern as Mar's timber elephants. Instead, breeding does not continue for long enough for the frequency of stillbirths to decrease again. Mar does not discuss the possible reasons for the high incidence of stillbirths in dams between 25 and 35 years of age, yet it certainly merits further study given the implications for zoo elephants.

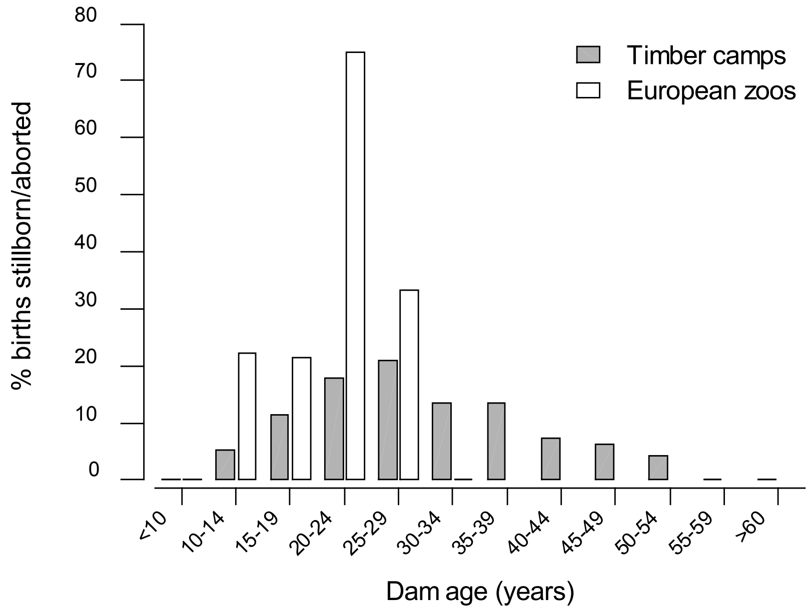

Figure 20. Stillbirth frequency and dam age in Asian elephants in timber camps and European zoos

The change in the percentage of all births that were stillbirth or aborted (timber camp data only) with dam age is shown. Data for Burma timber camps were taken from (Mar 2001), and zoo data were taken from the PETA database and the 1999 EEP Asian elephant studbook. Data represent 96 births in timber camps and 43 in zoos. Age classes with a line but no bar show that none of the births were stillborn/aborted, and those with no line represent zero births.

Stress

There is also strong evidence that for example, psychological stress affects various pregnancy outcomes in humans and other mammals (Tambyrajia & Mongelli 2000). In the captive environment, stress may be caused by environmental disruption. For example, in primates disturbance from caretakers and the public has been shown to increase the rate of premature births (Debyser 1995), and nearby construction work significantly reduced the number of live births and increased the number of spontaneous abortions (Johnson *et al.* 1991). Alternatively, the social environment may cause stress. For example, in the green acouchi (*Myopracta prattil*), the stress of living with a dominant female causes stillbirths and abortions in subordinate females (Kleiman 1986). Stress may therefore contribute to the high incidence of stillbirths found in zoo elephants, but as yet this has not been subject to study.

Infanticide and rejection of calves

In addition to stillbirths, zoo elephants frequently attack and sometimes kill their newborn calves. Numerous reports have described mothers trampling (e.g. Murray *et al.* 1996; Sulek 2001), suffocating (Anghi 1962), or tusking their calves (Sulek 2001). Data from the PETA database only contains data on five such attacks, all for Asian elephants (2 males, 2 females, 1 unknown sex), which represents 4.5% of all captive births, or 16.7% of all infant deaths in this data-set. In all cases, the calves were killed by their mother immediately after birth. Two deaths were attributed to rejection by the mother, one for each species. None of the infant deaths in the EEP database noted infanticide as the cause of death for African elephants. This frequency of infanticide in Asian elephants in these data is far lower than reports from other authors. Haufellner *et al.* (1993, cited in Kurt & Mar 1996) report that out of 121 calves born in European zoos, 9.9% were killed by their mothers and 5.8% were rejected and had to be hand reared. Similarly, of the 141 calves born between 1902 and 1996, 17.7% were killed by their mothers (27% of first year mortality) (Schmid 1998). In marked contrast, data from timber camps in Burma and Kerala (India) report that only two calves, out of a total of 426 captive births, were rejected by their mothers (Kurt & Mar 1996). Kurt (1996) believes that both rejection and infanticide is rare in wild elephants due to his observations of several births in the wild, although data are lacking for wild populations. As a comparison, infanticide in farmed pigs, which is considered a major problem, is reported to account for just 2.3% of pre-weaning mortality (Ahlstrom *et al.* 2002). Possible causes of this high infanticide rate in zoo elephants are considered below.

Early social environment factors

The early social environment of zoo elephants could explain the high frequency of infanticide and rejection. Zoo elephants are often separated from their mother when bonds would still be extremely strong in the wild. For example, data presented in Chapter 5 showed that the majority of transfers occurred when elephants were under five years of age, and involved separation from their mother. Females stay in their maternal herd for life and continue to maintain strong bonds with their mother throughout their lifetime, but males leave around the time that they attain sexual maturity at between nine to fifteen years of age (e.g. Eisenberg *et al.* 1971; Poole 1999). The premature separation that occurs in zoos could potentially impair the maternal behaviour of elephants later in life. Work on primates has shown that early separation can adversely affect the later parenting skills of the offspring, who frequently abuse, neglect or even kill their own young (e.g. Rogers & Davenport 1970; Hasegawa & Hiraiwa 1980). In captive elephants (in an orphanage), Kurt & Mar (1996) found that the rejection of young was significantly correlated with a prior lack of close contact with an older female when they were growing up. This correlation is likely to be mediated, at least in part, by the lack of learning the appropriate maternal behaviour from more experienced females. This is discussed in the following section.

Related to this is early social deprivation. As already discussed in Chapter 5, zoo elephants grow up, or are introduced to, a relatively impoverished social environment compared to the wild. This could greatly impact the development of normal social, and maternal, behaviour, particularly in young animals. No research has specifically been carried out on elephants, although Kurt & Garai (2001) note that individuals in a Sri Lankan elephant orphanage (Pinnewala) that were observed to be socially isolated tended to commit more infanticide. Studies on various mammals have shown social deprivation during infancy leads to deficits in social and sexual behaviour, which are often difficult to reverse (Nadler 1980; Maple & Warren-Leubecker 1983). Although most elephants have not been born in zoos (see Chapter 3), the vast majority have been imported from Asian timber camps under the age of ten, and from the wild at less than five years of age. Elephants mature over a relatively long period and are not considered to be adults until they reach around 20 years of age (Moss 1988; Sukumar 1989), and thus an impoverished social environment prior to maturation could have a significant affect on maternal skills and could perhaps explain, at least in part, the high rates of infanticide and rejection found in zoo elephants.

Lack of maternal experience and support

The lack of experience of elephant mothers in zoos has been suggested to be a major contributory factor to the high incidence of infanticide and rejection. In zoos, groups are far smaller than in the wild and consist predominantly of 'middle-aged' females, most of which have never given birth, and have very few calves and old experienced females (see Chapter 9). If a female does become pregnant, it is highly likely that she will never have seen, let alone cared for, a young calf. This is very different to the situation in the wild, where calves constitute a significant proportion of the population and females show a great deal of interest in young calves from a very early age (Lee 1987). Females, particularly young ones that have not had any calves of their own (Douglas-Hamilton & Douglas-Hamilton 1975), act as allomothers, or 'aunts', to young calves in the herd (Douglas-Hamilton & Douglas-Hamilton 1975, see Chapter 5; Lee 1987; Rapaport & Haight 1987). Therefore, by the time a female becomes pregnant herself, she is likely to have had a great deal of experience being around and caring for young calves.

Research on a range of species has shown that mothers that have given birth before generally have more success rearing their young and show lower rates of rejection and/or infanticide (sooty mangabeys, *Cercocebus atys*: Maestripieri *et al.* 1997; sheep: Dwyer & Lawrence 2000; e.g. cotton-top tamarins, *Saguinus oedipus* Bardi *et al.* 2001). Similar results have been found when females are given experience with infants which are not their own (rhesus macaques: Ruppenthal *et al.* 1976; dolphins, *Tursiops truncatus*: Cornell *et al.* 1987; e.g. chimpanzees, *Pan troglodytes*: Hannah & Brotman 1990). Conversely, females that have been removed from their mother prior to a successive birth, and hence deprived of infant care experience through contact with younger siblings, showed improper maternal care when they gave birth themselves (e.g. marmosets and tamarins, species name not given: Kleiman 1986). What data there are for elephants also suggest that experience plays a crucial role in the development of adequate maternal care. For example, Lee (1987) observed wild elephants and their calves and found that the calves of older mothers experienced fewer ‘distressing encounters’, defined by specific vocalisations of the calf (deep, low rumble or a loud bellow) and the behaviour of the other herd members, particularly the mother, which would rush towards the calf. It is not only the experience of the mother that is important. Douglas-Hamilton (2001) notes that herds that were led by older, more experienced matriarchs had greater calf survival compared to herds with younger leaders, and McComb *et al.* (2001) found a positive correlation between matriarch age and the number of calves produced per reproductive female in the herd per year. Thus, it would appear that adequate maternal care in elephants is to a large extent a learnt behaviour.

Very little work has been done on determining what effect this lack of experience, and hence learning, has on the mothering skills of zoo elephants. However, an example presented by Kurt & Hartl (1995) suggests that experience may indeed play a major role in the incidence of infanticide and rejection in zoo elephants. They discuss two groups of eight Asian elephants, both of which had been imported into zoos at an early age, but only the first group were place in a herd containing an old female. An additional difference is that all the elephants in the first group remained in the same zoo for the rest of their life, while five of the second group were transferred at least once. What is of interest is that all elephants in the first group successfully reared young, while all of those in the second group refused, attacked or killed their calves.

As already mentioned, ‘aunties’ play a significant role in the care of young elephants in the wild. For example, Lee (1987) found a trend for enhanced survival in calves that were cared for by aunts, and Moss (1988) found a positive correlation between the number of aunts and calf survival. This role is recognised in timber camps, where the aunts are exempt from work and remain with their ‘niece’ during the birth and for several months after (Gale 1974). Females that have shown high aggression towards their offspring can sometimes be taught to care for them by ‘aunts’ and through the assistance of the elephant handlers (Kock 1994, cited in Kurt & Mar 1996), and Taylor & Poole (1998) report that a female that initially rejected her calf was later persuaded to let it nurse once her ‘aunt’ was allowed access to them both. Kurt & Mar (1996) also note that the presence of ‘aunts’ is extremely important to calm down expectant mothers in timber camps throughout the parturition period and ensure the safety of the calf. The lack of such support from ‘aunts’ in zoo groups may therefore contribute to poor maternal care.

Thus, the available evidence suggests that one of the main reasons zoo elephants reject, and sometimes kill, their new-born calves is that they lack the appropriate experience in maternal care, which is learnt over many years from other experienced mothers in the wild. The violent reaction that some mothers have towards their calves could be caused by fear, because, as already mentioned, many zoo elephants will never have seen a calf before. (For example, this is thought to be one of the causes of infanticide in pigs, which have been observed "jumping in fear at their [piglets] approach"; a reaction that is most common in young inexperienced mothers (Leman *et al.* 1986)). This has led some to recommend that female elephants in zoos should grow up with at least one other older maternal female to learn essential mothering skills (Kurt & Mar 1996; Taylor & Poole 1998).

Stress

As discussed in relation to stillbirths, stress could also be a contributory factor to the lack of adequate maternal care seen in zoo elephants. Elephants usually experience a high degree of human interference, prior to, during and after the birth of their calf, and this has been suggested to be a contributing factor in infant mortality. For instance, females are often removed from the group and chained by all four feet in an indoor enclosure when the handlers suspect that she is close to giving birth (Schmid 1998). Veterinary intervention is commonplace both prior to the birth, in the form of an oxytocin injection (to stimulate muscle contraction) and/or an injection of sedative immediately afterwards (Schmid 1998). The reasoning behind this practice is that it allows the handler to quickly intervene and remove the calf if the mother attempts to attack it, while the sedative aims to calm the mother down and thus minimise the risk of an attack. This is very different to the situation in the wild where females give birth within the herd, and may be helped by other, more experienced, females (Moss 1988, also see previous section; Kurt & Mar 1996).

The removal of individuals prior to parturition from the group is associated with inadequate maternal care in a range of primate species in which usually give birth within the group (pig-tailed macaques, *Macaca nemistrina*: Wolfheim *et al.* 1970; squirrel monkeys, *Saimiri sciureus* Kalpan 1972; e.g. gorillas: Nadler 1980). A restrictive environment has been suggested to be a causal factor of infanticide in farm pigs (Ahlstrom *et al.* 2002). Furthermore, stress caused by alterations in the social and/or physical environment around the time of parturition has been implicated in impaired maternal behaviour, including infanticide, in a range of captive species (e.g. antelope, *Saiga tatrica*: Orbell & Orbell 1976, small spotted genet, *Genetta servalina*: Flint 1975, cited in Shepherdson & Carlstead 1995). Also postpartum stress, such as unpredictable noise, unpredictable food delivery or low temperatures has also induced infanticide in a range of species (e.g. tree-shrews, *Tupaia belangeri*: von Holst 1974; laboratory rats, *Rattus norvegicus*: Fride & Weinstock 1988; Fraser & Broom 1990; bonnet macaques, *Macaca radiata*: Andrews *et al.* 1993), and urinary cortisol levels (a stress indicator) have been found to correlate negatively with levels of maternal behaviour in zoo gorillas (*Gorilla gorilla*: Bahr *et al.* 1998).

Additional stress-related factors that may be involved, but which remain to be investigated fully, include enclosure size and complexity, which has been found correlate positively with maternal care and negatively with infant abuse in gorillas (Miller-Schroeder & Paterson 1989).

Additional causes of infant mortality

Other causes of infant deaths listed in the PETA database include an attack from another group member (1 Asian), accidents leading to severe injury and fractures (2 Asians), and heart problems (3 Asians). Similarly, the three infant deaths listed in the EEP data set were caused by drowning, a heart defect and an attack from another group member. However, given the figures, these appear to be only minor contributors to infant mortality.

Causes of mortality in older elephants

Mortality in the wild is due to a range of causes. For example, Sukumar (1989) lists the causes of death in wild Asian elephants as "disorders of the gastrointestinal tract, pulmonary and cardiovascular disease, miscarriage, starvation in old elephants due to wearing out of the last set of molar teeth, accidental fall from a steep slope and injuries from fights between bulls. Bacterial diseases such as anthrax have also been occasionally recorded." In zoos, a variety of health problems have been suggested to be major contributors to adult mortality in elephants, including foot problems (Rüedi 1990, cited in Schmid 1998), dental problems during the change in molars (Kurt 1995), attrition of joints (Lindau 1970, Adams 1981, cited in Schmid 1998) and elephant pox (Kuntze and Janetzky 1982, Pade et al. 1990, cited in Schmid 1998). In order to quantify the importance of each cause of mortality data, data from the PETA and EEP databases were used (see previous section for details). The data presented here represent mortality in elephants that had reached at least one year of age. As in the previous section, other studies with similar results (e.g. for other species) are also compared with our own.

The PETA database contained details of the cause of death for 44 (10 males, 34 females) Asian elephants and 34 (9 males and 25 females) African elephants, excluding diagnoses with some uncertainty. These figures also exclude the 30 Asian and 2 African elephants known to be infants, but as the age at death was not known for all individuals, some infants may not have been identified. Data from the EEP report the cause of death of 30 (12 males, 18 females) African elephants, excluding 3 infants. A total of 39 elephants over one year of age were registered as dead in the 2001 studbook and most died from known causes. Elephants in the PETA database were not identified by their studbook number and therefore it was not possible to tell whether they included the same individuals as the EEP dataset. However, where it was possible to work out the studbook number, using various details provided, including the date and location of death, the cause of death given by PETA matched that given by the EEP in 12 out of 13 cases. The only diagnosis that differed was one individual that was reported as having died under anaesthetic by PETA, but the EEP data listed the cause as "cardiogenic shock". Therefore, it appears that the information contained in the PETA and EEP datasets are similar, but results from both will be presented here for continuity, as the PETA data were used in the previous section and will be used here for the cause of death in Asian elephants.

Five broad categories that covered all the main causes of death were identified. These were i) illness, ii) aggression-related deaths, iii) accidental deaths, iv) anaesthesia-related deaths, and v) other. The number of deaths within each category was summed for each species and calculated as a percentage of all deaths (see Table 17). Illnesses and diseases made the largest contribution towards mortality, explaining almost two thirds of deaths in both species. Aggression-related deaths follow, which accounted for a small, but significant, number of deaths in both species. This includes elephants that were euthanased due to extreme aggressiveness, as well as those that died as the result of injuries sustained during inter-species aggression. Accidents, often relating to enclosure design, also accounted for a small number of deaths, as did anaesthesia and some other causes, including suspected poisoning and deaths attributable to multiple causes. In the sections that follow, deaths within these broad categories will be discussed in more detail, concentrating on those that could relate to the captive environment.

Table 17. Major causes of mortality in elephants held in European zoos, excluding infants

Data on the major causes of death in European zoo elephants are shown below, excluding data for individuals known to be infants (0-1 years) as this is covered in the previous section. These were calculated using data from PETA and the African elephant studbook co-ordinator, representing a total of 45 Asian and 34 African deaths from the PETA database, and 30 African deaths in the EEP database. The major causes of death are presented in rank order of importance for Asian elephants. Figures in parentheses give the data as a percentage of all deaths. See text for a description of each category.

Illness/Disease	Asian (data from PETA)	African (data from PETA)	African (data from EEP)
Illness	29 (64.4)	21 (61.8)	22 (73.3)
Aggression-related	4 (8.8)	6 (17.6)	3 (10.0)
Accidents	4 (8.8)	4 (11.8)	1 (3.3)
Anaesthesia-related	4 (8.8)	2 (5.9)	1 (3.3)
Other	4 (8.8)	1 (2.9)	3 (10.0)

Illness

The most common cause of death was illness, accounting for over 60% of deaths in both species (see Table 17). The contribution of each type of ailment towards the total death rate, taken from the PETA and EEP databases, is summarised in Table 18. In the following section, rather than give an exhaustive list and discussion of the conditions that affect zoo elephants, only those that are, or could be, induced by the captive environment will be discussed. Where data are lacking, this will be highlighted and, data relating to other species will be drawn upon where possible.

Table 18. Breakdown of illnesses and diseases causing mortality in elephants held in European zoos, excluding infants

Data from PETA and the EEP reveals the incidence of specific illnesses and diseases in zoo elephants, excluding data for individuals that were known to be infants (0-1 years) as this is covered in the previous section. The data below are based on a total of 28 Asian and 22 (PETA) or 21 (EEP) African deaths, given in rank order for Asian elephants. Figures represent the number of non-infant deaths attributable to each type of illness, and figures in parentheses give these as a percentage of all deaths.

Illness/Disease	Asian PETA data (no. deaths)	African PETA data (no. deaths)	African EEP data (no. deaths)
Circulatory problems/heart failure	6 (13.3)	5 (23.8)	6 (20.0)
Cancer/tumours	4 (9.1)	2 (9.5)	1 (4.5)
'Diseases of old age'	4 (9.1)	0	0
Foot problems	3 (6.7)	0	0
Unspecified infections	3 (6.7)	1 (4.8)	3 (13.6)
Herpes virus	2 (4.4)	0	1 (4.5)
Renal failure	1 (2.2)	1 (4.8)	0
Stroke	1 (2.2)	0	0
Blood poisoning	1 (2.2)	0	1 (4.5)
Enteritis	1 (2.2)	0	1 (4.5)
Pox	1 (2.2)	0	0
*Multiple causes	2 (4.4)	0	3 (13.6)
Arthritis	0	3 (14.3)	2 (9.1)
Parasitic infection (filaria)	0	1 (4.8)	0
Salmonellosis	0	2 (9.5)	0
Tuberculosis	0	1 (4.8)	0
Rachitis	0	0	1 (4.5)
Colic	0	0	1 (4.5)
Bowel problems	0	0	1 (4.5)
Liver failure	0	0	1 (4.5)
Unknown/unspecified disease	0	5 (23.8)	0

*Including circulatory problems, virus, bowel problems, enteritis, Salmonellosis, colic, pulmonary oedema, infection, septicaemia.

Circulatory problems

It can be seen from the table above that circulatory problems were the single most common illness in this category. The specific causes of deaths stated in the PETA database were heart failure (1 Asian, 3 African), circulatory collapse/failure (2 Asian, 2 African), circulatory debility (1 Asian) and pulmonary embolism (1 Asian). Heart failure and circulatory debility were one of multiple causes for an additional three Asian elephants. From the EEP dataset, circulatory problems listed as a cause of death in African elephants were arteriosis, myocarditis (inflammatory disease of the heart) and a "heart problem", each responsible for one death. In addition, myocarditis and degeneration of the cardiac muscle were listed as one of several causes of death in two elephants. Klös & Lang (1982) note that cardiac problems have also been identified in wild African elephants, such as thickening and calcification of the arteries (atheroma). They suggest that these also likely to affect captive elephants and be the cause of partial paralysis of limbs, ears and the trunk, stroke and cardiac failure (Klös & Lang 1982). However, the incidence of such problems has not been quantified in wild elephants, or those housed in extensive systems, and therefore it is impossible to determine whether zoo elephants suffer to a greater or lesser degree.

One possible causal factor in the development of circulatory problems is stress. Studies on humans suggest that chronic stress increases the risk of cardiovascular disease (e.g. Duncko *et al.* 2001; Maddock & Pariante 2001), for instance due to high blood pressure, atherosclerosis and/or thromboses (Su *et al.* 2001; Black & Garbutt 2002). Also, excessive body weight in female zoo elephants, along with the high fat content of most zoo diets examined, may be a contributory factor (see Chapter 4). Studies on humans have shown a relationship between obesity and the risk of cardiovascular disease (e.g. Sowers 1998; Abate 2000), and this may be the case for some other species (e.g. dogs: Hall *et al.* 1995), although Buffington (1994) notes that many domestic animals are not affected by all the conditions seen in obese humans.

Foot problems

Data from the PETA report show that foot problems were responsible for the deaths of three out of 28 Asian elephants, but no Africans. It is widely know that captive elephants are highly susceptible to foot problems. Conditions that are commonly encountered include overgrown nails, soles and cuticles, foot rot (necrotic pododermatitis), abscessation, split nails and soles (Klös & Lang 1982, see Appendix III for a summary; Hittmair & Vielgrader 2000; Fowler 2001). These can develop into chronic long-term problems and can lead to extreme measures being taken such as amputation or euthanasia, or fatalities (e.g. Boardman *et al.* 2001; Finnegan & Monti 2001; Kam 2001; Roocroft & Oosterhuis 2001).

Although not the highest cause of mortality, they are generally regarded as the single most important health problem in captive elephants (Schmidt 1986; Fowler 2001). Fowler (2001), an experienced zoo veterinarian, believes that untreatable foot infections, and arthritis, are the major reason for euthanising elephants. Csuti *et al.* (2001) estimate that 50% of African and Asian elephants will suffer from foot problems at some point in their life. However, a survey yielded more pessimistic data: Mikota *et al.* (1994) report medical foot problems in 50% of the 189 elephants they screened. Given that this was a cross-section of time, the results suggest that a far greater number will experience foot problems at some point in their life.

The first attempt at quantifying the incidence of different types of foot problems was recently carried out by Dimeo-Ediger (2001) in North American zoos, who reports the preliminary results of a survey on elephant foot husbandry and veterinary care, developed by Oregon Zoo and San Francisco Zoo. The survey covers a total of 54 facilities, most of which were accredited by the American Association of Zoos and Aquaria (AZA). The survey contained questions about the relationship between the incidence of foot disease and various aspects of husbandry within their zoo, and whether they regarded improvements in each area as a priority. The most common foot problems reported, depending on region, were soft nails (perionchyla with softening of the nail), erosion of the sole of the foot with penetration by a foreign body, and lesions between the nails (see Appendix III for descriptions of the main foot conditions).

Elephants kept in extensive conditions, such as in logging camps, also suffer from foot problems and although comparable data on the incidence of foot problems in these systems is lacking, most are said to be due to work-related injuries rather than captive conditions themselves (e.g. Chandrasekharan *et al.* 1995). Chandrasekharan *et al.* (1995) report a total of 125 cases of foot rot in Asian timber and wild elephants, and although they do not state how many elephants were examined, this was over a 20 year period. There are also some scarce reports of wild elephants suffering from foot problems (e.g. Bengis *et al.* 1991; Keet *et al.* 1997), but these again are mainly due to some type of injury, such as cuts, fractures or snare wounds (Fowler 2001).

The reasons behind such a high prevalence of foot problems in captive elephants are several fold and are summarised by Fowler (2001). Those related to the captive environment are as follows: lack of exercise; insufficient foot grooming by handlers; improper enclosure surface; unhygienic conditions; excessive moisture; malnutrition; the performance of stereotypic behaviours; joint problems and skeletal disorders such as arthritis (Roocroft & Oosterhuis 2001; Sampson 2001, see Appendix III for a summary of the main causes for each type of foot problem). Additional factors that could exacerbate the occurrence of foot problems is the excessive weight of many zoo elephants compared to those kept in extensive systems and wild elephants (Kurt & Hartl 1995), and general stress, which could impact immune functioning and hence the contraction and spread of infections (e.g. Broom 1991; Toates 1995). These factors will now be discussed in relation to the captive management of elephants, drawing predominantly from information published in the book '*The Elephant's Foot*' (Csuti *et al.* 2001), which is based on some of the presentations given at '*The First North American Conference on Elephant Foot Care and Pathology*', held in Beavertson, Oregon, 19-21 March 1998.

Lack of exercise

Zoo elephants get far less exercise than their wild counterparts, which spend between 68 and 93.5% of their waking hours walking and grazing (McKay 1973; Wyat & Eltringham 1974; Sale *et al.* 1992; Sivaganesan & Johnsingh 1995). As reviewed in Chapter 4, elephants in family groups travel between 0.95 and 7km per day, while adult males cover between 1 and 28.4km. This activity not only wears down their feet, but also exercises joints, ligaments and muscles and promotes blood flow to the feet. In captivity, in contrast, most elephants get little opportunity, or have little inclination, for exercise and this has been blamed for the development of overgrown soles and nails that can easily crack and get infected, a problem which potentially increases with age as the elephants exercise even less (Roocroft & Oosterhuis 2001). Although not yet subject to a comprehensive study, Dimeo-Ediger's (2001) survey of North American zoos (see the beginning of this section for details) revealed that 67% of zoos believed inactivity affected the incidence of foot disease, and 80% set 'more exercise' as a priority. These beliefs come from the general observations of veterinarians and those that work closely with elephants, and are supported by evidence showing a link between inactivity and the incidence of lameness in various hoofed livestock species (e.g. pigs: Leman *et al.* 1986). Overgrown soles are predominantly a problem for African elephants, whereas excessive nail and cuticle growth is far more common in Asian elephants, which is thought to be a result of the method of foraging in the wild. African elephants travel over rough terrain for long distances in search of food and it is assumed that rapid growth of the sole is an adaptation for this lifestyle in the wild, and hence the general requirement for regular hoof trimming in the captive environment. Asian elephants, in contrast, feed mainly by pulling at vegetation with their trunk while raking the ground with their feet. This could explain the more continuous nail growth in this species and hence the greater need for nail care (Roocroft & Oosterhuis 2001). Captive elephants thus require regular trimming to get rid of excess growth. Overgrowth of the cuticle is also a problem if trimming does not occur regularly. This can lead to the development of fluid pockets behind the cuticle, which can cause the elephant to alter their gait to avoid putting pressure on that part of the foot, and is therefore considered to be painful (Roocroft & Oosterhuis 2001).

This lack of exercise is probably caused by the spatial restrictions imposed by small enclosure sizes, and the practice of chaining overnight, which remains a common practice in many zoos (see Chapter 4). In dairy cattle, confined housing is associated with an increase in the incidence of foot problems. For instance, Gitau *et al.*(1996) report that lameness was 2.9 times lower in cattle that grazed on pasture compared to those in confined housing, although poorer hygiene in the latter is also likely to be a contributory factor (discussed in the section 'Climate'). However, careful enclosure design and management could lessen this problem. For example, adaptation of the enclosure and husbandry routine at Vienna Zoo resulted in their African elephants walking an average of 2.9 to 5.9km per day, a distance comparable to wild elephants. This was achieved using a range of methods. The outdoor enclosure was elongated and food was provided in various areas of the enclosure at several times throughout the day. The elephants were also allowed to move freely between the indoor and outdoor enclosures at night, and food was provided in both to encourage movement. It would be interesting to see whether these practices also reduced the incidence of foot problems in this herd, as one would expect.

Inadequate/improper foot care

Due to the problem in maintaining healthy feet, regular foot grooming is required (Roocroft & Oosterhuis 2001). As discussed in the Chapter 6, the majority of zoo elephants are trained to respond to commands. This allows handlers to move freely among the elephants and perform basic tasks such as foot care. However, not all elephants can be handled to the extent that they will allow handler to work safely on their feet for extended periods of time, and some are not trained at all. This makes foot care impossible unless the elephant is anaesthetised, which carries its own risks (see later in this section), and subsequently these elephants can develop serious foot problems. This could be overcome by training the elephants in protected contact situation, although this requires the necessary staff training (Desmond & Laule 1991, see Chapter 6). Conversely, regular foot care can actually cause, rather than prevent, problems if not done properly. For example, excessive nail filing can lead to weakening and cracking of the nail that can then develop into an abscess, and excessive trimming of the foot pad, which is a common problem, can cause pain when walking or if the elephant steps on a rock.

Inadequate substrate

As discussed in Chapter 4, many captive elephants are housed on dry, hard surfaces, such as concrete or tarmac, for most of the time. This, along with a lack of adequate exercise, can cause the soles to crack and abscesses to form in the nails or on the pad of the foot (Buckley 2001; Roocroft & Oosterhuis 2001). Furthermore, the middle nail of the rear foot is prone to cracking if elephants regularly have to get up and down on very hard surfaces (Roocroft & Oosterhuis 2001). Anecdotal evidence suggests that elephants housed on natural substrates are less prone to foot problems (Gage 2001). For example, the change from rock to a sand-clay mix at Milwaukee Zoo significantly reduced the occurrence of bruising on the soles of the feet in one individual (Sorensen 2001). Furthermore, Dimeo-Ediger's (2001) survey of North American zoos showed that out of the 91% of zoos that had concrete floors, 52% of zoos believed that there was a relationship between concrete flooring and foot disease, yet 67% saw changing the indoor flooring as a low priority. Research on domestic livestock has also shown a link between flooring substrates and incidence of foot problems, in that hard substrates such as concrete are associated with higher levels of lameness (e.g. Bergsten & Frank 1996; Faull *et al.* 1996; Ward 2001). The use of rubber mats has been shown to significantly decrease the incidence of lameness and foot problems in cows (e.g. Bergsten & Frank 1996; Vokey *et al.* 2001) and many zoos in the U.S.A. have now installed soft rubber flooring over the concrete of indoor barns (Scott Blais, pers. comm.), as have some in Europe (e.g. Schwammer 2001). This is thought to alleviate foot problems in the elephants, but it is not known how common, or effective, this practice really is.

Unhygienic conditions

Captive elephants' feet are regularly exposed to their own faeces and urine, especially when they are confined indoors, often chained, for a large proportion of the time (Roocroft & Oosterhuis 2001). These unhygienic conditions are likely to be very uncomfortable for the elephants, causing irritation and sometimes ammonia burns, and elephants have been seen to throw dust on themselves to dry their legs (Hughes & Southard 2001). This moist environment also provides ideal conditions for bacteria colonisation which can lead to foot rot (Hughes & Southard 2001). Contact with faecal material is another source of pathogens, and chronically wet and dirty conditions are considered a major cause of abscesses and foot rot (Schmidt 1986; Chandrasekharan *et al.* 1995; Boardman *et al.* 2001). To avoid this, many facilities scrub feet and legs on a daily basis (Roocroft & Oosterhuis 2001). This is thought to effectively acts as a substitute for the daily visits to waterholes in the wild in terms of foot health (McKay 1973), which keep feet relatively clean and healthy (Roocroft & Oosterhuis 2001). Alteration of facilities to minimise contact with excrement or excessive moisture has also met with success. For example, Hughes & Southard (2001) report a decline in the incidence of foot rot and abscesses when they stopped chaining at night and allowed the elephant to move to an area that was free of faeces. Similar hygiene conditions are a cause of lameness in cattle. For instance Ward (2001) reports a lower incidence of lameness in cattle that were housed in stalls designed to discourage them from defecating in the cubicle. Moist conditions have also been found to contribute to foot problems in dairy cattle (Wells *et al.* 1995). Many elephant facilities have now installed heated floors, or large fans, in indoor enclosures to ensure rapid drying of the floor (e.g. Hughes & Southard 2001). However, evidence for a quantitative change in the incidence of foot problems has yet to be collected to determine the most effective husbandry changes. Buckley (2001) does report a dramatic reduction in the previously chronic, long-term, foot problems of several elephants after they were moved from zoos to a very large enclosure (222 acres) containing grassland and woodland. Buckley attributes this to the large areas available for exercise and the natural substrates that clean and wear down the feet.

Climate

Related to hygiene is the effect of climate. Anecdotally, it has also been suggested that elephants housed in hotter climates, such as Mediterranean countries in Europe, suffer from fewer foot problems compared to those in countries such as the U.K. (e.g. Amelia Terkel, pers. comm.). This is thought to be due to weather conditions, such that more temperate climates are colder and rainier and so outdoor enclosures tend to get muddy and wet. Subsequently, elephants in these countries are also housed for a far greater portion of the time indoors and so the hygiene problems associated with this (reviewed in the previous section) such as damp conditions and contact with urine and faeces, will also be a greater problem. Although this has yet to be studied in elephants, evidence from livestock research suggests this is likely to play a role. For instance, cows are been found to have a higher incidence of foot infections (e.g. digital dermatitis) during colder, wetter seasons (e.g. Huang *et al.* 1995; Bergsten & Frank 1996; Vaarst *et al.* 1998; Rodriguez-Lainz *et al.* 1999).

Malnutrition

Various nutrients are thought to affect the health of elephant feet and nails, and a poor diet or poor assimilation of nutrients can cause slow nail and pad growth, brittle nails, excessively thin pads and soft nails (Buckley 2001). For example, the vitamin biotin (a B-complex vitamin) is used by a number of zoos to improve foot health (e.g. Sampson 2001; Seidon 2001). It is not known, however, whether captive elephants are actually deficient in this vitamin, as levels have not been measured in wild populations, and no trials have been done on elephants to assess the effectiveness of such supplements. A trial carried out on horses does suggest that this may be effective, however, as a significant increase in hoof strength and a reduction in cracking was recorded after eight to fifteen months of oral biotin supplements, and this reversed in most cases after supplements were stopped (Sadler 2001). Several trace elements have also been implicated in the maintenance of foot health, namely zinc, selenium and arsenic. Although detailed studies have not been carried out to evaluate the concentrations of these nutrients in captive elephants, or their effectiveness in reducing foot problems, their general role in skin and nail growth suggest that supplements may be advantageous.

Joint problems

Elephants in captivity often suffer from a range of conditions that affect their joints, causing lameness and abnormal gaits and thus affecting the development of foot problems (Roocroft & Oosterhuis 2001). These constitute a significant health problem in themselves and so they will be considered separately in the following section.

Excessive body weight

As discussed in Chapter 4, zoo elephants are far heavier than their wild counterparts. This exerts additional pressure on the footpad and is said to exacerbate foot and joint problems (Hardjanti 1997; Roocroft & Oosterhuis 2001; Rutkowski *et al.* 2001; Sadler 2001; West 2001). Again, this has yet to be subject to study in elephants, but research on livestock that suffer from foot problems, such as cows, show a positive correlation between the incidence of foot problems and body weight (e.g. Wells *et al.* 1993; Vaarst *et al.* 1998).

Stereotypic behaviours

Many elephants in captivity perform repetitive stereotypic behaviours such as weaving. This type of movement exerts abnormal pressure on the lateral toes of the front feet and can cause nail cracks (Roocroft & Oosterhuis 2001). Abscesses may also develop, thought to be due to the disruption of the blood supply to the feet, and can then become infected if they rupture (Boardman *et al.* 2001; Roocroft & Oosterhuis 2001). Factors influencing the development of stereotypic behaviours are discussed more fully in Chapter 10.

General stress

Chronic physiological and psychological stress is known to cause immunosuppression (see Chapter 1), for instance by reducing the efficacy of antibody responses and cell-mediated immunity (e.g. Broom 1991; Wiepkema 1993; Toates 1995; Schedlowski & Schmidt 1996; Tuchscherer & Manteuffel 2000). This stress could therefore play a role in foot health by increasing susceptibility to disease (e.g. Broom 1991; Dorshkind & Horseman 2001), but this not yet been investigated.

Therefore, there are a wide range of factors that affect the incidence of foot problems in captive elephants. Many of these remain to be thoroughly investigated in elephants, but the evidence reviewed in this section, coupled with inferences from studies on other species, suggest that the captive environment has a great effect on the foot health of elephants.

Endotheliotropic elephant herpes viruses (EEHV)

This disease has only recently been recognised in captive elephants (Richman *et al.* 1999). To date there have been 33 documented confirmed cases (Montali *et al.* 2001), since 1995, seven in North America and nine in Europe. It has been suggested that this disease is a major contributor to captive-born elephant mortality, which has largely been overlooked due to its recent identification (Richman *et al.* 2000). In the PETA database, herpes was responsible for the death of only two Asian elephants, and only one African elephant according to the EEP data (see Table 18).

There are two forms of the virus, one being fatal for African elephants and the other for Asians (Richman *et al.* 1999). They are fast acting and can be hard to diagnose until too late to treat (Fickel *et al.* 2000). African elephants appear to be the source of both forms of the virus. Lesions in otherwise healthy African elephants have been found to contain herpesvirus sequences that are identical to the virus lethal to Asians, suggesting that African elephants act as carriers for the disease without showing the symptoms. The virus that is fatal to African elephants has been found in the pulmonary lymphoid nodules found in some wild African elephants, suggesting that they may also carry this form of the virus (Bengis *et al.* 1991; Richman *et al.* 2000). However, as yet there is no direct proof of transmission along these routes and fatal infections have occurred in the absence of African elephants (Montali *et al.* 2001). Research is ongoing to determine transmission pathways (Richman *et al.* 2000).

The prevalence of this virus in zoos has only recently been studied, but the screening of samples from 72 elephants (live and dead) from European zoos revealed seven confirmed cases of the disease, all in Asian elephants. Only one out of these seven elephants had survived due to early recognition and treatment with Famciclovir© (Fickel *et al.* 2000) but recently, this drug has been successful in treating EEHV (Schmidt *et al.* 2000).

It has been recommended that transferring elephants between zoos should be minimised as this increases the risk of disease transmission (Montali *et al.* 2001; Ryan & Thompson 2001). Asians that have had contact with African elephants are also more at risk due to the infectious papillomas found in the Africans. Transmission requires intimate contact between elephant and handler (Ryan & Thompson 2001), and therefore handlers that work with both species in the same zoo, particularly those in free contact systems, could act as vectors of this disease even when the two species are housed separately.

Research on the herpes simplex and herpes labialis forms of the virus in humans have shown a positive relationship between stress and susceptibility to infection, as well as recurrence (e.g. Cohen *et al.* 1999; Buske-Kirschbaum *et al.* 2001; Loutsch *et al.* 2001). In humans, Creuss *et al.* (2000) also demonstrated an association between greater decreases in cortisol level reduction (through stress management techniques) and lowered concentrations of herpes simplex virus in the blood. Although not investigated for this specific form of the virus, or in elephants, the potential role of stress in susceptibility to infection thus deserves attention.

Tuberculosis (*Mycobacterium tuberculosis*)

This disease is found in both species of elephant, although only listed as a cause of mortality by PETA in one African elephant (see Table 18). Typical symptoms include chronic weight loss, anorexia, weakness, coughing and breathing difficulties (Mikota *et al.* 2000). Most cases of tuberculosis have been found in Asian elephants (Mikota *et al.* 2000). The prevalence amongst European herds is unknown, but a retrospective study of 379 elephants in North American zoos revealed eight deaths from TB over a period of 86 years (Mikota *et al.* 1994). A more extensive survey carried out by the National Veterinary Services Laboratory suggests a prevalence of 3.3% in the North American zoo population (Mikota *et al.* 2000). *Mycobacterium tuberculosis* is the human form of the disease and is thus considered zoonotic in elephants (Maslow 1997; Mickalak *et al.* 1998), as it can be transmitted from and to humans. A test of handlers that worked with an infected herd revealed 11 out of 20 positive tests for tuberculin (Mickalak *et al.* 1998), and at least one handler has been diagnosed with the active form of the disease (Shoshani 2000, p100). Close, daily contact is considered to be the major risk factor, for humans and elephants alike, and therefore the method of handling is likely to affect transmission (see Chapter 6).

Diagnosis can be made from culturing mycobacteria from the trunk of the elephant. This requires a trunk “wash” to be carried out and consists of inserting saline into one or both nostrils, elevating the trunk and then getting the elephant to exhale the liquid (e.g. Larsen *et al.* 2000). This of course requires a great deal of co-operation by the elephant and they must therefore be trained (Montali *et al.* 2001). This test is now mandatory in North America but not in Europe (AZA 2001).

This disease has also been recorded in working elephants (Chandrasekharan *et al.* 1995; Krishnamurthy 1995), but only three cases were reported to Tamilnadu state over a period of

80 years (Krishnamurthy 1995). It is not known whether zoo elephants have a higher incidence of the disease than timber (or wild) elephants.

Arthritis

It has been suggested that arthritis, along with foot problems, is the leading cause of euthanasia in captive elephants (West 2001). In the PETA data set, arthritis was the cause of death of two African elephants (8.8% of all deaths), and at least one of these was euthanased (see Table 18). In elephants, the front legs are more prone to this condition as they have a greater weight load than the back legs (Houck 1993). Arthritic elephants are believed to experience joint pain as they show a reduction in movement and reluctance to lie down, which in turn exacerbates the condition (Houck 1993). This condition is said to affect more zoo than wild elephants (Schmidt 1986), with a similar prevalence in zoos to that in domestic horses (Houck 1993). Arthritis also occurs in wild and extensively held Asian elephants, and Chandrasekharan *et al.* (1995) report a total of 55 cases of arthritis in Asian elephants, both wild and captive (timber), over a period of 20 years. The working elephants were found to be more susceptible than wild animals to swollen joints, due to work-related injury and ill treatment from mahouts (Chandrasekharan *et al.* 1995). The incidence of this condition has yet to be quantified in the living population of zoo elephants, although some estimates do exist for historical specimens (see below).

Until recently, it was believed that osteoarthritis was the primary cause of discomfort and lameness in captive elephants (Shoshani 1982; Rothschild *et al.* 1994). Osteoarthritis, or degenerative joint disease (DJD), is a condition involving degeneration of the cartilage and bone of the joints leading to joint pain, stiffness and swelling (Anon. 2002); a so-called "wear and tear" disorder (Rothschild *et al.* 1994). This condition is therefore difficult to cure, and the primary treatment is pain relief. However, work by Rothschild *et al.* (1994) examined bone specimens of elephants held in museums. From their observations of characteristic bone formations (e.g. joint fusion) they diagnosed not osteoarthritis, but rather spondyloarthropathy (Rothschild *et al.* 1994). The term spondyloarthropathy covers a range of similar conditions, but the diagnosis of Rothschild *et al.* (1994) suggests that the arthritis found in the elephant skeletons most closely resembled human Reiter's syndrome, also known as reactive arthritis, but also perhaps psoriatic arthritis. In humans, Reiter's syndrome causes pain, swelling, and heat in the joints, and commonly affects the spine, although this was not found in elephants. The condition is commonly accompanied by inflammation of the joints, urinary tract and eyes, and ulceration of the skin and mouth. Diagnosis of the disease often follows a bout of diarrhoea caused by eating food infected with bacteria such as *Salmonella, Shigella, Campylobacter, Yersinia and Escherichia coli*, the latter also causes enteritis. It can also be transmitted sexually by infection with *Chlamydia* (McEwan *et al.* 1971; Resnick & Niwayama 1988; Rothschild *et al.* 1994). This condition is far easier to treat than osteoarthritis, by using antibiotics and anti-inflammatory agents (Rothschild *et al.* 1994).

Rothschild *et al.* (1994) also evaluated the frequency of arthritis in elephants through their skeletal study of 145 Asian and 18 African elephant specimens at the American Museum of Natural History. Unfortunately, they do not state the source of the specimens and therefore it is impossible to tell whether they represent captive or wild animals. Their examinations found evidence of spondyloarthropathy in 8.3% of Asian, 4.56% of African, based on the fusion and erosion of joints. Rothschild and colleagues have also quantified the incidence of this condition in a similar manner for a wide range of other mammalian species, and found an incidence of 2.8% in canids (Rothschild *et al.* 2001), 3.7% in large cats (Rothschild *et al.* 2001) and 7% (male) to 10% (female) in macaques (*Macaca mulatta*) specimens (Rothschild *et al.* 1997). Figures for the former two species represent both captive and wild animals, and the incidence was not affected by the captive or wild status of canids (Rothschild *et al.* 2001). No such comparison was carried out with the other taxon. Although Rothschild *et al.* did not observe this condition in elephants, osteoarthritis may simply be rare in this species. For example, although it has yet to be fully quantified, studies of other species showed a far lower incidence. For instance, of the canid and rhesus macaque specimens studied only 0.3% and 4% (males only), respectively, showed evidence of osteoarthritis, and only around half of the felids that had spondyloarthropathy (Rothschild *et al.* 1997; Rothschild *et al.* 2001; Rothschild *et al.* 2001). However, a far higher incidence of 20% was found in female macaques (Rothschild *et al.* 1997). Thus, not all cases of arthritis are likely to have been misdiagnosed in elephants.

As yet, no study has attempted to determine the correlation between husbandry and the incidence of joint problems in captive elephants. However, various authors have commented on possible causal factors, and inferences can also be drawn from studies on other species.

Lack of exercise and excessive body weight

A lack of exercise has been cited as one of the major causal factors in the development of arthritis (West 2001). Restricted movement due to inadequate space and/or chaining (West 2001) has been implicated in the development of arthritis in elephants, as regular exercise increases flexibility to wrists, knees and their joints (Oosterhuis *et al.* 1997). For example, an African elephant at Schoenbrunn Zoo, Vienna, was diagnosed with severe DJD, which was attributed to a lack of movement in captivity (Hittmair & Vielgrader 2000). This has not been properly studied in elephants, but results from other species, including humans, show that inactivity is one of the risk factors for osteoarthritis (e.g. Anon. 2002). It is also likely that this is compounded by the weight of zoo elephants. As reviewed in Chapter 4, and the section on foot problems in this chapter, many zoo elephants are overweight. This has been identified as a significant risk factor in humans (Anon. 2002), and could well be an exacerbating factor in zoo elephants due to the additional pressure on the joints (Ruthe 1961, cited in Kurt & Hartl 1995).

Inadequate substrate and unhygienic conditions

Keeping elephants on unsuitable substrates, such as cold and damp concrete and wet, muddy substrates is thought to increase the frequency of arthritis (Sikes 1971; Hittmair & Vielgrader 2000). Given the recent evidence that the form of arthritis found in elephants is transmitted through bacterial infections, such unhygienic conditions could very well spread this disease. Bacterial joint infection has also been implicated in the development of osteoarthritis, and acute infection usually leads to chronic arthritis (Schmidt 1986).

Trained behaviours

Various studies have also implicated certain trained behaviours in the development of joint problems in captive elephants, as mentioned in Chapter 6. These are often referred to as "power behaviours" and include elephants standing on their hind legs or front legs, balancing on their forehead, sitting up on tubs and kneeling down. Although they are more the preserve of circus handlers, they can be seen in several zoos during public performances (Clubb, pers. obs.). These behaviours require a great deal of physical effort. The effect of these performances on the physical health of captive elephants has not been subject to study. However, as reviewed in Chapter 6 there is evidence that these behaviours can damage the joints of elephants causing painful swelling of the joints *(bursitis praepatellaris*) and callused elbow (*tyloma olecrani*) in circus elephants (Kuntze 1989).

General stress

As reviewed in the previous section on foot problems, stress can impair the performance of the immune system and thus increase susceptibility to infection. Although this has yet to be investigated in elephants, it is possible that the incidence of arthritis may be related to general stress levels, which in turn are affected by various husbandry conditions.

Aggression-related deaths

According to the PETA data, five Asian and seven African elephants died, or were euthanased, because of aggression-related problems. Of these, four Asian and four African elephants were euthanased because they displayed excessive aggression towards humans and were considered to be too dangerous and uncontrollable. The remaining deaths (1 Asian, 2 African) were due to injuries inflicted by other elephants. Data from the EEP are slightly different, and only one African elephant was listed as having been euthanased for excessive aggression, and a further two were due to interspecies aggression. Aggression in adult bulls is a well-known problem in zoos, usually resulting in the animals being kept in protect or no contact situations to reduce the risk to keepers (see Chapter 4). However, many of the aggression-related deaths involved female elephants. Five (3 Asian, 2 African) out of the eight that were euthanased because of their aggressiveness, according to PETA, were females, as was the single African elephant in the EEP dataset. Similarly, the two females (1 Asian, 1 African) in the PETA data that died because of interspecies aggression were attacked by other females, and no details were available for the male African that was killed. Both African elephants in the EEP dataset, one male and one female, died from injuries inflicted by exhibit males. Elephants in the wild are an extremely peaceful species, and acts of outright aggression are rare, particularly in females (see Chapter 6). The causes for the development of aggressive tendencies have been subject to some speculation, but not study. These will be discussed in Chapter 10.

Accidents

Injury or deaths because of accidents claimed the lives of four Asian and four African elephants according to the PETA data. Due to elephants' size, fractures are extremely difficult to treat and often result in euthanasia. Four of these deaths (3 Asian, one African) were due to elephants falling into dry moats/ditches, and an additional African elephant died as a result of injuries caused by spikes that lined the edge of the enclosure. Falls into dry moats are a well-known problem in zoos for a variety of species, and many are now phasing out the use of dry moats and spikes, opting for solid walls and electrical fencing instead (AZA 2001). The causes of the remaining deaths are as follows: one male African slipped on his own excrement during mating; one male Asian elephant drowned in a pond after having been attacked by the females; and one female African was euthanased because of fractures sustained from unspecified causes. Data from the EEP list only two African accidental deaths: one was due to a fracture of unknown cause, and the other was caused by drowning.

Anaesthesia-related

It is commonly mentioned that elephants are particularly at risk when placed under anaesthetic, and this is one of the arguments put forward for training elephants to respond to commands (e.g. Molter 1980, see also Chapter 6). Data from PETA include six elephants that died while, or shortly after, they were under general anaesthetic. Three of these (2 female, 1 male African) occurred during routine care of the feet and/or tusks; one during surgery to remove an obstruction from the mouth (1 African female), and two for an unspecified reason (1 Asian male, 1 African female). The EEP data only list the death of one male African that died under anaesthetic.

Whether or not elephants are more at risk than other zoo species has not been studied. While under anaesthetic, elephants lying down are at risk from severe respiratory depression due to the excessive weight of the sternum and diaphragm which limits air exchange, as well as causing circulatory depression and reduced oxygen perfusion (Bush 1996). Furthermore, prolonged lying can cause an unusually slow heart beat (bradycardia) in elephants, which can result in cardiac arrest, but only after a period of 12-18 hours (Klös & Lang 1982). Elephants are regularly anaesthetised in the wild (e.g. Osofsky 1995) and thus a further possible risk factor for zoo elephants may be poor body condition or excessive body weight.

Malnutrition

A study by Mikota *et al.* (1994) found 81 cases of disease in zoo elephants that related to nutrition. Most of these (72%) were caused by changes in the diet (treats or overfeeding) or poor quality hay. The remainder were attributed to malnutrition, including several deaths particularly of young elephants. As discussed in Chapter 4, the level of vitamins and minerals in zoo elephant diets are frequently below recommended doses, which could impact their health.

Vitamin E

Vitamin E deficiency has been a concern for zoo animals, especially elephants and rhinoceroses (Sadler *et al.* 1994). This vitamin is composed of a group of compounds called tocopherols and tocotrienols (Wallace *et al.* 1992). These compounds are quite unstable and so are found in far greater quantities in fresh produce compared to processed foodstuffs. For this reason, captive animals are often deficient in vitamin A. Symptoms of deficiency include muscle degeneration, reproductive failures, nervous system disorders, and vascular and immune system deficiencies (Dierenfeld & Dolensek 1988). Specifically, cardiac and skeletal myopathies and neuronal degeneration have been linked to this deficiency in ungulates (Sadler *et al.* 1994).

Vitamin E deficiency has been found in a number of zoo elephants (Brush & Anderson 1986; Dierenfeld & Dolensek 1988). A study that sampled the serum or plasma of 35 elephants from 11 zoos and one private owner confirmed that low levels of circulating alpha-tocopherol are a common and persistent problem in captive elephants (Papas *et al.* 1991). Several deaths, including one from cardiomyopathy, have had vitamin E cited as a contributory factor (Dierenfeld & Dolensek 1988; Kaufman 2001; Kenny 2001; Dolensek & Combs in press). Deficiency in this vitamin has also been suggested to be a major cause of white muscle disease in elephants (Schmidt 1986). This condition has also been reported in Asian timber elephants and is also cited as a major cause of corneal opacity (Chandrasekharan *et al.* 1995). The dried forage given to captive elephants has far lower levels (2 to 10 fold) of vitamin E than fresh vegetation (Dierenfeld & Dolensek 1988), and wild ranging and timber elephants are reported to have 3.75 to 5 times greater circulating tocopherol levels compared to zoo elephants (Dierenfeld & Dolensek 1988; Kenny 2001; Dolensek & Combs in press). In contrast, elephants working in Nepalese camps were found to have adequate levels (Shrestha *et al.* 1998), probably due to the fact that timber elephants are free to roam and browse in the forest at night.

Supplementation through the diet has been shown to effectively increase circulating levels of the vitamin (Papas *et al.* 1991; Sadler *et al.* 1994; Dolensek & Combs in press), in some cases up to levels resembling that of wild populations (Wallace *et al.* 1992; Kenny 2001). A study by Papas *et al.* (1991) found that water-soluble D-alpha-tocopheryl polyethylene glycol 1,000 succinate (TPGS) was the most effective treatment, causing a rapid increase in circulating blood alpha-tocopherol following administration of 4.8 or 6.6 IU/kg body weight. Micellized tocopherol was found to be an acceptable source of supplemental vitamin E activity for prolonged feeding to captive elephants (Wallace *et al.* 1992).

Calcium

Calcium is extremely important for elephants particularly because of their tusks, with the exception of female Asian elephants which do not grow tusks. Calcium metabolism is also very susceptible to changes in diet. For instance, Klös & Lang (1982) demonstrated that a slight change in the level of protein in the diet could lead to a significant reduction in calcium excretion. Calcium deficiency can lead to *hypocalcemic tetany* (low blood calcium muscle twitchings) causing stiffness, abrupt body movements, eye twitching, partial paralysis and loss of co-ordination of the trunk and paralysis of the pharynx (Klös & Lang 1982). Deficiency in this mineral has been linked to the death of at least two elephants (Kaufman 2001). The condition is obviously related to the diet. For example, Klös & Lang (1982) notes that two elephants that suffered from *hypocalcaemic tetany* were fed a large amount of greens rather than the usual rolled oats, thus causing this condition. Provision of calcium supplements can reverse this condition (Klös & Lang 1982).

Iron

Captive elephants are susceptible to anaemia, which results from iron deficiency. Typical symptoms include emaciation, a weak pulse, pale mucous membranes and eventually oedema (Klös & Lang 1982). In the wild, elephants obtain iron from the water and by ingesting earth. In captivity, levels of iron are insufficient for young elephants and so supplementation is required.

Other nutrients

A case of osteodystrophy in an orphaned Asian elephant was thought to be caused by nutrient deficiency in vitamin D, calcium and/or phosphorus (Ensley *et al.* 1994).

Intestinal problems

The gastrointestinal tract is the most susceptible site of disease, as in other zoo animals (Klös & Lang 1982). Stomach ulcers have caused the death of several elephants, although these were only found on post-mortem examination. Intestinal problems, such as enteritis, are a common occurrence in captive elephants and were responsible for 2.3% of deaths in Asian elephants (PETA data) and 3.3% of African deaths (EEP data, see Table 18). These respond to vitamin C treatment and hence may be caused by a deficiency in this vitamin. Spastic colic had also been reported in elephants and has been implicated in mortality (Klös & Lang 1982). Symptoms are very similar to those in horses, namely cautious movement, falling and rolling on the ground (Klös & Lang 1982). No records were found that reported the incidence of this problem with wild or captive elephants. Potential causes of gastric ulcers include stress (e.g. Toates 1995) or acidosis related to diet, such as those low in bulk (reviewed by Mason, in press).

Impaction of the colon (constipation) is a very common condition in captive elephants, far more so than in wild elephants (Chandrasekharan *et al.* 1995), which can be fatal (Klös & Lang 1982). As well as an absence of defecation, symptoms include the almost complete cessation of eating and drinking, dehydration, weakness, bloating, colic and high temperatures (Klös & Lang 1982; Chandrasekharan *et al.* 1995). This condition can last for up to 75 days, and can result in death due to rupture of the colon or small intestine (Klös & Lang 1982; Chandrasekharan *et al.* 1995). In timber elephants, the primary cause is considered to be management errors (Radhakrishnan 1992), such as feeding and watering the elephants immediately after a strenuous walk and also highly fibrous diets (Chandrasekharan *et al.* 1995).

The incidence of constipation has not been documented in wild or zoo elephants, however Chandrasekharan *et al.* (1995) report a total of 169 cases in Asian elephants (wild and timber) over a period of two decades, considered by the authors to be a high incidence. They also note that the incidence was far higher in captive timber than wild elephants, but no figures are provided.

Dental problems

Captive elephants commonly experience problems with their teeth. Elephants have two upper incisors (tusks) and six molars on each side of the jaw, although these molars are not all functional at the same time. Each molar gradually wears down and is replaced by another molar from behind. The production of new molars in the alveolar pocket of the jaw causes the molars to move towards the front of the mouth, replacing the old worn teeth. The eruption of each molar occurs at 1-2 months, 2-3 years, 4-5 years, 10-14 years, around 25 years, and for the last molar sometime after 30 years of age. Difficulties may be experienced during these periods, particularly during the eruption of the last molar (Klös & Lang 1982). Problems are largely due to insufficient forward movement of the molars, for instance due to obstructive fragments of old molars (Klös & Lang 1982). This often leads to feeding difficulties and starvation if left untreated. Kurt (1995) states that he has never seen this problem in Asian elephants in the wild or timber camps and suggests that the probable cause is the wrong quality or type of fodder.

Female Asian elephants are also said to be susceptible to occasional extreme deformations of the molars (Kurt & Hartl 1995). Tooth decay is also commonly encountered in captive elephants, but is very rare in wild elephants, and has been the cause of death in at least one zoo case (Klös & Lang 1982). Instead, wearing out of the last set of molars is one of the commonest causes of death in timber elephants (Richard Lair, pers. comm) and wild elephants (e.g. Moss 1988). However, few, if any, zoo elephants reach the age at which this would be an issue (see Chapter 7).

Skin problems

Although not fatal, skin problems are nevertheless a health, and hence welfare, concern and so will be reviewed here. Regular skin and foot care is considered essential to maintain healthy elephants in captivity (e.g. Weinmann 1960; Shoshani & Eisenberg 1982; NCCAW 2001). As discussed earlier in this chapter, wild elephants regularly bathe, wallow in mud, cover themselves in dust and rub against trees (McKay 1973; Shoshani & Eisenberg 1982; Moss 1988). This is considered essential for keeping the skin, particularly the horny surface layer (stratum corneum), supple and permeable to water, as well as aiding in temperature regulation, because elephants do not possess sebum or sweat glands (Spearman 1971; Wright & Luck 1984; Lillywhite & Stein 1987). Bathing and wallowing is also believed to aid the removal of dead skin, prevent sunburn and reduce irritation from flies and other insects (Sikes 1971; Gale 1974). If elephants are unable to perform these activities, their skin becomes dry and flaky (Kurt & Hartl 1995) and skin diseases may develop (Ali 1991). Klös & Lang (1982) believe that elephants have a "strong tendency to produce subcutaneous pus". Elephants frequently develop small abscesses (see '*Foot problems*' section), boils and pustules from minor injuries and infected hair follicles (Klös & Lang 1982).

Pools, mud wallows, trees and scratching posts are often unavailable in zoos, although guidelines for keeping elephants in captivity often state that they should be made available (e.g. AZA; EMOA 2001; Schwammer 2001). Even when these objects are provided they are often restricted to outdoor enclosures, and considering that elephants in U.K. zoos spend an average of 60% of their lives indoors, these are unavailable for most of the time (Green 1989). There have also been reports of elephants not using these enrichment objects even when they are available (Adams & Berg 1980).

Other possible causal factors include deficiency in certain vitamins, which has been highlighted as a problem in Chapter 4. For instance, symptoms of Biotin deficiency include dermatitis and skin dryness (Sadler 2001). Also, psychological stress is associated with an increase in susceptibility and reinfection rates for a range of skin conditions in humans (e.g. Riddell 1991; Kimyai-Asadi 2001; Picardi & Abeni 2001). Furthermore, a study on rhinoceroses reports a relationship between episodes of a skin and mouth disease and stressful events, such as transportation, cold periods and intraspecific harassment (Munson *et al.* 1998).

Summary

- Stillbirth, infanticide and rejection of calves are together the main causes of infant mortality in European zoos, and are collectively responsible for 74.1% of infant deaths in Asians, and both deaths of African calves, listed in the PETA database.
- 15% of births in Asian elephants held in European zoos are stillborn. Other reports put this figure higher, at between 17.7% and 25% for the European and North American population. In contrast, stillbirths are significantly lower in the African elephant population, constituting 0% to 2.2% of births. In contrast, the frequency of stillbirths in extensive systems in Asia is reported to be between 0% and 3.1%. Stillbirths are also thought to be rare in wild populations, but this is difficult, if not impossible, to quantify. Possible causes of high levels in zoo Asian elephants include excessive calf weight, young age of dams and stress.
- Infanticide accounts for 16.7% of deaths, or 4.5% of births, in Asian zoo elephants. This is far lower than other reports of 15% to 17.7% of births. Similar to stillbirths, infanticide is much rarer in extensive systems, and is estimated to occur in 0.5% of births.
- Mothers rejecting their calves is also a common occurrence in zoo elephants, which has been reported to occur after 5.8% of all births. Rejection is rare in extensive systems, occurring after 0.5% of births. This is also thought to be rare in the wild, but like stillbirths and infanticide, it is difficult, if not impossible, to quantify. Possible causes of poor mothering include premature separation from the mother, which is common in zoos; a lack of 'aunts' when growing up; a lack of social support around the time of birth; a lack of experience with calves; and stress.
- In 'non-infants', the most common cause of death is illness, which accounts for over 60% of deaths in Asian and African zoo elephants.
- Circulatory problems, such as heart attacks, were the most common fatal illness, responsible for 11.4% to 20.0% of deaths in 'non-infants'. Possible casual factors include excessive weight, lack of exercise, and stress.
- Foot problems have been estimated to occur in 50% of zoo elephants and were associated with the death of three elephants. Possible causal factors include a lack of exercise, improper foot care by handlers, inadequate substrate in the enclosures, damp unhygienic conditions, malnutrition, the occurrence of joint problems, excessive body weight, the performance of stereotypic behaviours and the general effects of stress.
- Herpes virus is a fatal disease that has recently been diagnosed in elephants, and screening suggests an incidence of 9.7% in European zoos. This disease is zoonotic, meaning that it can be contracted by humans, and thus transmitted through close contact. Asian elephants can also contract the virus from Africans, which act as carriers. Risk factors therefore include contact between species, as well as close contact with humans that mix with both species.

- Tuberculosis is another zoonotic disease found in zoo elephants. Although unknown in the European population, a prevalence of 3.3% has been estimated for the North American population. Risk factors are movement between facilities and close contact with humans that may be infected, or have been in contact with infected animals.
- Arthritis appears to be common in zoo elephants, although estimates of prevalence do not exist. A skeletal study suggests that the major form in elephants is spondyloarthropathy, rather than osteoarthritis, found in 8.3% Asian and 4.56% African specimens studied (of unknown origin). Risk factors are thought to include a lack of exercise, excessive body weight, inadequate substrate, damp unhygienic conditions, the training of specific 'power' behaviours and general stress.
- Aggression-related deaths accounted for 9.4% to 17.6% of all deaths, excluding infants, and these included elephants that were euthanased due to excessive aggression and deaths from injuries sustained from other elephants.
- Accidents accounted for the death of 6.3% to 9.1% of deaths in zoo elephants. Most of these involved falls into dry moats surrounding the enclosure.
- Several elephants also died under anaesthetic for routine procedures, accounting for 3.1% to 9.1% of all deaths.
- Malnutrition, through an inadequate diet, can lead to deficiencies in vitamin E, calcium, iron and other nutrients, and thus health problems.
- Intestinal problems, such as enteritis, colic and impaction of the colon are believed to be more common in zoo compared to wild elephants. These can largely be attributed to inadequate diet.
- Although non-fatal, zoo elephants are susceptible to skin problems. Possible causal factors include a lack of bathing facilities and appropriate substrates, such as scratching posts, and general stress.
- Non-lethal pathologies of the reproductive system are also common (covered in Chapter 9).

Chapter

9

Reproductive problems

In this chapter we review the incidence of reproductive problems in both male and female zoo elephants. We begin by giving an overview of the breeding rate in European zoos, in terms of the number of captive births past and present. The age-specific fecundity for both sexes is then presented for the current population, which shows at which age most births take place. Finally, we present the typical ages of the onset and cessation of reproduction in zoos. Wherever possible these data are compared with similar data from the wild or extensive systems. Where problems are apparent, we then go on to discuss the various behavioural and physiological causes that have been implicated, firstly in females and then males. We also discuss how these may relate to captive husbandry.

Captive-breeding rate: an overview

We begin by assessing the reproductive rates of zoo elephants. Captive breeding in zoos has been minimal until quite recently. Demographic analyses of the North American population show that given the current rates of mortality and fecundity, neither species currently has a self-sustaining population (Olson & Wiese 2000; Wiese 2000). For example, Wiese (2000) estimates that to maintain a population of 250 Asian females, 9.54 female births per year would be required given the current mortality rate. Given that the sex ratio at birth is approximately 1:1, a total of around 14 living births per year would be required to sustain the population. This analysis has not been done for the European population, but as rates of mortality and fecundity are similar, it is highly likely that the European zoo population is also not currently sustainable. We discussed one half of this problem - the high rates of infant mortality - in Chapter 7. Here we examine breeding rates: why is zoo elephant fecundity so low? Before trying to address this, we examine captive breeding rates to get a more detailed picture of the situation for zoo elephants.

Past elephant-breeding in zoos

According to EEP studbook data, a total of 160 Asian elephant births have occurred in European zoos. Very few individuals were held before 1960, but between 1960 and 1999 121 Asian elephants were born in European zoos. During these years, there was a significant increase in the absolute number of captive births (1961 - 1999: $r = 0.608$, $n = 39$, $p < 0.001$, see Figure 21a), with a peak of six births in 1985, and a steady increase up to a record 13 births in 1998 (this includes all births and does not account for infant mortality. As discussed in Chapter 2, Asian elephants were awarded CITES Appendix I protection in 1976, severely limiting the importation of wild elephants, which until this stage had been the primary source (Wiese 2000). This resulted in a concerted effort to improve breeding rates in zoos, and this may explain the peak in births that occurred in 1978 (elephants have a two year gestation period, see later in this chapter), and the increase from around 1980 onwards. The series of peaks and troughs evident in Figure 21a is likely a result of the small number of births, and the sporadic nature of breeding success.

However, because the number of elephants held has also increased over the years, to analyse this finding further we divided the number of captive-born calves each year by the size of the relevant female population of breeding age (over 10 years according to Olson & Wiese 2000; Wiese 2000, although breeding can take place earlier, see later in this chapter). These data are shown in Figure 21a, and it can be seen that although the absolute number of captive-born Asian calves has increased, the number produced per female has actually decreased over time. Again, the data show a number of peaks and troughs, but considering 1961 onwards (no births were recorded in 1960), there has been a significant decrease in the number of captive births per female ($r = -0.375$, $n = 39$, $p < 0.05$).

Far fewer African elephants have been born in captivity, with a total of 46 calves born in European zoos, all between 1960 and 1999. The first captive birth took place in 1974. After another two births in 1977, no more were produced until 1985, after which there was general increase up to a peak of four births in 1997 and again in 1999 (see Figure 21b). This rise in total output from the first birth onwards was significant ($r = 0.626$, $n = 26$, $p = 0.001$, see Figure 21b). However, again the absolute population size of breeding females had increased over the years, and so this needed to be corrected for. The number of births per female of breeding age (over 10 years) was therefore calculated, to take into consideration the population size during each year. These data are also presented in Figure 21b, and it can be seen that there has been no significant increase in the number of calves produced per female ($r = 0.259$, $n = 26$, $p > 0.05$), although unlike the Asians there has been no decrease.

These data were also used to compare the captive breeding success of Asian and African elephants over the years. A Wilcoxon signed rank test using data for the years 1974 to 1999 revealed no significant difference between the two species in terms of average number of young per female ($T = 155$, $n = 24$, $p > 0.05$), showing that the greater absolute breeding rate in Asian elephants is due solely to the larger population size held in European zoos.

Current elephant-breeding in zoos

Over the last decade (1990 – 2001), the average annual number of young per adult Asian female was 0.029 (i.e. one birth per 45 females annually), while for Africans over the same period, that figure was 0.018 (i.e. one birth per 55 females annually). Expressed another way, the EEP studbook data show that the median zoo female produces only a single calf throughout her lifetime (although two females gave birth to six calves). In contrast, Asian females in timber camps produce on average 0.095 calves per year per female (or one calf per year for every 10.5 adult females), increasing to 0.155 in a good year (or one calf per 6.4 females a year) (Sukumar et al. 1997). For wild Asians, the figure was put at 0.175 in one study (one calf per 5.8 females a year) (McKay 1973), and 0.21 in another (one calf per 4.8 females a year) (Sukumar 1989). In wild Africans, reproductive output is similarly higher than in zoos, cycling between 0.08 and 0.35 births/female/year (or one calf to every 12.5 – 2.8 females a year), depending on conditions (Douglas-Hamilton 1972). Given these breeding rates, and the average breeding period of approximately 40 years in wild elephants (see later in this chapter), the typical wild female produces six calves over her whole lifetime (Laws 1969a; Sukumar 1989), although Laws (1969b) reports that some females show signs of up to 11 pregnancies.

Three factors underlie the low overall breeding rates in zoos: i) the small proportion of females that ever actually breed; ii) the slow rates of reproduction, even amongst these animals; and iii) the relatively short reproductive lifespan of zoo elephants. Points i) and ii) are considered in more detail next, and iii), later in the chapter.

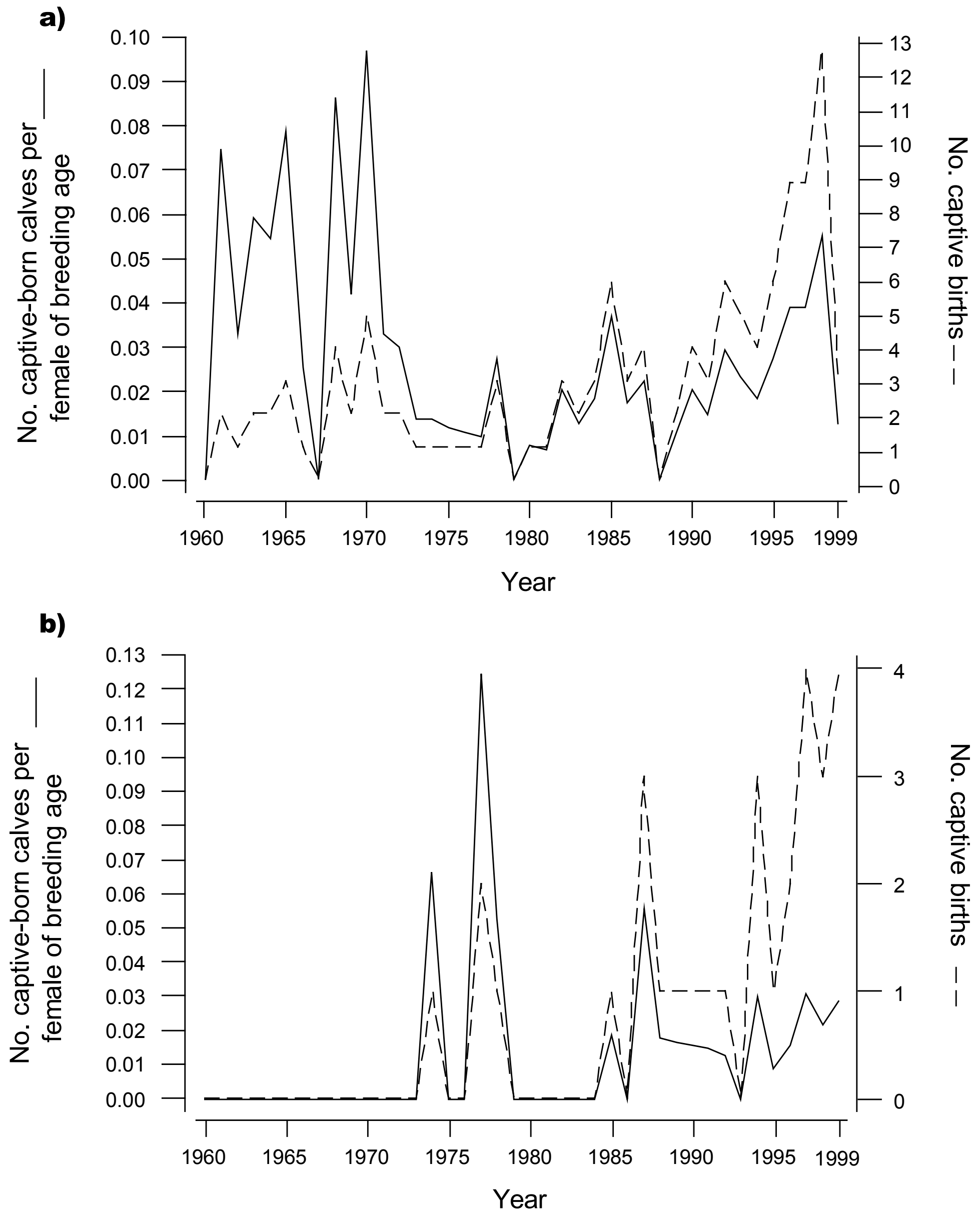

Figure 21. Number of captive births in a) Asian and b) African elephants over the years in European zoos

Data are presented as the total number of captive births (right-hand y-axis) and the annual number of captive births per female of breeding age (i.e.over 10 years) (left-hand y-axis). It can be seen that although the number of captive births has significantly increased over the years in Asian elephants, there has actually been an overall decrease in the number of calves per female. Far fewer African calves have been born in European zoos. Again, there has been a significant increase in the number of calves born, but no overall increase in the number of calves produced per female. Instead, various peaks and troughs can be seen due to the small number of calves which make the data very stochastic.

The EEP data show that 84.6% of zoos that have held Asians, and 79.6% that have held African elephants, have not had any births in captivity since 1980, and up until last year (2001). The data also reveal that all Asian elephant reproduction has been attributable to 64 females, where their identities were known, representing just 20.5% of the population that reached breeding age (11 years and above, using criterion from Wiese (2000)). Reproduction in African elephants was limited to just 28 females, which is 21.9% of females that reached at least 11 years of age. For both species, a far larger proportion of the male population were involved in reproduction, and this is reflected by the far higher fecundity found in males compared to females (compare the y-axis scales of the graphs of Figure 22 a and b, in the section below). All the Asian captive births in European zoos were sired by 27 males, representing 44.3% of the male population that reached 10 years of age or over, and hence of breeding age according to the data presented here. All captive-born African calves were sired by 12 males, which is 50.0% of the male population that reached breeding age (12 years and above according to the data presented here). In terms of the proportion of the zoo population that was actively reproducing, Schmid (1998) reported a far lower figure for proven breeders, of just 7% of females, in the 1992 European population. For males, he also reports a smaller proportion - 33% - of the male 1992 European population as having sired a calf. However, birth rates have increased in recent years which may have led to the higher percentage found here.

However, even if we take our own, higher, figures as the more currently reliable, they still contrast greatly with those from the wild and extensive systems. Taylor & Poole (1998) found that 87-100% of Asian elephants held in extensive systems had produced at least one calf. Kurt (1995) reports the slightly lower figures of 50 to 60% of females in Burma and South India being active in reproduction. In the wild, however, the figures seem even higher. In wild Asians, 95.8% of the populations have had a calf once older than 20 (Sukumar 1989), and 95% wild Africans have done this by the age of 18 (Whitehouse 2000).

Not only are fewer females reproducing than in the wild, but their individual reproductive rates seem to be slower too. In timber camps, females bear young once every 5 to 11 years (Sukumar *et al.* 1997; Taylor & Poole 1998). Wild elephants produce a calf every 2.5 to 8 years in Asians (McKay 1973, Sukumar 1989; Kurt 1974) and 3 to 5 years in African elephants (Douglas-Hamilton 1972; Laws *et al.* 1975; Jachmann 1980; Moss 1983; Jachmann 1986; Lee & Moss 1986), although in less favourable habitats, this may increase up to 9.1 years in Africans (Laws *et al.* 1975). In contrast, Taylor & Poole (1998) found that out of a sample of 20 European and North American zoos keeping both males and females, only 10% females produced a calf every 6 - 7 years, and 50% produced a calf every 17 - 25 years (i.e. probably just once in their lifetime). 35% of females in fact had never given birth at all.

There may well be practical, logistical reasons for these low figures, and we consider these below. However, biological reasons are likely too, as we discuss later in the chapter.

Is the low breeding rate simply caused by breeding opportunity?

One potentially important reason that such a small proportion of zoos, and so few females, have produced captive-born calves is the simple lack of breeding opportunities (Dorresteyn & Belterman 1999; Schulte 2000). Very few males are held in zoos (see Chapter 5), and most of these do not have access to females (Brown 2000; Dorresteyn & Terkel 2000). Thus in Europe, only around 50% of zoos house males and females of the same species, and even then, most of these are probably kept apart due to the practical and financial constraints of housing mature males (Fritsch *et al.* 2000). For example, Taylor & Poole (1998) found that out of a sample of 20 modern zoos that housed males, only 10% kept them continuously in the same enclosure as females, and only a further 45% mixed them when the females were thought to be in oestrus. If this is representative of the zoo population as a whole, elephants are only provided with an opportunity to breed on-site in 29.3% of facilities for Asian elephants and 37.2% for African; and males are housed with females in only 5.1% and 6.8% of facilities with Asians and Africans (51.4% of zoos with Asians and 67.6% with Africans have males, see Chapter 5)

As highlighted in Chapter 5, many zoos therefore move their elephants to another facility to be mated, a complex and expensive business. For example, until recently, it has been difficult to successfully time introductions to ensure that females are in oestrus, and thus mis-timed matings have been a significant problem (Taylor & Poole 1998). Recent developments in the detection of reproductive hormones in the blood and urine have greatly improved the accuracy of determining oestrus (e.g. Brown *et al.* 1999; Brown 2000). The AZA therefore now recommends that zoos routinely monitor hormone levels to facilitate reproduction (AZA 2001), but not all zoos use this technology and so this may still be a problem (Taylor & Poole 1998).

However, the practical difficulties of mating elephants are not the whole story. As discussed above, Taylor & Poole (1998) found that in their sample of Asian females with access to males, 35% had never had a calf, and another 50% only gave birth to live young only once every 17 - 25 years, on average. In addition, Kock (1994, cited in Kurt 1995) noted that only 20% of females transported to another zoo for mating actually conceived. Thus factors other than logistical constraints must be partly responsible for the overall low breeding rates of zoo elephants. Various authors have highlighted a range of likely physiological and behavioural problems. In the sections that follow, these will be presented and their possible causes discussed, concentrating on those that may relate to the captive environment.

The first possible reason for the small number of reproducers and/or their slow rate of reproduction is that zoo elephants seem reproductively active for a relatively short period of time. We begin to examine this by looking at zoo elephants' age-specific fecundity, below.

Age-specific fecundity

Methods

Similar to the procedure used to present age-specific mortality data in Chapter 7, data from the SPARKS database were analysed using the computer programme DEMOG to estimate age-specific fecundity in male and female zoo elephants. These data represent the current population of elephants (living by the 1st Oct 2001 for Asians and 17th July for Africans). Fecundity is calculated as half the average number of young produced by parents of age x. As with mortality data, data on 333 (62 male, 271 female) Asian and 191 (41 male, 150 female) African elephants, accurate up to 01/10/01, were used to calculate age-specific fecundity for the age intervals 0-1 years, 1-2 years, 2-3 years, etc. These data have not been smoothed. These figures are supplemented with other calculations made on the studbook data, presented in the following section.

Age at onset of female reproduction

The fecundity curve for Asian females (see Figure 22a) shows that few zoo animals produce calves until around eight years of age, although some have given birth at five and six years of age. Age-specific fecundity then fluctuates between 0.01 and 0.05 until 34 years of age. For the North American Asian zoo population Wiese (2000) similarly reports that female fecundity began at around eight years of age. During their reproductive life span, fecundity varies between 0.01 to 0.02 per year, with peaks between 14 and 15 years of age and again between 19 and 20 years.

The EEP studbook data show that the average age at first calving was 15.2 years (range 6 - 30) in Asian elephants. Due to the almost two year gestation period of elephants in zoos (Kurt & Mar 1996), this means that the average age at conception would be 13 years. However, Asian elephants have conceived as early as three and four years of age. At the birth of their first calf, 14.1% of Asians were under 10 years of age, and 53.1% were under 15 years (see Figure 23). Similarly, Taylor & Poole (1998) found that out of a sample of 20 western zoos, 43% of births were in dams under 15 years of age, and similar estimates of between 6 and 9 years of age for first calving have been reported for populations held in European and North American zoos (Schmidt 1986; Schmid 1998; Wiese 2000). The welfare implications of mating and pregnancy for such young females are will be considered later in this chapter.

Comparison with the age at first calving of Asian elephants held in timber camps in Burma, taken from Mar (2001), reveals a very different pattern. As can be seen from Figure 23, extensively held elephants begin breeding far later, primarily between 20 and 25 years of age, although Mar (2001) reports that one female gave birth at 6.5 years of age, and Kurt (1995) also notes that births at seven or eight years of age can occur. Between 3.5% and 18% of females in timber camps were under 15 when they gave birth (Taylor & Poole 1998; Mar 2001). Wild elephants reach sexual maturity at a similar age. Sukumar (1989) estimates that the mean age at first calving is 18 to 20 years in wild Asian elephants. Thus the average age at first calving for Asians is 3 - 5 years earlier in zoos than in the wild or extensive systems; and around half first give birth by the age of 15, compared with less than a fifth in timber camps.

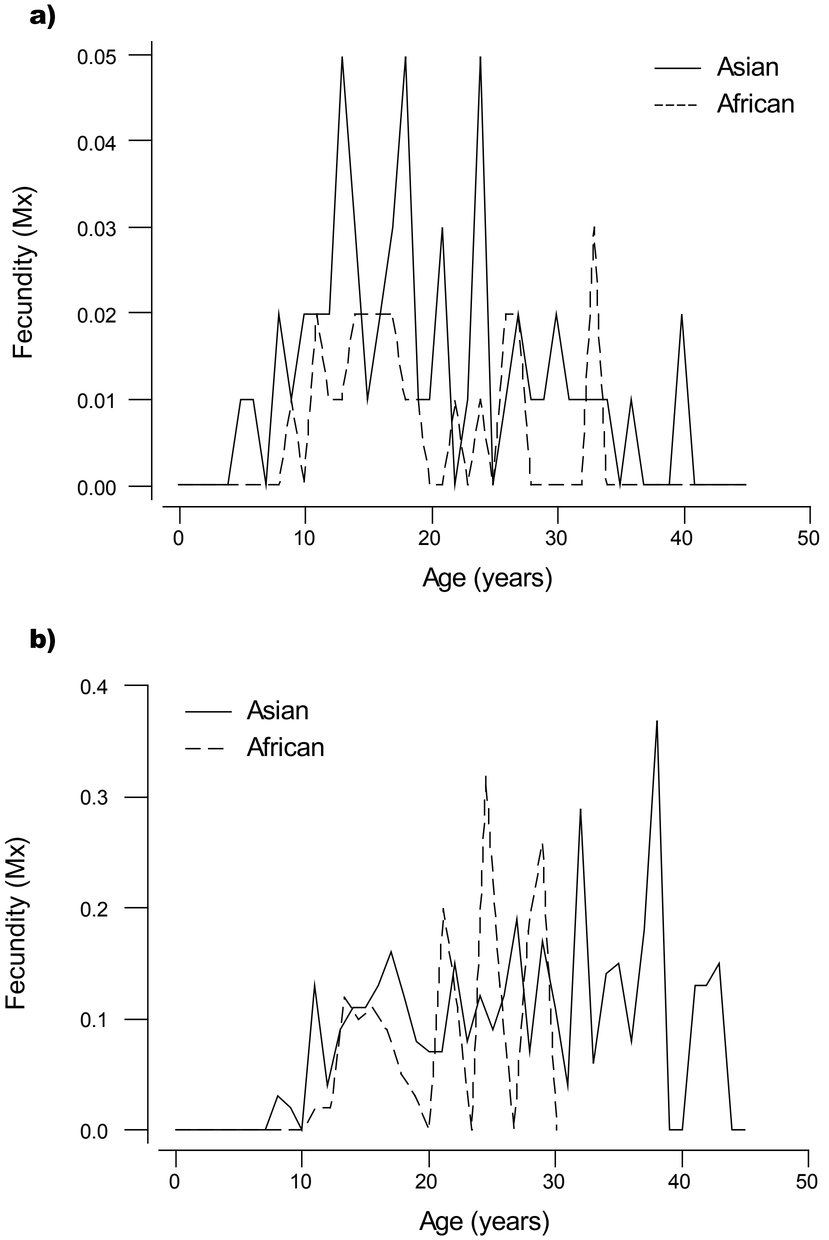

Figure 22. Fecundity in a) female and b) male elephants held in European zoos
The graphs above show the number of captive births for a) females and b) males in European zoos. Data are presented as the total number of captive births per adult of breeding age.

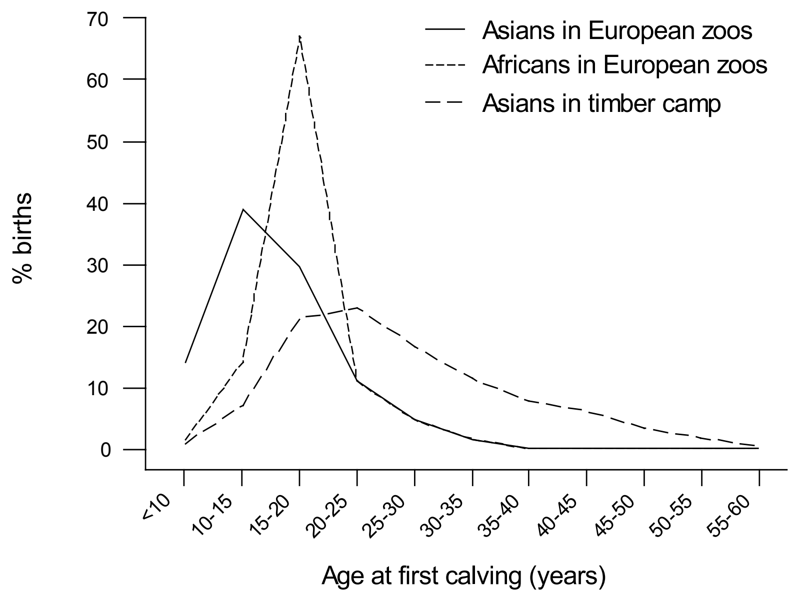

Figure 23. Age of mother at first calving in Asian and African elephants held in European zoos (both species) and a timber camp (Asians only)

Data on the age of female elephants at first calving shown above. Zoo data taken from the EEP studbooks are compared to data for Asian elephants held in a timber camp, taken from Mar (2001). Data that fell into two categories were included in the lower one. (The African zoo elephant is included here for comparison).

Reproduction in African females in European zoos begins at around 11 years of age, although some have reproduced at nine years of age. Fecundity then ranges between 0.01 and 0.02 until 28 years of age. The EEP studbook data show that the average age at first calving was 15.4 years (range 9 - 25) in African elephants. However, African elephants have conceived at as young as seven. At the birth of their first calf, 4% of African females were under 10 years of age, and 40.0% of Africans were under 15 years (see Figure 23).

For comparison, the average (median) age at sexual maturity in wild female African elephants, taken from 14 studies summarised by Croze *et al.* (1981), was 12.2 years of age (range 7.5 - 23). Thus, the mean age at first parturition in wild Africans would be in the region of 14 years of age. As can be seen from the range provided, there is considerable variation between studies, and hence populations, in the mean age at maturity. The most precocious mean age at maturity in wild elephants is generally considered to be 10 to 11 years of age (Laws 1969a; Jachmann 1980; Moss 1988), although females as young as eight and nine have been found pregnant (Jachmann 1980; Croze *et al.* 1981). Thus for African females, and unlike Asians, the average age at first calving in zoos and the wild is very similar.

Age at cessation of female reproduction

In Asian zoo females in Europe, although some females have given birth at 40, reproduction generally ceases when the elephants are in their mid-thirties. Note that data presented in Chapter

7 also showed rising mortality in this age group, too – but the age-specific fecundity data are not a by-product of this, as they correct for the female population-size within each age class. Taylor & Poole similarly report a decline in the incidence of births at 11-15 years in zoo elephants, and a maximum breeding age of 40 years (Taylor & Poole 1998). The North American Asian population has also ceased to reproduce at around 32 years of age; indeed, the US female population is said to be "reproductively senescent" by the age of 35 (Wiese 2000).

Data on all EEP captive births where the age of the dam was known (111 Asian calves) also show that females over 24 years were responsible for 13.5% of Asian captive births, and only 4.5% were produced by females over 29 years of age. The oldest breeding female in Europe was 36. These calculations are descriptive and do not control for the fall in population size for older females, but they do illustrate well how skewed in age is the current population of mothers. In comparison, extensively held females continue to show a relatively high breeding rate until around 40 years of age (Sukumar *et al.* 1997) and continue to breed until 62 years of age (Sukumar 1989; Taylor & Poole 1998). In wild Asian elephants, Sukumar (1989) reports that the largest and oldest females were still breeding, even when as old as 50 to 60.

In African zoo females, reproduction largely ceases after the age of 28, although a secondary peak (possibly an artefact) is evident at 33 (see Figure 22). EEP data on all captive births, where the age of the dam was known (35 African calves), and uncorrected for maternal population size, also show that females over 24 years were responsible for just 17.1% of African captive births, and only 5.7% were produced by females over 29 years of age. The oldest breeding female in Europe was 39. In comparison, reproduction in wild populations does not appear to decline until somewhere between 40 and 55 years (Laws *et al.* 1975; Smuts 1975; Hanks 1979), and wild African females as old as 50 to 60 years of age have been seen still actively breeding (Smuts 1975).

Thus zoo females of both species appear to cease reproducing early compared with the wild. Several factors could be responsible. The first is that zoo females are dying before the end of their reproductive lives (see Chapter 7). However, while important, this cannot be the whole story: age-specific fecundity data show that the number of calves *per female* falls drastically with age after about 27 in Africans and 33 in Asians. A second possibility is that zoo personnel choose not to breed from older females. Although a real possibility, it is hard to imagine however why they would choose such a young cut-off age. The third possibility is that zoo females undergo some biological change that renders them effectively infertile by their mid-thirties.

Relationships between age of onset and age of cessation of breeding in zoo Asians

Asian elephants in zoos are remarkable for their early onset of reproduction, as well as their early cessation. To test whether these were linked, we conducted a Pearson's correlation analysis to compare the age at which females produced their first calf to the age they produced their last calf (for females that produced more than one calf, had moved through the zoo population and were now dead; n = 9). There was a trend towards a positive correlation between the two ($F_{1,7} = 25.49$ $p < 0.10$, Figure 24). Thus, a risk factor for premature reproductive cessation is the attainment of early sexual maturity. This has not been reported for any wild or extensively-living population.

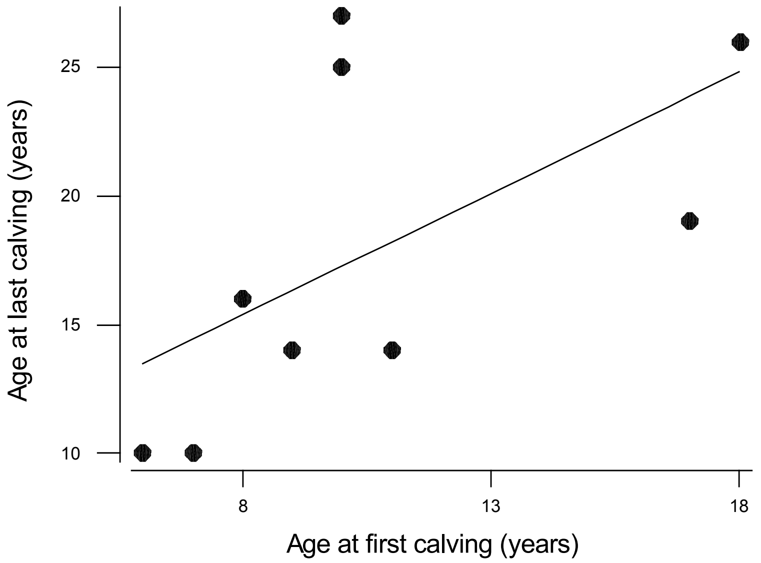

Figure 24. Age at first and last calving in Asian females held in European zoos
A positive correlation was found between the age at which Asian females produced their first and last calf. This shows that females that attain sexual maturity early and/or who are lated early are also likely to stop reproducing at an early age. These data consider solely females that have already passed through the zoo population and died.

Reproductive lifespan of females

Despite the fact that breeding begins earlier in zoo elephants, they have a restricted reproductive period. Asians in zoos seem, at the population level, to have a reproductive lifespan of about 20 years (see Figure 22). However, if individual animals are examined using the data presented in Figure 24, the average length of time between first and last calf is just 7.2 years (range: 2 - 17; n = 9). Hildebrandt *et al.* (2000) also suggest that from the onset of sexual maturity, zoo females only have a period of 10 to 15 years during which they are able to breed. They further note that some of their study animals had started to breed at four years of age, and were unable to conceive by the time they reached 14 to 19 years of age, despite being repeatedly mated. Their suggestion that early onset predicts early cessation is backed by the data we present above.

In comparison, the breeding period of Asian elephants in the wild seems to last far longer. It is more difficult to estimate this accurately in wild elephants as few studies report comparable data. However, breeding appears to continue for around 32 years, or even longer (18 to 50 + years) (see e.g. Sukumar 1989). Some timber camps yield similar data; for example, Sukumar *et al.* (1997)

report that on one, fecundity only started to fall after 50 years, and even then only slightly (thus giving a reproductive lifespan of about 30 years). However, in another camp, reproductive lifespan depended on the source of the elephants. Wild-caught females showed little decline in their ability to produce calves until about 44, but captive-bred females reproduced more slowly from their mid twenties, and were virtually barren by 43 Mar (2001). We discuss possible causes for this difference, and its significance for zoo animals, later in this chapter.

The reproductive lifespan of zoo Africans is similarly brief compared with that in the wild. Both wild and zoo elephants begin breeding at 14 –15 or so, but while zoo elephants cease by around 30 (see Figure 22), wild females regularly breed into their late 40's or early 50's (Hanks & McIntosh 1973; Laws *et al.* 1975; Whitehouse & HallMartin 2000).

Age at onset and cessation of male reproduction

In male Asian elephants in zoos, fecundity generally begins at 10 years of age (although some as young as eight and nine have sired a calf) and fluctuates between and 0.04 and 0.37 before dropping off between 39 to 43 years of age (see Figure 22b). The pattern is rather different for African males, as there are no breeders older than 28. (see Figure 22b; also Ch. 7). Reproduction also begins slightly later, at around 12 years of age and after a series of peak and troughs. In European zoos, studbook data reveal that the mean age at which males sired a calf was 21.8 years of age (range 9 - 40 years) in Asians and 18.0 years (12 - 27 years) in Africans. This means that on average, mating occurred when they were 19 years old (7 - 38 years) in Asians and 16 years (10 – 25 years) in African males. Only 3% of Asian and no African males were under 10 years of age when the calf they sired was born, 20.8% of Asian and 2.9% of African males were under 15 years of age. These last figures are descriptive, summarising the current picture without correcting for reductions in population size with age.

No comparative data exist for the age at breeding for males in extensive systems. In the wild, however, males are capable of producing sperm when they are between 10 to 12 years in Asian (Eisenberg 1981) and 14 to 17 years of age in African elephants (Laws 1969b). However, young males are not active in reproduction until they reach at least 20 to 25 years of age in Asians (Sukumar 1989) and 30 to 35 years in Africans (Poole 1994), because they are not physically able to compete with older, mature bulls (Poole 1982).

Sexually active males are typically in musth. As well as sexual activity, this state is characterised by urine dribbling, temporal gland secretion (an opening on the side of the head above the eye), an increase in aggression and a 'regal' posture (Jainudeen *et al.* 1972b; Gale 1974; Poole 1981; Hall-Martin 1987; Moss 1988). Male elephants in zoos have been observed to come into full musth, displaying the typical rise in testosterone concentrations and all the characteristic physical and behavioural signs of musth, at between 10 to 20 years of age (Rasmussen *et al.* 1984; Cooper *et* *al.* 1990; Niemuller & Liptrap 1991). In contrast, males held in timber camps do not come into musth until 18 to 22 years of age (Taylor & Poole 1998), although there are reports of working Asians coming into musth as young as 11 years (Eisenberg *et al.* 1971). Estimates for wild bulls range between 14 to 17 years of age in Asians (Jainudeen *et al.* 1971; Eisenberg 1981; Sukumar 1989; Kurt 1995) and 24 to 37 years in Africans (Eisenberg *et al.* 1971; Poole 1987). Although, there are exceptions of African males coming into musth in their early teens (Eisenberg pers. comm., cited in Poole 1987). Thus, it would appear that for African elephants in particular, males held in zoos are coming into musth at an earlier age compared to those in extensive systems and those in the wild. However, it is not known how wild and zoo reproductive life spans compare in males.

Possible causes of the shortened reproductive life of zoo females

Pathologies of the reproductive tract

The cessation of reproduction in relatively young zoo females is not believed to be early natural reproductive senescence (menopause) (Hildebrandt, pers. comm.). Instead, it appears to be due, at least in part, to an increase in incidence of pathologies of the reproductive system. For example, ovarian cysts are more prevalent in females over 30 years of age (Hildebrandt *et al.* 2000). These are large fluid-filled sacs which form in the ovary, and they are a significant cause of infertility in women, dairy cows, swine and sheep (Christman *et al.* 2000; Jainudeen & Hafez 2000).

One possible cause is excess body fat. Zoo females are overweight (see Chapter 4), and the difference in bodyweight between them and timber camp conspecifics reaches a maximum in their late 20's (Kurt & Kumarsinghe 1998). Such excess weight has been implicated in ovarian cysts in several species. Christman *et al.* (2000) found that ewes that developed ovarian follicular cysts were significantly heavier than ewes that experienced normal ovulation; dairy cows fed higher levels of nutrients often develop ovarian cysts (Jainudeen & Hafez 2000); and obesity is also associated with a higher incidence of ovarian cysts in humans (Fedorcsak *et al.* 2000; Hunter & Sterrett 2000; Wang *et al.* 2001).

Deleterious effects of early reproduction

Earlier we showed that starting to calve early in life predicted an early cessation of reproduction in zoo females. The mechanism underlying this relationship is unknown. However, we hypothesised that if there are deleterious consequences of reproducing before the age that would be normal in the wild, and these are in turn responsible for the early reproductive cessation of these animals, then early-bred females might also be expected to show higher levels of morbidity and mortality. Morbidity data were unavailable, but longevity data are present in the EEP studbook. We therefore plotted age at first calving against longevity (excluding one animal that seemed to have died during parturition). There was a significant quadratic relationship between the two ($F_{2,8}$ = 5.95, p = 0.026), with longevity increasing the later a female started to breed. The turning point at the curve was at about age 11.

However, the fact that breeding *per se* did not affect longevity (see Chapter 7) suggests that parturition at an early age may not be the causal factor behind this relationship. Instead, some other related aspect, such as the age at which females start to cycle, may be responsible, perhaps because this indicates particularly high body fat.

Mar (2001) emphasised the burden that rearing calves placed on her timber elephant subjects. However, in our dataset there was no relationship between age of first breeding and number of calves produced, and so this cannot explain our observed relationship either (r = 0.057, n = 13, p > 0.1).

As the early onset of reproduction predicts an early cessation, and both of these seem premature in zoo elephants (particularly Asian), we next consider the possible reasons for an early onset of sexual maturity.

Figure 25. The relationship between age at first calving and life expectancy
A significant positive correlation was found between the age at which females calved and the age at which they died. Thus breeding before age 12 is associated with early death.

Possible causes of early onset of sexual maturity in female zoo Asians

Rearing environment

As reviewed above, in timber elephants, Mar (2001) found that captive-born females showed a significant decline in the production of calves after the prime breeding age of 21 years, compared to wild caught elephants which showed no decline until after 44 years of age. She presents no real explanation for this phenomenon. However, analysing the EEP data reveals a very similar pattern (see Figure 26): wild-caught zoo elephants have a later age of first calving – and by implication a later age of last calving – then do captive-bred animals. Thus females born in zoos gave birth to their first calf significantly younger than females born in Asian timber camps (Two-sample t-test: $T = 2.33$, $df = 23$, $p < 0.05$) and those that had been caught from the wild ($T = 2.67$, $df = 8$, $p < 0.05$). There was no significant difference between these latter two categories ($T = 1.18$, $df = 53$, $p < 0.05$, see Figure 27a). Females were imported from Asia (it is unknown whether these were wild caught or captive born in the timber camps) at the average age of 8 years (range 1 - 22), suggesting that it is early experience of the zoo environment which causes early sexual maturity.

A similar result was found for African elephants (see Figure 27b), in that zoo-born females gave birth significantly earlier than wild-caught ones ($T = -6.45$, $df = 22$, $p < 0.001$).

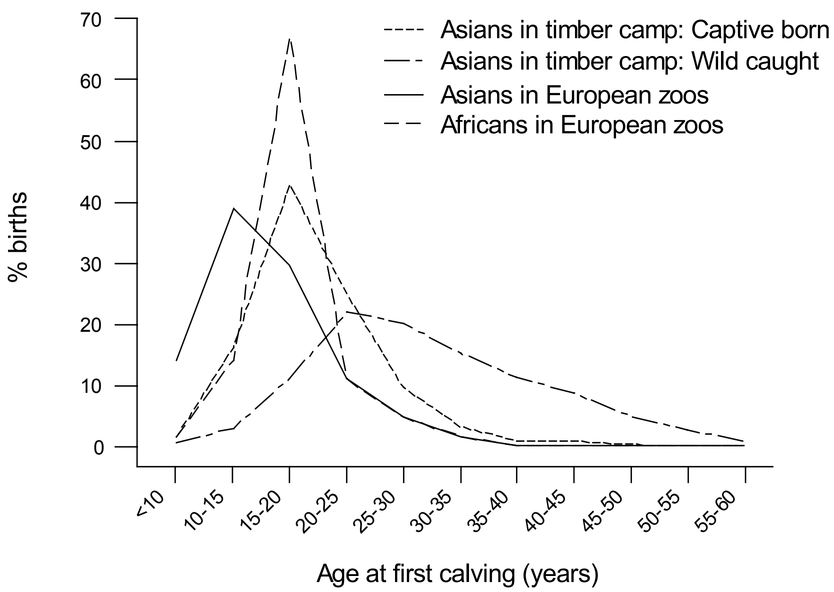

Figure 26. Age of mother at first calving in captive-born and wild-caught Asian elephants held in a timber camp compared to European Asian and African zoo elephants

Data on elephants held in timber camps in Burma, taken from Mar (2001), show a decline in reproductive ability at a far younger age compared to those captured from the wild. Data from the EEP studbooks on elephants held in European zoos shows that the captive-born timber elephants show a similar pattern to zoo elephants.

Nutrition

In relation to the results found above, Mar suggests that this may be due to the greater level of nutrition received in captivity compared to the wild. It is certainly the case that reproduction is greatly reduced during periods of drought in the wild (e.g. Moss 1988). Barnes (1982) also notes that more breeding takes place in the wet season in wild African elephants and attributes this to the need for females to raise their fat reserves above the threshold required for ovulation. By inference, the larger amount of body fat found on zoo elephants (see Chapter 4) may induce early ovulation, as suggested by Kurt (1995). Studies on a range of species have shown that an increase in nutritional level and/or the resultant increase in growth, leads to early sexual maturation (e.g. seals: Laws 1973; e.g. chimpanzees: Tutin 1980; cows and ewes: Kinder *et al.* 1987; goats: Hoefs & Nowlan 1998; Bearden & Fuquay 2000).

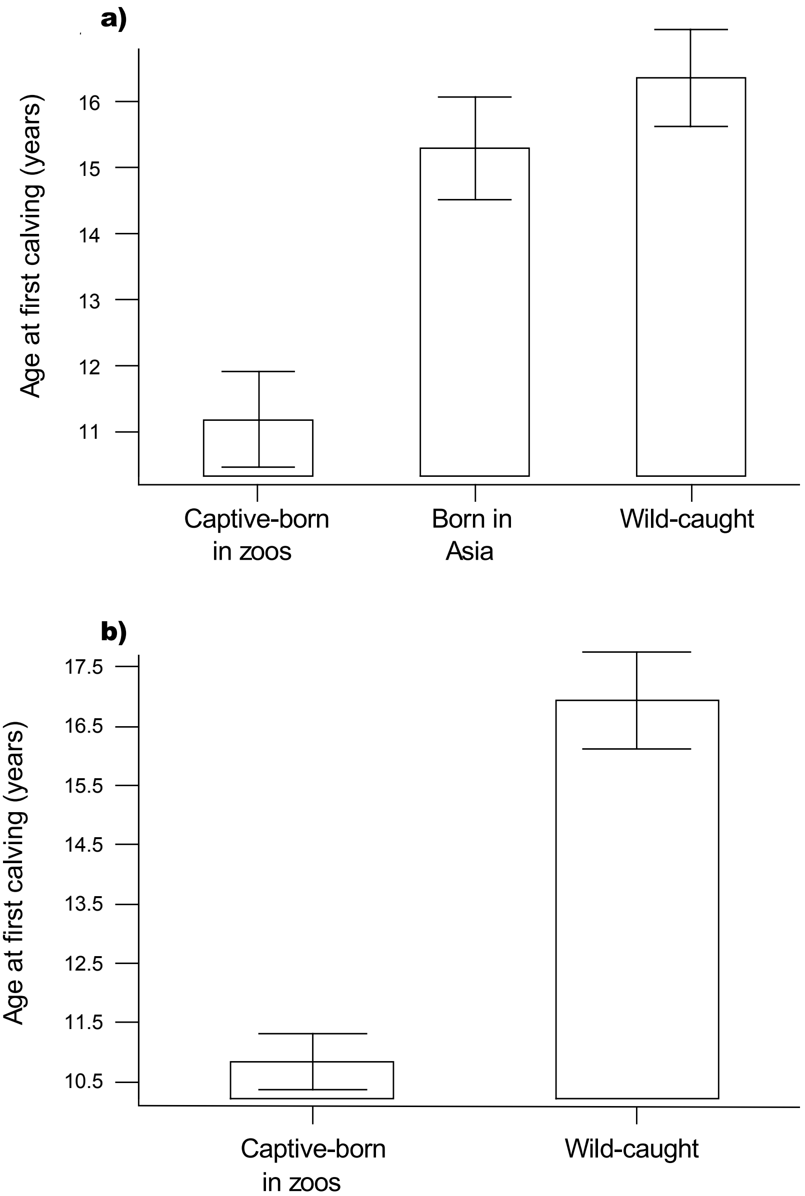

Figure 27. Age at first calving in a) Asian and b) African females held in European zoos according to their origin

The age at which females produced their first calf in European zoos was compared between females from different origins: those born in zoos, imported from Asian timber camps and those caught from the wild. Zoo-born females started reproducing significantly earlier than those imported from camps or caught from the wild.

Physiological problems affecting breeding rates in reproductive females

Even during their reproductive life, many female elephants appear unable to conceive, despite being repeatedly exposed to bulls and even observed to mate (e.g. Hess *et al.* 1983; Mainka & Lothrop 1990; Niemuller *et al.* 1993). Research on a range of other species has identified a range of factors known to affect female infertility, and likely to apply to elephants. Furthermore, recent advances in the study of endocrinology and ultrasonography have shed some light on problems affecting fertility in elephants themselves.

Acyclicity/ovarian inactivity

Many female zoo elephants of reproductive age are not experiencing normal oestrus cycles, i.e. they are acyclic and hence infertile (Brown & Lehnhardt 1997; Brown 1999; Brown *et al.* 1999). The normal peak in progestogens during the oestrus cycle is lacking in these animals, and instead they remain at baseline – a condition termed 'flatlining' (Brown 2000). This is a widespread problem in zoo elephants. Brown (2000) surveyed over 250 females (139 Asian, 115 African) in North America and found that, of regularly tested animals, 17% Asians and 26% Africans were acyclic, even though most were of breeding age (24 ± 4 years). Data from the EEP studbooks also show that out of a total of 226 Asian females listed, 92 are known to be cycling (40.7%), but 16 are not (7.1%). The status of 113 (50.0%) is unknown and the remainder are too young (under 3 years) to be reproductively active; therefore, 15% of sexually mature females that have been tested in the European population are similarly not cycling. Until recently, this condition was assumed to persist for an elephant's life (Brown 1999). However, Schulte *et al.* (2000) report temporary ovarian inactivity in a group of three African zoo elephants, i.e. low progestogen levels during some, but not all, oestrus cycles.

Without equivalent data from the wild or extensive conditions, it is impossible to say whether this phenomenon is special to zoo females. However, it certainly merits further research, especially as some of its possible causes are potentially linked with aspects of husbandry.

Possible causes of acyclicity

Ovarian cysts

Ovarian cysts may cause acyclicity. These occur in a far greater proportion of zoo elephants (c. 5% of Asians and c. 15% of Africans) then free-living African elephants (<1%) (Hildebrandt *et al.* 2000). The occurrence of ovarian cysts in these species is characterised by the lack of ovarian cycling, and there is some evidence that these cysts also cause acyclicity in affected elephants. Brown *et al.* (1999) describe an ovarian cyst in an African female that was not cycling, and all four elephants (2 Asian, 2 African) studied by Hildebrandt *et al.* (2000) afflicted with the same complaint were found to be acyclic. Research is ongoing to determine whether all ovarian cysts disrupt cycling (Hildebrandt *et al.* 2000).

The aetiology of these cysts remains unclear, despite considerable research on other species (Webb *et al.* 1998). Extensive work reveals that the likely cause is a hormone imbalance (Hamilton *et al.* 1995; Garverick 1997; Brown *et al.* 1999). External causal factors have not been elucidated, but nutrition and excess bodyweight may well be involved, as discussed earlier and later in this section.

Other hormonal problems

Another possible cause of flatlining is suggested by Brown & Lehnhardt (1997). They found that the acyclicity of one African female was associated with chronic hyperprolactinemia (excessive secretion of the hormone prolactin). This condition is often associated with impaired functioning of the ovaries, and is a common cause of infertility in other female mammals (Johnson & Everitt 1988). However, this may be a rare condition, as Brown (2000) points out that elevated prolactin levels have not been reported for other elephants.

Social suppression

Social suppression of reproduction may also play a role in the loss of ovarian cycles. This is a well-documented phenomenon in a range of social mammals, particularly in captive populations (Abbott 1989). In species where most, or all, of the females within the group breed, subordinates commonly experience a lower reproductive success compared to dominant females. For example, in cattle, individuals that have decreased in social status require far more artificial inseminations before conception is achieved (Dobson & Smith 1998). Reproductive suppression may occur through the disruption of the ovarian cycles of subordinates (e.g. talapoin monkeys, *Miopithecus talapoin*: Bowman *et al.* 1978; common marmosets, *Callithrix jacchus*: Abbott *et al.* 1981; golden hamsters, *Mesocricetus auratus*: Huck *et al.* 1983; mole rats: Abbott 1988), and subordinate talapoin monkeys were found to have hyperprolactinaemia (Johnson & Everitt 1988). The mechanism may be harassment-induced stress, shown to inhibit ovulation in some species (e.g. cynomolgus monkeys, *Macaca fascicularis*: Kaplan *et al.* 1986).

In wild African elephants, Dublin (1983) found that dominant females produced more calves than subordinates early in the rainy season - a time when a larger proportion of calves survive. This suggests that dominant females may be able to manipulate the timing of breeding in subordinate females. In zoo elephants, Schulte *et al.* (2000) also found that the duration of acyclic periods was correlated with the dominance status of the elephant, such that the subordinate female experienced the longest period. The external mechanisms behind the social suppression of cycling are not yet clear (e.g. Abbott 1989). Schulte *et al.* (2000) found that five out of six acyclic periods occurred during winter, when the time spent outdoors was considerably reduced. One of the explanations they out forward is that lengthy periods spent in close proximity to each other may affect ovarian activity (although the change in weather is another possibility). It would thus be interesting to see whether dominance status predicts whether or not a female cycles normally.

Stress

In a range of species, non-social stress, too, can interfere with normal cycling (Bearden & Fuquay 2000). Stressors (e.g. electric shock, restraint) cause the release of ACTH from the anterior pituitary, which stimulates the secretion of cortisol and other glucocorticoids (hormones involved in the stress response). These glucocorticoids suppress the release of luteinizing hormone (LH), which causes a lack of, or disruption in ovarian cycling, among other things (Shepherdson & Carlstead 1995; Bearden & Fuquay 2000; Dobson *et al.* 2000). Psychological distress, for example during transportation to a new location, mild shock, restraint, or adverse handling, all interfere with oestrus cycles and delay ovulation in domestic species, probably due to the suppression of LH by glucocorticoids (Dobson & Smith 1995; Bearden & Fuquay 2000). Isolation has also been shown to significantly reduce the number of cycling females and conception rates in social species, such as pigs and beef cows, particularly in the period around insemination (Bearden & Fuquay 2000).

In zoo elephants, Brown *et al.* (1999) observed that ovarian cycling stopped when new animals arrived into the herd, perhaps due to the re-establishment of dominance relations and/or challenges from a young male. As discussed in Chapter 5, zoo elephants frequently experience changes in group structure due to the relatively frequent transfer of elephants between zoos. It would be interesting to determine whether the frequency of transfers predicts the acyclicity in females, and whether stress is the causal factor. In addition, the high rate of staff turnover, which is common in many elephant sections (e.g. Ruhter & Olsen 1993), could also be a source of stress.

Excessive body weight

The problem of excessive body weight found in zoo elephants (see Chapter 5) may also be implicated in acyclicity, even when not causing ovarian cysts (see above). Obesity is a well-recognised cause of infertility in humans (Wittemer *et al.* 2000;

Cogswell *et al.* 2001; Cooper *et al.* 2001). Excessive body weight in women interferes with ovulation (Clark *et al.* 1998; Kably-Ambe *et al.* 1999), and the percentage of acyclicity has been shown to increase with body mass index (Hamilton *et al.* 1995). Conversely, weight loss has (if not taken to extremes) been shown to increase spontaneous ovulation overall, as well as smooth out irregular cycles, in women (e.g. Hollmann *et al.* 1996; Norman *et al.* 2000). Although this is a possible cause of acyclicity in zoo elephants, it remains to be studied.

Physical obstructions in the reproductive tract

Some females continue to cycle normally yet still appear unable to conceive. Studies have shown that female elephants over the age of 30 are more prone to the development of reproductive tract abnormalities. Not only do ovarian cysts increase in incidence (see previous section), but benign muscle tumours in the uterus (uterine fibroids or *leiomyoma*), ranging from a few grams up to 60kg in weight, also show a drastic increase in prevalence (Hildebrandt pers. comm., cited in Kurt & Hartl 1995). In humans, specific forms of these tumours are associated with lower rates of fertility (e.g. Pritts 2001). It has been suggested that they may also interfere with reproduction in elephants, due to impediment of sperm transport through the oviduct and/or the "maintenance of the implanted embryo due to negative impacts on the endometrium." Although the causal factors have not been studied in elephants, Hildebrandt (pers. comm.) suggests that this high prevalence of reproductive tract abnormalities is largely the result of a lack of breeding. Research does not appear to have been conducted on elephants, or other species, to test this hypothesis.

Other factors affecting fertility – further roles of stress

Stress can also affect fertility in females with normal reproductive cycles, via blocking conception and/or also increasing early embryonic loss. For example, restraint stress can block early pregnancy in the rat (MacNiven et al. 1992); and stress is well known increase early embryonic loss and abortion in humans (Paarlberg et al. 1995, Neugebauer et al. 1996, Hjollund et al. 1999). In many species, being transported when pregnant also reduces their later litter size (e.g. agouti deer mice, *Peromyscus maniculatus*: Hayssen 1998). Data on early embryonic losses are not available for elephants, but it is possible that the poor conception rate (20%) of female elephants that had been transferred for mating reported by Kock (1994, cited in Kurt 1995) do not reflect prior reproductive problems with those animals, but instead the acute stresses of transportation and being introduced to a new herd. General chronic stress to do with husbandry may potentially also lead to embryonic losses in other females, too.

Physiological problems affecting breeding rate in males

Zoo males do not seem to show any equivalent of the acyclicity of females. Indeed they tend to experience more frequent musth episodes than wild males (Kurt & Touma 2001). Their musth periods also tend to be longer, too. For example, zoo males can experience musth periods for up to 8 months (Kurt 1995). Cooper *et al.* (1990) report that a male in Columbus Zoo, U.S.A., was in musth for between 124 and 187 days every year for four years. In contrast, wild young Asian males (10-20 years) experience only short (a few days), sporadic periods of musth, two to three times per year, while adult males (>20 years) come into musth once a year and this lasts for 3-4 weeks (Kurt & Touma 2001). Similarly, young African elephants (25-35 years) experience musth for a few days to weeks, while older males come into musth for 2-5 months on a predictable annual basis (Poole 1987). Asian bulls in extensive systems in Burma are reported to have a musth period lasting on average 33 days (range 3-80) (Gale 1974), whilst those in an intensive system in Kerala last 68 days on average (range 30-151) (Chandrasekharan *et al.* 1992).

The relatively frequent, long musths of males (and their onset at a young age; see earlier) are likely to reflect the better nutritional status of zoo elephants compared to wild males (e.g. Cooper *et al.* 1990). Social factors may well be important too. Most zoos with males only hold one (see Chapter 5) and so for most bulls, there are no dominant animals around to suppress their musth periods (Poole 1987).

However, this does not mean that all is fine for male reproduction. Infertility in males is considered a major contributing factor to the low breeding rate of elephants in captivity, and may constitute a more significant problem than infertility in females (Hildebrandt *et al.* 2000). Hildebrandt *et al.* (2000) examined 71 captive elephants (61 Asian and 10 African) from 30 institutions (North America: 9; Europe: 13; Africa: 2; and Asia: 7) and four wild African elephants. From this sample of bulls, 75% were described as 'non-breeders' (47 Asians, 10 Africans). After excluding castrates, and males that were too young to reproduce, there remained a total of 62.7% males (40 Asians, 7 Africans) that were not reproducing. However, it is not possible from the existing data to accurately determine what proportion of the male zoo population truly suffers from infertility, as a significant proportion of males over the age of ten (breeding age) that are not proven breeders very possibly have not had access to females. Nevertheless, Hildebrandt *et al.* did find that 13.8% (14.8% Asians, 9.1% Africans) of males studied had reproductive tract pathologies, which although low compared to that found in females (see previous section), is still likely to interfere with breeding success (Hildebrandt *et al.* 2001). All these males were defined as 'older' and had unknown histories, but no information on their ages were provided by the authors apart from the fact that bulls sampled were up to approximately 50 years of age. A further 32% of apparently healthy bulls were apparently infertile due to other causes, indicated by low sperm motility. These problems, as well as possible causes, will be discussed in the following sections – although note that interpretation is hindered by the lack of equivalent data for wild animals.

Low sperm quality

Hildebrandt *et al.* (2001) obtained semen samples from the 74 male Asian and African elephants mentioned above in free and confined contact a (restraint chute). Samples were obtained using three methods: electroejaculation (n = 4), post-mating collection (n = 2) and manual stimulation (n = 59). They found that most bulls (76%) examined produced very low amounts of ejaculate (under 100ml), and these individuals were also characterised by a lack of libido or unsuccessful copulations. A sample of 'older' males (8 Asian, 1 African), see above, produced almost completely aspermic ejaculates because of testicular pathologies, i.e. the development status of the accessory glands was disproportionate (see above). The lack of consistent production of good quality ejaculates also means that artificial insemination is often not an option (Hildebrandt *et al.* 2000).

Possible causes of low sperm quality

The cause of low quality sperm production/quality is not yet known, but various factors have been suggested, and extensive research has also been carried out on livestock species.

Nutrition

Nutrition is known to affect the production and development of sperm (spermatogenesis) in males. No studies have assessed the role of nutrition in male infertility in zoo species, but studies on humans and domestic mammals show a definite relationship between specific minerals and fertility problems (Wildt 1996). Zinc is particularly important, and deficiencies in rats, bulls and humans result in a significant reduction in sperm quality (Wildt 1996; Jainudeen & Hafez 2000). Analysis of zoo elephant diets, reviewed in Chapter 4, reveal that they contained, on average, levels of zinc 22% lower than recommended levels. Manganese deficiency can also cause sterility due to testicular degeneration (Wildt 1996), and a diet deficient in selenium causes a high incidence of abnormal sperm and infertility in mice and rats (Wildt 1996). A range of other nutrients, namely amino acids, essential fatty acids, and vitamins A, B, C and E, all have a negative impact on spermatogenesis (Asa 1996). Given the composition of the average zoo diet, the most likely candidate is a deficiency in vitamin E (see Chapter 4). However, the effect of nutrition on male fertility remains to be investigated in elephants, and thus these remain speculations.

Excessive body weight

Excessive body fat can also cause secondary sperm abnormalities, probably due to overheating of the testes (Skinner 1981, cited in Asa 1996). As reviewed in Chapter

4, zoo elephants often have far greater body masses than timber and wild elephants and so this too could potentially play a role in the production of abnormal sperm.

Social suppression

Social factors may also lead to poor sperm quality. Anecdotal speculations suggest that suppression of reproduction by dominant bulls, cows or even handlers (but see Chapter 6) may play a role in male reproductive problems (Hildebrandt *et al.* 2000). This has yet to be empirically investigated, but Hildebrandt *et al.* (2000) note that bulls classified by their keepers as being subordinate to female elephants, or to their keeper, had different sperm quality compared to those that were dominated by other breeding bulls. This latter group produced sperm-rich ejaculate, but with very variable motility (0 - 90%), compared to 30 - 90% in the former group, although no average is provided. These data contrast with sperm motility results from proven breeders, which ranged from 75 to 90%.

Social interactions between adult and juvenile males also inhibit reproductive development in other species, causing impaired spermatogenesis and decreased weight of accessory glands (e.g. house mice: McKinney & Desjardins 1973) or decreased development of the seminiferous tubules (e.g. field voles, *Microtus agrestis*: Spears & Clarke 1986). It could be that domination by other elephants or possibly handlers is thus at least partly responsible for the poor sperm quality found in zoo bulls. However, males in zoos shown extended periods of musth which may contradict this suggestion although further research is obviously required (see the section '*Possible causes of low libido*' overleaf)

Physical and psychological stress

Stress affects sperm quality in domestic species, probably due to changes in the endocrine system. For example, daily injections with adrenalin (naturally produced during stress) resulted in a marked reduction in sperm quality in bulls (Bearden & Fuquay 2000). Not all males are affected equally, but some with show an increase in abnormal sperm as a consequence of any stress or changes in the normal routine (Bearden & Fuquay 2000).

Behavioural problems affecting fertility in males

Low libido

The lack of sexual interest of male elephants in captivity is a well-known cause of lack of breeding success (e.g. Hildebrandt *et al.* 2000), and is also a one of the most common causes of infertility in male livestock species (Vandeplassche *et al.* 1979).

Possible causes of low libido

Social suppression

Sexual behaviour is largely governed by androgens, one of the sex hormones (Asa 1996), and poor libido is generally believed to be caused by a deficiency in these (Jainudeen & Hafez 2000). Could captivity affect these hormones? It has been suggested that bull elephants that are dominated by other elephants, or even their handler (but see Chapter 6), have lower testosterone than those controlled by indirect means, and thus have a reduced reproductive potential (e.g. Koontz & Roush 1996; Hildebrandt *et al.* 2000). In the wild, there is also evidence that musth can be suppressed by older, higher ranking males (e.g. Poole 1987; Poole 1989b; Slotow *et al.* 2000). However, this may simply relate to the obvious external signals of musth, such as temporal gland secretion and urine dribbling, as bulls 'forced' out of musth continue to have the characteristic elevated testosterone levels of musth bulls (Poole 1982). In other species, the presence of dominant group members has been shown to inhibit male reproduction (e.g. macaques, lemurs and rabbits), which is attributed to the reduction or inhibition of gonadotropin and androgen secretion (hormones that control reproductive cycling in males) in subordinates (Signoret & Balthazart 1993). In many species, subordinate males display less sexual behaviour than dominants (e.g. mice: D'Amato 1988; rats: Blanchard & Blanchard 1989; lesser mouse lemur, *Microcebus murinus*: Perret 1992).

Lack of social experience

Notes on the reproductive potential of the European male population, in the EEP studbook, state that at least two do not know how to mate. Most bulls over the age of around 10 are housed alone, and there is often very little contact between males and females prior to breeding attempts. While the male is housed with females, attempts at mounting may be made but it is likely that adult females will not allow this. In the wild, the advances of young males are spurned and females will chase them off. In other mammalian species, an increase in the production of testosterone in males can be stimulated by regular contact with females (e.g. rams: Illius *et al.* 1976) and mating activity (e.g. bulls: Katongole *et al.* 1971; giant panda *Ailuropoda melanoleuca*:

Bonney *et al.* 1981). Furthermore, contact with females may be essential for the stimulation of sexual behaviour. In the wild, males between 25 to 50 years of age tend to only come into musth after they have associated with a group of females for a period of several weeks (Poole 1987).

Stress

Stress is implicated in low libido in many species, including humans (Arborelius *et al.* 1999). For example, libido is reduced in beef bulls that are lame or suffering from severe frostbite (Barth & Waldner 2002); in laboratory rats exposed to repeated invasive manipulations, such as feeding liquid into the stomach through a tube (Ratnasooriya *et al.* 2002); and in pigs subject to heat stress and undernutrition (Flowers 1997). This has not been studied in male elephants, although anecdotally the use of severe physical punishment has been associated with refusal to reproduce (Kurt 1992, cited in Schmidt *et al.* 1992; Kurt 1995).

Inability to copulate

Some males may be unable to copulate with females even when give the chance. Mounting involves considerable physical effort and puts a lot of pressure on the joints. This is a common problem in older male cattle and boars, and is caused by various physical impairments, such as injury and osteoarthritis of the hind limbs and vertebrae (Jainudeen & Hafez 2000). As reviewed in Chapter 8, foot and joint problems are a common problem in zoo elephants, and thus this could impair reproductive performance.

Summary

- Asian females in zoos produce on average 0.029 calves/year/female, or one birth per 45 females annually, while zoo Africans produce 0.018 calves/year/female, or one birth per 55 females annually. This is around ten times slower than rates in the wild or in extensive conditions (which range from one birth to every 12.5 females a year to one birth to every 2.8 females per year).
- The mean rate of calves per female has even decreased in the Asian zoo population since 1960 (for reasons unknown), despite an increase in the total number of calves born. The median zoo female thus produces just one calf in her whole lifetime, compared with six in the wild.
- One reason for this low mean is that only a small proportion of zoo females have bred - around 20%. In contrast, almost all females in wild or extensive conditions breed at least once.
- One cause is a logistical one - the relative paucity of males in the zoo population (present in 51.4% of zoos with Asians and 67.6% with Africans); the lack of mixing sexes held in the same zoo (this may only occur in 29.3% of facilities with Asians and 37.2% with Africans); and transporting males between zoos to females known to be in oestrus can also be difficult.

- However, even females with constant access to males breed rarely (35% do not breed at all, 50% produce a calf only once every 17 to 25 years, and only 10% calve once every 6 to 7 years, compared to every 2.5 to 9.1 years in the wild). Furthermore, only 20% of zoo females taken to another zoo to mate actually conceived.
- One biological explanation is the low fertility of zoo females. They have an apparently high incidence of acyclicity (unfortunately there are no data on the pre-natal loss of early embryos). Around 15 to 20% of adult females in zoos are acyclic at any one time. No comparable data are available for wild animals, but a risk factor seems to be ovarian cysts, and these occur in c. 5% of zoo Asians and c. 15% of zoo Africans, cf. <1% of wild Africans. Other potential causes of female low physiological fertility include excessive body weight (also linked with cysts), stress, and reproductive stress/suppression, for example related to the relative instability of zoo herds. The latter issues have yet to be empirically investigated.
- A second biological explanation is the short reproductive lives of zoo females - 7.2 years in Asian females, at least four times shorter than that seen in the wild (c. 30 years). Zoo females undergo a type of reproductive senescence or failure not seen in the wild (where animals can keep producing calves up until their 50's or 60's).
- Possible causes include infertility linked to increasing body weight; a growing incidence of pathologies such as cysts; and early reproduction (see below).
- Low male fertility and/or libido also seems a contributory factor to the low reproductive rates in zoos. Approximately 30% of males are infertile due to low sperm quality; and about 75% males tested have low sperm volumes (though equivalent data are not available for wild or logging camp elephants). Behavioural problems (e.g. lack of sexual motivation) may also play a role.
- Possible, but uninvestigated, causes of low male fertility include stress, social subordinancy, excessive body weight, and specific nutrient deficiencies (e.g. zinc).
- Another notable feature of zoo reproduction, at least for Asians, is that females breed at far younger ages than in the wild (calving occurs at 15 years, on average, in zoo females compared to 20 to 25 years in timber camps and 18 to 20 years in the wild). This is particularly marked in zoo-bred animals (although not unique to them), suggesting early social experience or early nutrition is important (e.g. greater body fat reserves in zoo elephants).
- This early breeding may have deleterious consequences. Females which start breeding earlier also stop breeding earlier - i.e. they 'senesce' in a manner particularly different from wild animals. More seriously still, they also have a decreased longevity, with females mated before the age of 12 years dying at a younger age than other animals. However, as breeding *per se* does not increase mortality (see Chapter 7), it may be that early onset of cycling, rather than early calving itself, underlies this relationship (with excess bodyweight being a possible mediator).

Chapter

10

Behaviour problems

In this chapter we review the incidence and frequency of behaviours associated with poor welfare. First, we look at stereotypic behaviours - potential indicators of frustration. We summarise the few data available, compare zoo data with those from other systems, and consider the possible causal factors of these behaviours. Second, aggression is considered, partly as it too may be enhanced by frustration, but also as it is a *cause* of poor welfare, at least for its recipients. We briefly discuss both intra-specific aggression and that directed towards humans. Due to the lack of data for zoo elephants, we draw on studies on other species to identify possible causal factors relating to the captive environment.

Behaviour studies

A literature search revealed a number of studies that quantified the behaviour of elephants held under different captive conditions. In these studies, authors recorded the behaviour of elephants either by direct observation or from video-recordings, and quantified behaviour as a percentage of all observations. The sample size across studies was not large enough to carry out any in-depth statistical analysis to determine the correlates of different levels of behaviour, especially given the number of confounds that would have to be controlled for (e.g. location, species, sex, etc). Thus, primarily descriptive data are presented and discussed here, to provide estimates of the incidence and frequency of particular behaviours in zoo elephants. Studies that have recorded behaviour under different conditions, or carried out manipulations of the environment or husbandry, are discussed later in this section to highlight which factors of the captive environment might be important.

We identified ten studies that quantified behaviour, four of which were on zoo elephants (Hardjanti 1997; Schwammer & Karapanou 1997; Schmid *et al.* 2001; Wilson *et al.* 2001), five on circus elephants (Schmid 1995; Friend 1999; Friend & Parker 1999; Gruber *et al.* 2000; Kirkden & Broom in prep) and one on Asian elephants in a Sri Lankan orphanage (Kurt & Garaï 2001). Data were available for a total of 58 Asian elephants (zoo = 13, circus = 40, extensive system = at least 6) and 19 African elephants (zoo = 9, circus = 10). The zoo elephants were held in seven facilities: six in Europe (London Zoo, Whipsnade Wild Animal Park, Schönbrunn Zoo in Vienna, Hamburg Zoo, Rotterdam Zoo and Munster Zoo) and one in the U.S.A. (Zoo Atlanta). The circus elephants were part of a show travelling around the U.S.A. (Texas and Mississippi), Germany and Switzerland. The orphanage in Sri Lanka (Pinnawela) acts as a refuge for abandoned or unwanted elephant orphans.

Stereotypic behaviour

What are stereotypies?

Stereotypies are repetitive, unvarying behaviours with no obvious goal or function (Keiper 1969; Ödberg 1978; Mason 1991a & 1991b). These rhythmical behaviours often develop in captive animals, and well-known examples include the pacing of zoo polar bears or farmed mink (e.g. Mason 1993; Clubb 2002); bar-biting and chain manipulation in tethered sows (Terlouw & Lawrence 1993; Bergeron & Gonyou 1997; Dailey & McGlone 1997); and the rocking movements of maternally-deprived primates (Mason & Green 1962; Davenport & Menzel 1963; Draper & Bernstein 1963).

Stereotypies are often used as indicators of poor welfare for three main reasons. Firstly, animals that are housed in environments we would consider to be poor, such as barren, cramped conditions, tend to develop more stereotypies than similar animals in large, enriched, surroundings (Hediger 1955; Morris 1964; Powell *et al.* 1999). Secondly, they tend to develop in animals that are frustrated or thwarted from performing highly motivated behaviours, such as feeding and foraging (Duncan & Wood-Gush 1972; Terlouw *et al.* 1991); escape (Meyer-Holzapfel 1968; Fox 1971); or nest-building (Duncan 1970). Thirdly, they are sometimes associated with other indicators of poor welfare, such as injury (e.g. Meyer-Holzapfel 1968), adrenal hypertrophy and adrenocortical hyper-activity (Bareham 1972; Ödberg 1987; von Borell & Hurnik 1991). They are thus signs that animals are motivated to perform natural behaviours that cannot be performed naturally - exacerbated if this motivation is high and/or if the animal has much free time to fill (e.g. Mason 1991a). Many studies therefore report reductions in stereotypies through providing the captive animal with more, or better preferred, activities to do (e.g. Kastelein & Wiepkema 1989; Carlstead *et al.* 1991; Powell *et al.* 1999).

However, the relationship between stereotypy and individual welfare is complex. There is some evidence that the performance of stereotypies may actually help animals to cope with adverse conditions; for example, some are associated with lowered heart rates, the release of endogenous opioids (hormones associated with pleasant experiences), or lower cortisol levels (suggestive of lower stress) (Dantzer 1986; Mason 1991a; Rushen 1993). This may be because – like the use of some environmental enrichments – stereotypies offer animals an outlet for expressing high motivations to perform natural behaviours (albeit in an unnatural-looking manner). Many of the stereotypies seen in other species do resemble some 'normal' behaviours in form (Mason 1991a; Mason & Mendl 1997); for example, oral stereotypies in tethered sows consist of mouthing and nosing movements directed towards bars and chains within the pen, which look very similar to their foraging movements seen in the wild (e.g. Terlouw & Lawrence 1993). Thus some high stereotypers may have found a satisfying or semi-satisfying way of spending their time, for some reason not utilised by low stereotypying individuals.

Furthermore, characteristics of stereotypies can change with time, and may come to be elicited by cues that previously had no effect, or actually suppressed them: a process called emancipation (Fox 1971; Ödberg 1978; Dantzer 1986). They may also become extremely persistent and continue to be performed even after considerable improvement in captive conditions (e.g. Davenport & Menzel 1963; Meyer-Holzapfel 1968). It is unknown whether such changes occur in elephants, although their stereotypies do seem to change in form (Kurt & Garaï 2001). However, such studies show that stereotypies can become rather like ingrained habits, with recent research suggesting that this may be due to changes in the brain that affect the control of behaviour (Garner 1999; Würbel 2001; Garner & Mason, in press). For these reasons, the level of stereotypies shown by an individual may not necessarily be an accurate reflection of its welfare at that specific point in time, but may instead reflect its past history (Mason 1991b).

Overall, conditions that yield a high incidence of stereotypy are thus very likely to be poorer than ones in which animals instead perform more normal-looking behaviours from their natural repertoire. However, within a given type of husbandry system, stereotyping individuals are not necessarily worse off than non-stereotypers.

Stereotypies displayed by elephants

Stereotypies are a well-known phenomenon in captive elephants, particularly those housed in intensive systems where they are chained in small stalls (Hediger 1950; Meyer-Holzapfel 1968; Kurt & Hartl 1995; Kurt & Garaï 2001). A common belief among elephant handlers and trainers is that stereotypy is a normal behaviour and should not be of concern. For instance, swaying stereotypies (weaving) are said to aid circulation in lieu of walking (Friend 1999); Chipperfield (1983) states that 'weaving' is actually a sign of good health, and that if an elephant stops weaving it is a sign that something is wrong; and a veterinary advisor to the Circus Proprietors Association argues that weaving is a natural behaviour pattern that serves to aid digestion (Ormrod 1983).

Such weaving, consisting of swaying side to side or backwards and forwards, is the most common stereotypy of captive elephants. It may involve the entire body or just the head and neck (e.g. Stoinski *et al.* 2000). Whilst weaving, the elephant may lift one or more feet up as it shifts its weight, although sometimes all feet are kept firmly planted on the ground. Weaving may also be accompanied by a nodding of the head and/or trunk swinging (Benedict 1936; Kurt & Garaï 2001), especially in older animals (Kurt & Garaï 2001). Trunk-swinging may also occur on its own with no other movement of the body or head. The repeated extension of the trunk ('trunk tossing') has also been observed in some animals (e.g. Friend 1999; Friend & Parker 1999). Some elephants also pace along the same route or backwards and forwards in the same spot (Rees 2000; Wilson *et al.* 2001). Finally, a more unusual form that also recently been reported involves throwing faeces around the enclosure or onto the body with the trunk, in a repeated and unvarying manner (Stoinski *et al.* 2000; Wilson *et al.* 2001).

Stereotypic behaviour in zoo elephants

The studies discussed at the beginning of this chapter were used here to determine the incidence and frequency of stereotypies. However, note that the criteria used in each study to specify whether a behaviour was stereotyped or not is likely to differ between papers due to the nature of the behaviour. Furthermore, some authors explicitly outlined their criteria (e.g. repeating the movement three times in a row), whereas others did not. This is a common problem with stereotypy studies, but one which is not likely to introduce systematic bias but simply to add noise to the data.

Among the 21 female zoo elephants studied, nine (40.9%; 38.5% Asians and 44.4% Africans) had been observed stereotyping to some degree. The mean frequency of stereotypy across all elephants was 5.2% of observations (range 0 - 34%): 6.8% (0 - 29.0%) for Asian elephants and 0.9% (0 - 4%) for African elephants. However, the *median* frequency of stereotypies was 0%, showing that most elephants studied did not stereotype at all. Considering only those individuals that displayed stereotypies, the mean frequency for these animals was 9.6% (0.6 - 34%): 14.8% (3 - 29%) for Asian elephants and 2.0% (0.6 - 4%) for Africans.

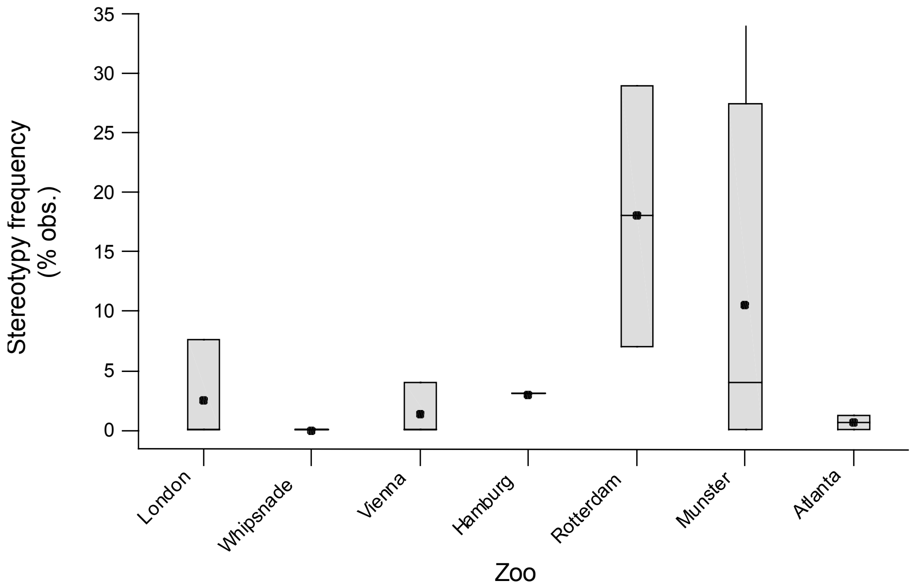

Figure 28. Stereotypy frequency in Asian and African elephants held in zoos

Stereotypy levels show considerable variation between individuals, even those held in the same zoo. The graph above shows the average (solid dot), median (central line), upper and lower quartiles (top and bottom of the shaded bars), and minimum and maximum values (lines extending from the bars) for several zoos. No significant difference was found between these zoos.

The most common form was weaving, which was observed in all elephants that stereotyped, followed by head bobbing and faeces throwing (both recorded in African females). No observations of trunk tossing or pacing were reported for these individuals, although the former is often performed whilst weaving (Friend 1999; Friend & Parker 1999), and thus this stereotypy, and perhaps other subtle ones, may simply not have been recorded.

Unfortunately, there were insufficient data to investigate thoroughly the factors affecting stereotypy levels. However, it was possible to look at the average stereotypy levels in different zoos. Data were first arc-sine transformed to meet the assumptions of the ANOVA model. There was no significant difference between zoos ($F_{6,12} = 1.47$, $p > 0.05$, see Figure 28), although it was clear from the data that there was a great deal of site and individual variation (see Figure 28). This is not surprising given the variation in history and age found in zoo groups.

Comparison with stereotypy in circus and extensively held elephants

Circus elephants are usually kept on 'picket-lines' when they are not performing, which involves chaining two opposing legs to chains or cables that run parallel to each other along the length of the compound (Friend 1999; Friend & Parker 1999). Some circuses now erect temporary paddocks, enclosed by electrical fences, which can hold a number of elephants and negates the need for chaining (Schmid 1995; Friend & Parker 1999). This condition is more comparable to the data collected on zoo elephants free in outdoor enclosures, and so these data will be used for comparison here.

Schmid (1995) reports the frequency of stereotypic behaviour of 19 Asian and 6 African female elephants held in paddocks in five circuses. The author expresses stereotypy as an average frequency per circus. Overall, 65.5% of the elephants showed weaving stereotypies. The average frequency per circus ranged between 0% and 12% of the time. An average per elephant is not provided. Friend & Parker (1999) conducted a similar study on nine female Asian elephants travelling with one circus. All individuals displayed stereotypy to some degree, with an average frequency of 8.7% (range 0.7 - 23.7%) of observation time, or a median of 5.4%. A Mann-Whitney test revealed that the elephants in Friend & Parker's (1999) study displayed significantly higher levels than those in zoos ($W = 201.0$, $n = 9,22$, $p < 0.05$). The most common form of stereotypy in both studies was weaving. Friend & Parker (1999) also report infrequent head-bobbing and trunk-tossing in one elephant.

Baseline data on stereotypy levels shown by elephants held in timber camps were not available. However, Kurt (1995) states that they generally do not develop stereotypies. Similarly, there are no quantitative data from wild elephants, and indeed very rigid, unvarying stereotypies would seem to be absent in the wild. However, transient weaving has been observed in some social situations, in African elephants apparently signalling submission or apprehension (Langbauer 2000). Slight bobbing movements have also been seen in wild Asians while resting (McKay 1973).

Factors affecting, and possible causal factors of, stereotypy

Restriction of movement

Work on circus elephants has shown that chaining is associated with significantly higher levels of stereotypy compared to when they are free in paddocks. For instance, whilst on chains, all nine female Asian elephants studied by Friend & Parker (1999) and all 29 studied by Schmid (1995) performed stereotypies. When the same elephants were moved to paddocks, those in the former study still performed some degree of stereotypy, but the frequency of weaving decreased significantly from an average of 69% of the time to 57% (excluding three elephants that stereotyped for less than 1% of the time). Similarly, Schmid (1995) found that only 19 of his 29 elephants showed weaving when in paddocks (65.5%, cf. 100% on chains), and the frequency significantly decreased by approximately 77%-100% (varying with circus). These data combined are shown in Figure 29, in comparison to the data for zoo elephants. A study of six Asian elephants in Chester Zoo in the U.K. also found that stereotypy levels were significantly higher when the elephants were chained for routine husbandry (e.g. washing) in the morning, compared to just before and after they were chained (Williams unpubl.). There are also anecdotal accounts of stereotypic behaviour showing a marked decrease in frequency once the practice of chaining at night was ended (Wiedenmayer 1995; Juniper 2001). Finally, Kurt & Garaï (2001) made similar observations in an orphanage in Sri Lanka. They note that young Asian elephants chained for 22 hours per day rapidly develop stereotypies, rising from 0% at one month to over 50% of their time by three months. They also observed the development of stereotypies in a group of young Asian elephants chained for 14 to 20 hours per day in the same orphanage. Initially, the elephants made complete steps forwards and backwards and explorative movements with their trunk. Over time, they stopped moving their feet off the ground and instead swayed backwards and forwards with all four feet flat on the ground. Movement of the head was replaced in some elephants with rhythmical trunk swinging and head nodding. Kurt & Garaï (2001) also note that the rate at which elephants moved their feet matched that of travelling wild elephants: 30 movements per minute in young elephants and 10 movements per minute in older elephants, suggesting that weaving may develop from normal locomotion that is restricted by chaining.

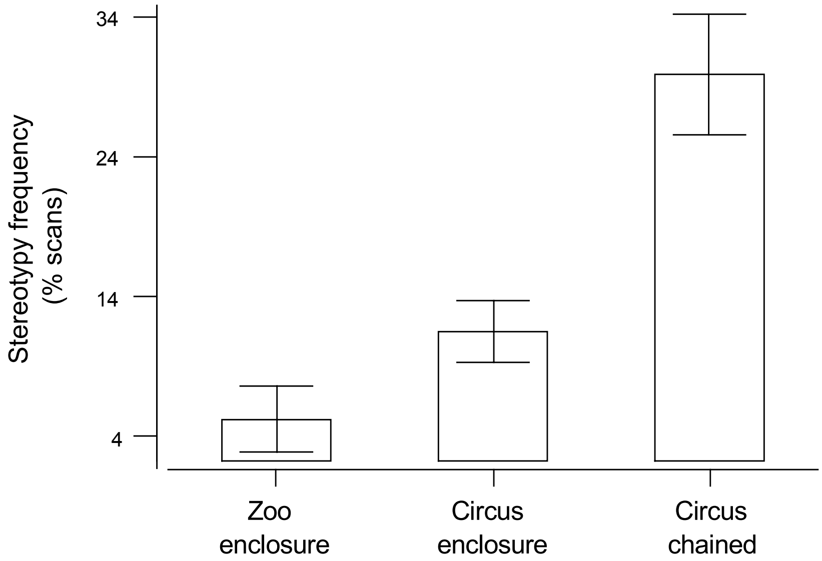

Figure 29. Stereotypy frequency in Asian and African elephants held freely in enclosures or on chains in zoos and circuses

Stereotypy frequency is significantly greater in circus elephants that were chained compared to those free to move in paddocks (Schmid 1995; Friend & Parker 1999). Data from four papers on zoo elephants are provided for comparison (Hardjanti 1997; Schwammer & Karapanou 1997; Schmid *et al.* 2001; Wilson *et al.* 2001).

The size of the enclosure may also affect the development of stereotypies. For instance, enlarging the available area was reported to cause a reduction in stereotypy in an elephant at Chester Zoo (e.g. Rees 2000). Also, a reduction in stereotypy frequency was observed in a female African elephant held at Schönbrunn Zoo, Vienna, following various alterations to the enclosure and management. This included enlarging the enclosure, but also involved various other changes in husbandry making it difficult to assess what caused the reduction. Many studies, mentioned in Chapter 4, have demonstrated a reduction in stereotypy levels in various species following an increase in the available space. However, such changes are not always successful as the contents of the captive environment are often equally, of not more, important (Erwin & Deni 1979).

Social factors

Kurt & Garaï (2001) suggest a link between the degree to which young elephants engage in social interactions and their frequency of stereotypy. Garaï (2001) studied 48 young Asian elephants held in Pinnawela Orphanage and quantified how socially integrated each individual was using nearest neighbour and cluster analysis. Kurt & Garaï note that young orphaned elephants classified as socially integrated displayed a significantly lower frequency of weaving compared to those that were socially isolated (i.e. that spent a large amount of time on their own, and had few social companions). Furthermore, socially integrated individuals only displayed stereotypies when they were chained out of reach from their social companions, and stopped stereotyping when they could establish physical contact with them again. Of further welfare concern, Kurt & Garaï (2001) found that the stereotypic, socially isolated calves also had stunted body growth compared to socially integrated individuals. Garaï (2001) suggests that such calves had been deprived of the necessary learning opportunities necessary for the development of appropriate social skills. This could have implications for the age at which young are separated from their mothers in zoos (as reviewed in Chapter 5, which also further discusses early social deprivation as a causal factor for stereotypies).

Another related factor, but one which has not been studied in elephants, is group size. Studies on a range of social species have shown that stereotypies are higher in singly housed animals compared to group-housed, and tend to decrease when they are housed with more companions (e.g. domestic dogs, *Canis familiaris*: Hubrecht 1992; rhesus macaques: Mason 1960; canaries, *Serinus canarius*: Sargent, 1967). Thus, the small group sizes of zoo elephants compared to those in the wild (see Chapter 5) could plausibly play a role in the development of stereotypies.

Complexity of the physical environment

Studies on a range of species have demonstrated that environmental enrichments aimed at making the environment more complex and stimulating often cause a reduction in stereotypy. This may involve the addition of 'toys' or objects the animals can manipulate (e.g. chimpanzees, Paquette & Prescott 1988, brown bear, *Ursus arctos*, sloth bear, *Selenarctos thibetanus*, and polar bears, *Ursus maritimus*: Forthman *et al.* 1992); alteration of the feeding regime so the animal has to work to find and/or process its food (e.g. walruses: *Odobenus rosmarus*: Kastelein & Wiepkema 1989; rhesus macaques: Bayne *et al.* 1991; bears: Forthman *et al.* 1992); increasing the number of social partners (e.g. foxes, *Vulpes vulpes*: Whiterow 1999, see above); or simply providing a view of the surrounding environment (Keiper 1969; Cooper *et al.* 2000).

Various enrichments have been tried with elephants, with varying objectives (see Chapter 4). However, few studies report quantitative data on changes in behaviour. Williams (unpubl.) found that enrichment items (things that could be manipulated and/or contained food items) significantly reduced the stereotypy displayed by six elephants within the hour or so when they were chained for washing. Schwammer &

Karapanou (1997) also observed a reduction in the frequency of stereotypic behaviour after several alterations to the enclosure, including the addition of enrichments.

Foraging motivation

The development of stereotypies in a range of species, particularly ungulates, has been attributed to the persistence of feeding motivation after the daily food allowance has been consumed. Not only do the stereotypies of some animals closely resemble the behaviours used during foraging in the wild (e.g. canaries: Keiper 1969; pigs: Rushen 1985; polar bears: Kolter & Zander 1995), but they also tend to increase with hunger (e.g. sheep: Cooper *et al.* 1994; chickens: Savory 1996) and decrease with satiation (e.g. mink: Bildsøe *et al.* 1991; lambs: Whybrow *et al.* 1995; pigs: Robert *et al.* 1996). Furthermore, these stereotypies can be reduced by providing suitable foraging substrates (e.g. canaries: Keiper 1969; pigs: Whittaker *et al.* 1998) and/or by increasing the fibre content of the diet (e.g. pigs: Robert *et al.* 1993). Such effects may be mediated by reducing the motivation to forage, increasing satiation, or allowing the specialised digestive system of herbivores to function optimally (Whittaker *et al.* 1998; Mason in press).

As reviewed in Chapter 4, elephants in the wild spend extended periods of the day grazing and browsing, filling most of their daylight hours. This is not feasible in the zoo environment, and thus foraging often comprises a relatively short period of time (see Chapter 4). The diet in the wild is also more bulky and fibrous. Although this remains to be investigated in elephants, the persistence of feeding motivation in zoo elephants may well be a causal factor in the development of stereotypies.

Intra-specific aggression

Aggression is clearly a welfare problem for those at the receiving end of it; for instance, injury and even deaths caused by fighting between individuals have been reported (see Chapter 8). However, it can also indicate reduced welfare on the part of the aggressor, as raised aggression can be a sign of frustration (caused for example by the thwarting of natural behaviours; see e.g. Fraser & Broom 1990, Broom & Johnson 1993), or stress or pain (for example, it can be elicited in rats by subjecting them to electric shocks, as reviewed by Toates 1995).

Although not quantified, aggression between zoo elephants appears to be relatively common. Adams (1980), for example, reports many acts of physical aggression directed at subordinate members of the group elephants; and the perception of intra-specific aggression as a real problem underlies one of the suggested advantages of free contact systems, that handlers can intervene (see Chapter 4). In contrast, aggression among wild elephants is rare, particularly in females, and instead threat displays are used to resolve disputes (see Chapter 5).

Possible causal factors of intra-specific aggression

Social factors

The fact that most zoos seem to hold groups of unrelated females (see Chapter 5) has been suggested to be one reason for aggression (Garaï 1992). In the wild, the matriarch often chases off females from unrelated groups when they try to approach the family group, yet aggression is rare amongst family members (Moss 1988).

The mixing of unfamiliar elephants due to transfers between zoos (see Chapter 5) may also be a cause of aggression. As discussed in Chapter 6, Garaï (1992) reports that a female was subject to frequent acts of aggression when she was returned after a two year absence to a group she had been in for 16 years. This has also been observed in other species, such as pigs, where aggression shows a dramatic increase when unfamiliar animals are mixed (e.g. Tan *et al.* 1991), even if they have previously been a member of the same group (e.g. Ewbank & Meese 1971). This is discussed in more detail in Chapter 6.

Space and enclosure design

The effectiveness of threat displays in preventing aggression, as occurs in the wild, is dependent on there being sufficient space for subordinate animals to retreat and maintain the necessary distance from dominants. Furthermore, restricted space is known to increase aggression in other social species. For instance, increasing the space available reduces aggression in pigs (Arey & Edwards 1998; Turner *et al.* 2000). The amount of space required has not been studied in elephants, but anecdotal accounts suggest that it could be important. For instance, in a study of translocated African elephants, Garaï (1994) observed a high frequency of aggressive interactions in a confined spaced, particularly when food was restricted. In addition, Juniper (2001) notes a large decrease in aggression between females housed in Port Lympne Zoo, U.K., after alterations in the enclosure that allowed them to be housed indoors but off chains. Thus, although requiring further study (see '*Future research*' section), small enclosure sizes and the restriction of movement may perhaps exacerbate intra-specific aggression in zoo elephants.

Aggression directed at humans

The first elephant ever imported into the U.K., the famous Jumbo, progressively changed from a docile, gentle animal to an "unmanageable beast" which resulted in him being shot (Shoshani *et al.* 1986). Aggression towards humans continues to be a problem today. Benirschke & Roocroft (1992), for example, report 31 incidences in European zoos, 15 during the period 1976 to 1991, four of which resulted in the death of the handler. An investigation by John Lehnhardt (1991) also revealed that 15 handler deaths occurred in zoos in the U.S.A. between 1976 and 1991, with elephants thus killing an average of one out of the nation's handlers per year. This is far more than any other zoo species (Statement of Joel Parrott, DVM Director, The Oakland Zoo, In Anon. 2000), and according to the U.S. Bureau of Labor Statistics, makes elephant keeping the most dangerous profession in North America, ranking above coal mining, policemen and firemen.

It is uncertain how husbandry and welfare affect tendencies to be aggressive towards humans. However, a number of suggestions have been made, as we outline below.

Possible causal factors of aggression to humans

The dominance and punishment components of free contact management

Free contact training involves attempting to dominate the elephant, sometimes using punishments and negative reinforcers, and requiring the animal to sometimes do things it may be unwilling to do (see Chapter 5 for more details). All these features may potentially increase the risk of aggression. For example, the handler's dominance over the animal may be challenged (though see Chapter 5 for more discussion of this hypothesis). In terms of the use of punishments and similar, painful stimuli have been shown to induce aggression in humans and other animals, and directed towards the person who is delivering the stimuli (e.g. Kazdin 1975; Berkowitz 1993; Polsky 1994; Schwizgebel 1996; Sullivan 2001). Anecdotally, physical punishment is associated with attacks by elephants directed at their handlers (e.g. Schmid 1998; Hart 1994; Kurt 1995, discussed more fully in Chapter 6). However, none of these ideas have been properly investigated.

Other sources of pain or stress

Elephants in pain can show dangerous and abnormal behaviour (Shoshani & Foley 2000). For example, the reason for a bull elephant killing a tourist in a South African reserve was said to be discomfort due to dental problems (Durrheim & Leggat 1999). In extensive systems, Hart (1994) also notes that drivers recognise "poor welfare, poor or insufficient food, excessive work, or having to respond to too many different people" as causes of aggressive outbursts in their animals. Hart also reports that drivers observing a change in one particular elephant, from well tempered to unpredictable and aggressive, attributed this to high turnover in handlers (Hart 1994). Elephants that have limited space or are shackled are also said to behave more aggressively towards humans and conspecifics than elephants able to move freely (Schmid 1993, cited in Kurt 1995). It is therefore possible that clinical or sub-clinical conditions such as foot sores or arthritis (see Chapter 8), and potential sources of stress such as chaining or high staff turnovers, exacerbate aggression in zoo elephants.

How husbandry affects musth

There is a saying among handlers that for every adult bull in captivity, a handler has died (Koehl 2000). Males are clearly the more dangerous sex; for example, in one Asian camp study, 40.2% (33/88) were regarded as dangerous, compared with 25.2% (24/99) females (Ilangakoon 1993, cited in Kurt 1995). Musth bulls become particularly aggressive (Slotow *et al.* 2000). However, husbandry may interact with this state to exacerbate aggression. For example, Poole *et al.* (1997) point out that aggression associated with musth is not a problem at the Pinnewala elephant orphanage. This set up differs in many ways from the typical zoo (for example, the males were kept in a mixed group with adult females), but the role husbandry may play in reducing aggression remains unknown. Musth may also be a particular problem for zoos as it is so frequent and prolonged in captivity (see Chapter 9).

Summary

- The few studies available suggest that c.40% of zoo elephants perform stereotypies (particularly weaving), although it tends not to take up much time. There is much individual variation, many animals not stereotyping at all, others spending c. 30% observation time in this behaviour. The reasons for this individual variation, and its implications for welfare, are unknown.
- Zoo elephants are less prone to stereotypy than circus elephants (even circus elephants in outdoor enclosures), but anecdotally, more prone than elephants in timber camps that have been reported not to stereotype.
- The causal factors of stereotypies in captive elephants have not been investigated, but anecdotal evidence implicates physical restriction (small enclosure sizes and/or chaining), and social problems in young orphaned elephants. Weaving has been suggested to be a modified form of normal locomotion. However, some weaving is also seen in wild submissives when apprehensive, and the relationship of this behaviour to the stereotypies of captive animals is unknown.
- Intraspecific aggression seems to be more severe among zoo elephants than wild females. Although there are no proper data to test this, possible causal factors include the grouping of unrelated animals, mixing unfamiliar animals, and enclosure sizes and designs that do not permit subordinates to hide or retreat.

- Aggression towards humans makes elephant-keeping currently the most dangerous of all professions in the U.S.A.
- Potential causes relating to husbandry include the use of attempted domination and punishment in traditional systems, chaining, health problems, and aspects of husbandry that prolong the state of musth in bull elephants, and thus the associated aggressive behaviour.

Collated chapter summaries

Introductory information

Elephants in the wild (Chapter 2)

- There are three species of elephant, which can be distinguished by various morphological features: the African savanna elephant (*Loxodonta africana*) the African forest elephant (*Loxodonta cyclotis*) and the Asian elephant (*Elephas maximus*). Very few African forest elephants are held in captivity, and therefore for conciseness, the term 'African elephant', or similar, will be used to refer to the savanna species throughout this report.
- Species differences include: body size (Africans are larger); preferred habitat type (Africans are found on open, savanna areas, Asians prefer forested areas); differences in foraging style (Asians make greater use of their feet); maximum home range size (ranges are larger in Africans) and maximum group size (Africans sometimes congregate in their hundreds).
- Elephants spend a great deal of time feeding (60-80% waking hours) on a wide variety of low quality vegetation, including grass, browse, roots, fruit and flowers.
- Some populations travel great distances during migrations in search of food. The range occupied on a regular basis can vary greatly between populations, mainly due to variations in food and water availability. Home ranges of 10 to 800km^2 have been recorded for Asian elephants, and 14 to 5527km^2 in Africans.
- Sociality in males and females is very different. Females form very strong bonds within the herd, which is comprised of related females and their offspring and led by a matriarch (the largest and oldest female). Males often congregate in loose bachelor herds, but during periods of musth (when males are sexually active) males become highly aggressive and remain solitary when they are not associating with females.
- Breeding occurs all year round. A single calf is produced after a 22 month gestation period and calves remain dependent on their mothers milk for 6 to 24 months, although full weaning is usually delayed until three to six years when the next calf arrives. Females remain within the herd all their lives, but males leave once they reach puberty (at 10 to 15 years of age) to establish their own home range.
- Wild elephant numbers have been greatly reduced in recent years, mainly through poaching and habitat loss. Both species are endangered in the wild and trade has been severely restricted by CITES, by classifying Asian elephants, and the majority of African populations, in Appendix I. This means that the export and import of all Asians and most Africans is allowed only for reasons of research, conservation or education, and according to CITES both species must go to facilities that are "suitably equipped to house and care for it" (all Asian and most African elephant populations) or "appropriate and acceptable destinations" (African elephants from Botswana, Namibia and Zimbabwe) as designated by the appropriate Scientific Authority.
- Priorities in elephant conservation have been identified and include the establishment of more protected areas, enforcing anti-poaching legislation, and various strategies to reduce conflict with humans.

Elephants in captivity (Chapter 3)

- Elephants have a very long history of being tamed and trained by man, dating back some 4000 years. Today, Asian elephants are still used in logging camps, religious ceremonies and for wildlife tourism in Asia, as well as being kept in zoos and circuses all over the world. Training African elephants is far less common and the majority of captive ones can be found in zoos and circuses.
- Elephants are sometimes said to fulfil a conservation role in modern zoos. However, the conservation organisations WWF, IUCN and the African Elephant Specialist Group (AfESG) do not consider that captive breeding makes a significant contribution to elephant conservation, due to the currently low breeding rates and high levels of mortality (see Chapters 7 and 9). There are also issues regarding the cost of *in situ* elephant conservation compared to *ex situ* and the value of zoo elephants for conservation education.
- According to the Captive Elephant Database, there are currently at least 1713 elephants held in various types of facilities world-wide. Zoos hold 634 Asian and 453 African elephants, and Europe has the greatest number (330 Asian and 230 African), most of which are included in the studbooks.
- The current zoo population in Europe consists primarily of elephants caught from the wild (59.7% Asians, 83.3% Africans). The remainder have probably been imported from timber camps (21.0% Asians) or born in zoos (19.4% Asians, 14.7% Africans). Over the years, there has been an increase in the number of Asian imports and zoo-born elephants, and a corresponding decrease in the number caught from the wild, which is probably due to the imposition of trading restrictions.
- Data from the CITES Trading Database shows that most wild caught elephants have been imported from Burma (where capture from the wild is legal) and Zimbabwe (where elephants are listed in Appendix II).
- The biggest importer of wild elephants in Europe is Germany, although the Netherlands has imported slightly more Asian elephants.
- Due to the lack of sustained captive breeding, and hence genetic selection, despite their long association with man zoo elephants must generally be regarded as wild, not domesticated, although most have been tamed. For example, there are no third generation zoo-bred Asians and only 10 second generation (3.1% of the population), plus only 3 (1.5%) third generation and 14 (7.1%) second generation Africans. There is also no evidence that timber elephants have undergone artificial selection, as breeding is not controlled and females are able to mate with wild males.

Possible causes of poor welfare in zoos

General husbandry (Chapter 4)

- Elephants are currently managed using three main handling systems: free contact (hands on); protected contact, and no contact (hands off). Free contact is used in 79.7% of European zoos with female Asian elephants and juvenile males, 32.8% use no contact and 21.9% use protected contact. With bulls, 51.0% of facilities use no contact management, 41.9% use free contact, and 35.5% use protected contact. These figures include facilities that use more than one system.
- Elephants in European zoos are often held in colder, and wetter (in the case of African elephants) conditions compared to their natural environment. The effect of climate on welfare is not known, but of particular concern is very cold weather below freezing, and

the amount of time elephants are confined in small indoor enclosures during adverse weather conditions.

- The EAZA recommends outdoor enclosures measure at least of 400m^2 for three animals, with another 100m^2 for each additional animal. The AZA recommends at least 167.2m^2 per elephant, with an additional 83.6m^2 for each additional elephant. These recommendations are not based on hard data and are likely affected by what is physically feasible in zoos, rather than from the viewpoint of maximal welfare. It is clear that some zoos do not meet these minimum standards, while others far exceed them. In contrast, elephants held in extensive systems have 100,000m^2, or just under, of natural habitat. Wild elephants roam over considerable distances in the wild, the minimum being between 60 to over 100 times larger than these recommended enclosure sizes.
- The use of natural substrates and enrichments such as sand, mudwallows, trees and other large objects is recommended by the EAZA and AZA. They seem important for foot and skin care, and allow the expression of natural behaviours. Pools are also considered essential for these reasons. Elephants in the wild and in extensive systems engage in these activities on a regular, often daily, basis.
- Other environmental enrichments are used in some zoos, although the actual effects on elephant behaviour and welfare are rarely rigorously assessed.
- Dry moats as a barrier are dangerous and can cause injury or death. Alternatives such as electric fencing are recommended by the EAZA and AZA.
- Minimum standards of the EAZA for indoor enclosures are 36m^2 per female and 45m^2 per male. The AZA states that each animal should have 37.2m^2, or 55.7m^2 in the case of bulls and females with calves. Data on European zoos suggest some do not meet these criteria, while others far exceed them. The effects of indoor enclosure area on elephant welfare are not known. In colder climates elephants are often confined for 16 hours or more per day, which is likely to be detrimental given the small area available and the frequent lack of enrichments indoors (e.g. pools, wallows).
- The use of hard surfaces, such as concrete and tarmac, is anecdotally associated with foot and joint problems, but for hygiene reasons, surfaces are recommended to be impervious to water and quick drying. Some facilities now use rubber mats, or poured rubber surfaces.
- Chaining occurs for routine maintenance (e.g. foot care, washing) and overnight when elephants are housed indoors. Elephants are the only zoo species managed in this way. In the U.S.A., 48% of zoos regularly chain their elephants overnight, and an additional 13% do so occasionally, and elephants are generally chaining for 16 hours per day. No quantitative data are available for European zoos but it is believed to still be common, although not in the U.K.. The large amount of time elephants are confined is also of concern regarding the lack of exercise, and the subsequent implications for elephant health.
- A dietary survey of European zoos revealed that most were deficient in various vitamins and minerals (e.g. zinc, iron, vitamin E), while 86.8% had a fat content in excess of recommendations. In another survey of European zoos, 90% did not provide grazing opportunities within the enclosure. Elephants in the wild feed on a wide range of low quality vegetation, and elephants held in extensive systems are allowed to graze on natural vegetation. The effect of diet on elephant welfare has yet to be assessed, but the relatively short time zoo diets take to consume is of concern as this has been linked to the development of stereotypic behaviours in other species; furthermore the effects on body weight may well be a problem.
- A study found that female zoo elephants were 31 to 72% heavier than their wild counterparts. This is likely related to the high fat content of the diets and a lack of exercise due to small enclosures and long periods of confinement and/or chaining. In the

same survey, elephants that were regularly trained had less of a weight problem than those that were not, but both were heavier than their wild counterparts.

Social aspects of the zoo environment (Chapter 5)

- Groups of females are much smaller in zoos compared to the wild. The AZA recommend that a minimum of three females are held together, but the most common group size in European zoos is two (both females) and solitary females are held by several facilities. In contrast, elephants in extensive systems are kept in large mixed groups containing between 51 and almost 3000 individuals, although when working, groups typically contain only around seven individuals. Females in the wild, which remain in their natal herd throughout their lifetime, associate in stable groups of between six and eight elephants, on average, in Asian elephants, and between four to twelve in Africans. Possible welfare concerns regarding small group sizes are stress and a lack of stimulation.
- Most facilities with males only housed one. The AZA state that this is acceptable from the age of six years onwards, a time when some males would still be suckling in the wild and none would have dispersed from their natal herd. After dispersal, which occurs between 10 and 15 years of age, males are found either alone or associated with two to three other males, on average. As mentioned above, extensive systems keep males in groups containing a large number of males and females.
- There is a lack of males in the European zoo population, particularly adult bulls. Male Asian elephants comprise a far smaller portion of the population in zoos compared to an extensive system (18.1% cf. 49.5%) and wild populations (Asian: 18.1% cf. 42%; African: 22.6% cf. 42.5%). Adult bulls (over 15 years) in particular are lacking, making up just 10.1% and 9.7% of the Asian and African zoo population, respectively. This contrasts with an extensive system, where adult bulls made up 22.8% of the Asian population, and also the wild, where they constitute 18.5% of the Asian, and 20.1% of the African, population. Even in facilities that do house both sexes, there are four females to every male.
- Young calves are relatively rare in zoos. Infants under five years of age comprise a far smaller portion of the population in zoos compared to extensively held Asian elephants (8.7% cf. 15.1%) and wild populations (Asian: 8.7% cf. 29.1%; African: 10.8% cf. 23.2%). Infants were also confined to just a few facilities, being found in 18.1% with Asian elephants, and 27.8% with Africans.
- In the zoo population, middle-aged females are very common compared to wild and extensively held populations. Females between 30 and 34 years were the most common age class of Asian elephants found in zoos, compared to infants in an extensive system and wild population. However, in Asian males, infants were the most common age class, which is likely due to the large number of male calves born in the last few years (see Chapter 9). In African zoo elephants, the most common age in males and females was 15 to 19 years, compared to infants in the wild population. Old animals are very rare due to high mortality (see Chapter 7).
- Elephant groups within facilities do not have different age classes represented. Most facilities (65.9% with Asians and 44.5% with Africans) housed elephants belonging to just one or two age classes: adult Asian elephants; adult and sub-adult Africans. Only 3.7% of facilities that housed Asian elephants and 10.6% that housed Africans had a group with representatives from all four age classes. This has possible implications for the acquisition of learnt skills, such as sexual behaviour and maternal care (see Chapter 9).
- There is a probable lack of relatedness between members of the same group within zoos. Only 17.7% of facilities housed a group containing the mother of at least one group member. This, along with the fact that most (74.3%) facilities held elephants with wild-born parents, makes it unlikely that many individuals in the zoo population are related to

other group members, although this has yet to be subject to rigorous study. In the wild, females stay in their natal herd for their entire lives, and associations of unrelated females are rare. Wild bulls do seem to associate with unrelated males in bachelor herds, although it has been suggested that they may share some degree of genetic relationship. This may affect the forming of strong bonds between females, as seen in the wild, and possibly aggression within zoo groups (see Chapter 10).

- Movement between different facilities, and hence social groups, is relatively common. In the zoo population, 30.0% of Asian and 37.1% of African elephants have been transferred to a different facility at least once, in addition to transportation from the wild or Asian camps. There has been a significant increase in the number of transfers experienced by individuals over the years. The majority of transfers involved only one elephant (90.2% Asian and 76.9% African transfers), showing that most were not accompanied by a group member to the new facility.
- This movement between facilities often occurs when elephants are still juveniles. Musth transfers (69.7% of Asian, 79.2% of African transfers) occurred when the elephants were under 10 years of age. The average (median) age at transfer was 4.8 and 4.9 in male and female Asian elephants, respectively, and 5.7 and 6.7 years in male and female African elephants, although there appears to have been a significant increase in age over the years. In extensive systems, elephants typically remain in the same facility, and hence social group, throughout their life. Similarly, in the wild, females stay in the same herd throughout their life, but males leave the herd when they become sexually mature at 10 and 15 years of age. Although remaining to be fully investigated, removal from social partners may cause stress in both the transferred and remaining group members, and aggression may increase due to readjustment of social hierarchies.
- Captive-born zoo elephants are removed from their mother when they are still infants. The AZA state a minimum age of separation from the mother of three years, but the EEP recommend five years. The average (median) age that captive-born calves were moved to a different facility was 2.9 and 3.4 years in male and female Asian elephants, respectively, and 3.7 and 3.0 years in male and female African elephants. Most calves would still be suckling from their mother at this age in the wild. None of the Asian elephants were transferred to the new facility with their mother, and only a few were moved with a companion (13.5%). Although based on a far smaller sample size (11 cf. 52 transfers), most African elephants were transferred with a companion from their present original facility (72.7%) and two (18.1%) were transferred with their mother. Such early weaning has several possible welfare implications, including: the experience of at least short-term stress; susceptibility to the development of stereotypies; impaired immune functioning; and impaired reproductive performance.

Training (Chapter 6)

- Several handling systems for zoo elephants are in use, which dictate what type of training is used: traditional training is used in free contact systems; protected contact training is used in protected contact systems; passive control is used in both free and protected contact systems; and no training is used in no contact systems.
- Traditional elephant training (as used by mahouts and many zoos) is based on a system of dominance, the principle being that the handler becomes the dominant member of the herd and thus maintains control of the subordinate elephants. It allows free contact between handlers and the elephants. Training uses negative reinforcement (pain/discomfort) and punishment, as well as positive reinforcement, and elephants must comply with commands. This is the only system where ‘power behaviours’ are trained. Elephants can be taken for walks around the zoo with their handlers.

- A critical examination of the underlying principle of traditional training, i.e. dominance, suggests that elephants are unlikely to view their handlers as high ranking members of the herd. In traditional systems in Asia, dominance is said to be established once the elephant has been ‘broken’. Breaking involves severe physical restriction, deprivation of food, water and sleep, the use of, sometimes severe, physical punishment, and rewards such as affection and food. Captive-born timber elephants are subject to less severe breaking involving physical restriction, but published details are not available concerning what occurs in zoos and procedures are not monitored. There is no equivalent of breaking in the natural social system of the elephant, where dominance is primarily determined by size; disputes are resolved through threats, displays and displacement and rarely physical aggression; and the hierarchy is said to resemble a ‘democracy’. A further contrast is that matriarchs are with the herd almost constantly throughout their lives, compared to zoos where handers are present only during working hours and where staff can change regularly. The resultant obedience of the elephant is thus more likely to be due to a combination of conditioning, habituation, fear and learned helplessness, rather than an acceptance of a subordinate position in a social system that includes the handler.
- The methods handlers use to maintain ‘dominance’ in traditional systems involve psychological means, physical restriction with ropes and chains, and physical punishment. Handlers may also take steps to ‘re-establish dominance’ if an elephant is disobedient. This ‘discipline’ may involve physical restraint and severe physical punishment. Again, it is highly unlikely that handlers are ‘maintaining’ or ‘re-establishing dominance’, but are instead simply strengthening the conditioning achieved during breaking or training.
- Reports of elephants physically attacking, and in some cases killing, their handler may relate to the methods used during training. For instance, the use of physical punishment has been suggested to cause the build up of ‘resentment’. Another possible risk factor is high staff turnover.
- The methods used to ‘maintain dominance’ are also used to train behaviours and the ankus, or elephant hook, is the basic tool used. Following initial training, however, the ankus is mainly used simply as a cue. The degree to which aversive techniques are used varies between facilities and some are known to use the electric prod as a training tool. Use is often at the discretion of an individual handler and not monitored in any way.
- The process of breaking has severe welfare implications for elephants due to the apparently common use, at least in Asia, of severe physical restriction, deprivation of food, water and sleep, and the use of severe physical punishment.
- Physical punishment such as repeated beating with an elephant hook potentially compromises the welfare of elephants, although the threshold is uncertain. Use of the electric prod on livestock has been shown to be stressful and highly aversive, and its use is under strict control with these species. Rough handling could also lead to chronic stress (e.g. as seen in pigs), possibly because of repetition and associations between pain and particular people and/or locations.
- Traditionally trained elephants commonly perform ‘power behaviours’ such as standing on the hind-legs and sitting. Although similar behaviours are occasionally seen in wild elephants (e.g. standing on hind-legs to reach upper branches), repeated performance, at least in circuses, is associated with several health problems. These include hernias, swelling of the joints and other premature wear and tear of the joints, tendons and muscles of the legs.
- There are no good data on the welfare consequences of different training regimes. However, bulls that have been identified as ‘subordinate’ to keepers (or female elephants) may have lower sperm quality and lower testosterone levels. On the other hand, regularly trained elephants have lower weights compared to those that are not trained (see Chapter 4).

- In protected contact elephants are separated from the handler by a barrier at all times, behaviours are trained using positive and negative reinforcement, and punishment (time-out) with the help of targets. Compliance is not mandatory and so this training method is sometimes called voluntary management.
- Comparison of protected contact with traditional training indicate that: i) breaking is not required and physical punishment is not used in the former system; ii) experts state that foot and skin care can apparently be adequately achieved; iii) sufficient exercise can be achieved given adequate enclosure design and husbandry; iv) the loss of close physical contact with the handler, and the removal of the handler from within the social group may be stressful for elephants changing over from free (traditional) to protected contact, but this may be minimised with the appropriate procedure; v) elephants in protected contact can benefit from the enriching qualities of training more than traditionally trained elephants, as the latter must comply with commands; and vi) aggressive behaviour can be reduced through training in protected contact.
- Passive control has only recently been developed and is only used in handful of facilities. In this system, no dominance or physical punishment is used and compliance is entirely voluntary. Similar operant conditioning techniques to those used in protected contact are used, but no negative reinforcement is used. Passive control can be used to work with elephants in both protected and free contact systems. Due to the fact that the facilities that use this technique are sanctuaries, and thus differ in several respects from zoos, and it has yet to be tried in a zoo setting, its use as a viable alternative to other zoo elephant training techniques is currently questionable.
- Comparison of passive control with protected contact and traditional training suggests that this method may provide the greatest welfare benefits to the elephants. As well as all of the above attributable to protected contact training, elephants can maintain a close physical interaction with their handlers (if they so wish). However, the method remains unproven in a zoo setting and so cannot currently be considered a viable alternative to other training methods, particularly given handler safety concerns.
- No contact (hands off) management involves no training at all and is comparable to the management of other zoo animals. Elephants must therefore be anaesthetised in order to receive any handling or veterinary treatment. It is thus important that elephants kept in this way have high quality facilities to minimise the need for human intervention.
- No contact (hands off) management is potentially capable of providing the most natural environment for zoo elephants. However, these benefits are wholly dependent on adequate enclosure size, design and social grouping. These are rarely found in European zoos (see Chapters 4 & 6) and given that maintenance procedures such as foot care would have to be carried out under general anaesthetic, which carries significant risks, it is unlikely that this method would be beneficial in most existing facilities.

Indicators of poor welfare

Mortality rate (Chapter 7)

- The mean life expectancy of European zoo elephants is 21 years in Asian and 18 years in African elephants, excluding first year mortality. The former is 9 years fewer than Asian elephants living in extensive systems.
- Factors found to correlate with low life expectancy were age (see below) and source of elephants. Female Asian elephants born in zoos have a significantly lower life expectancy (15.4 years) compared to those that have been caught from the wild and imported (25.1 years). A similar trend was found in male Asians, with captive-born

animals surviving to 15.8 years compared to 25.0 years in males caught from the wild. Insufficient data were available to test this in African elephants. Whether elephants had bred or not did not affect longevity.

- Age-specific mortality was also found to be higher in captive-born Asian elephants compared to wild-caught individuals for juvenile animals, but not adults. A similar relationship has been found for elephants in extensive systems in Asia.
- The likelihood that infants born in European zoos will die within their first year is 26% and 13% for Asian male and female calves, respectively, and 8% and 7% for African male and females calves, respectively, according to EEP studbook data. However, data from other studies of the European and North American populations report the higher figure of 33.6% in Asians and 47.0% in Africans (median across studies), for the sexes combined. Analysis revealed that this is a current problem.
- Compared to extensively held elephants, mortality is significantly higher in Asian zoo infants (more than double: 165% higher) and adults (76-389% higher depending on the age range analysed), but not juveniles.
- In Asian elephants, mortality is higher in young European zoo elephants (under 10 years) than in wild populations in India, particularly for calves between 0 and 5 years of age (58% higher). However, this is not statistically significant.
- In African elephants, mortality is significantly higher in European zoo elephants compared to one wild population (Addo Elephant National Park, South Africa), but not when compared to another two wild populations (Tsavo National Park, Kenya and Kasungu National Park, Malawi). Again, analyses were hampered by small sample sizes and so non-significant results were perhaps not surprising. In contrast, were suggestions that infant mortality in one wild population is higher than in zoo calves, however the reliability of such comparisons is uncertain due to the very small sample size for the African zoo calf population.
- However, with this possible exception mortality in the wild was never significantly higher than in zoos, despite this being the norm for other species.

Causes of mortality and morbidity: disease rates and injuries (Chapter 8)

- Stillbirth, infanticide and rejection of calves are together the main causes of infant mortality in European zoos, and are collectively responsible for 74.1% of infant deaths in Asians, and both deaths of African calves, listed in the PETA database.
- 15% of births in Asian elephants held in European zoos are stillborn. Other reports put this figure higher, at between 17.7% and 25% for the European and North American population. In contrast, stillbirths are significantly lower in the African elephant population, constituting 0% to 2.2% of births. In contrast, the frequency of stillbirths in extensive systems in Asia is reported to be between 0% and 3.1%. Stillbirths are also thought to be rare in wild populations, but this is difficult, if not impossible, to quantify. Possible causes of high levels in zoo Asian elephants include excessive calf weight, young age of dams and stress.
- Infanticide accounts for 16.7% of deaths, or 4.5% of births, in Asian zoo elephants. This is far lower than other reports of 15% to 17.7% of births. Similar to stillbirths, infanticide is much rarer in extensive systems, and is estimated to occur in 0.5% of births.
- Mothers rejecting their calves is also a common occurrence in zoo elephants, which has been reported to occur after 5.8% of all births. Rejection is rare in extensive systems, occurring after 0.5% of births. This is also thought to be rare in the wild, but like stillbirths and infanticide, it is difficult, if not impossible, to quantify. Possible causes of poor mothering include premature separation from the mother, which is common in zoos; a

lack of 'aunts' when growing up; a lack of social support around the time of birth; a lack of experience with calves; and stress.

- In 'non-infants', the most common cause of death is illness, which accounts for over 60% of deaths in Asian and African zoo elephants.
- Circulatory problems, such as heart attacks, were the most common fatal illness, responsible for 11.4% to 20.0% of deaths in 'non-infants'. Possible casual factors include excessive weight, lack of exercise, and stress.
- Foot problems have been estimated to occur in 50% of zoo elephants and were associated with the death of three elephants. Possible causal factors include a lack of exercise, improper foot care by handlers, inadequate substrate in the enclosures, damp unhygienic conditions, malnutrition, the occurrence of joint problems, excessive body weight, the performance of stereotypic behaviours and the general effects of stress.
- Herpes virus is a fatal disease that has recently been diagnosed in elephants, and screening suggests an incidence of 9.7% in European zoos. This disease is zoonotic, meaning that it can be contracted by humans, and thus transmitted through close contact. Asian elephants can also contract the virus from Africans, which act as carriers. Risk factors therefore include contact between species, as well as close contact with humans that mix with both species.
- Tuberculosis is another zoonotic disease found in zoo elephants. Although unknown in the European population, a prevalence of 3.3% has been estimated for the North American population. Risk factors are movement between facilities and close contact with humans that may be infected, or have been in contact with infected animals.
- Arthritis appears to be common in zoo elephants, although estimates of prevalence do not exist. A skeletal study suggests that the major form in elephants is spondyloarthropathy, rather than osteoarthritis, found in 8.3% Asian and 4.56% African specimens studied (of unknown origin). Risk factors are thought to include a lack of exercise, excessive body weight, inadequate substrate, damp unhygienic conditions, the training of specific 'power' behaviours and general stress.
- Aggression-related deaths accounted for 9.4% to 17.6% of all deaths, excluding infants, and these included elephants that were euthanased due to excessive aggression and deaths from injuries sustained from other elephants.
- Accidents accounted for the death of 6.3% to 9.1% of deaths in zoo elephants. Most of these involved falls into dry moats surrounding the enclosure.
- Several elephants also died under anaesthetic for routine procedures, accounting for 3.1% to 9.1% of all deaths.
- Malnutrition, through an inadequate diet, can lead to deficiencies in vitamin E, calcium, iron and other nutrients, and thus health problems.
- Intestinal problems, such as enteritis, colic and impaction of the colon are believed to be more common in zoo compared to wild elephants. These can largely be attributed to inadequate diet.
- Although non-fatal, zoo elephants are susceptible to skin problems. Possible causal factors include a lack of bathing facilities and appropriate substrates, such as scratching posts, and general stress.
- Non-lethal pathologies of the reproductive system are also common (covered in Chapter 9).

Reproductive problems (Chapter 9)

- Asian females in zoos produce on average 0.029 calves/year/female, or one birth per 45 females annually, while zoo Africans produce 0.018 calves/year/female, or one birth per 55 females annually. This is around ten times slower than rates in the wild or in extensive conditions (which range from one birth to every 12.5 females a year to one birth to every 2.8 females per year).
- The mean rate of calves per female has even decreased in the Asian zoo population since 1960 (for reasons unknown), despite an increase in the total number of calves born. The median zoo female thus produces just one calf in her whole lifetime, compared with six in the wild.
- One reason for this low mean is that only a small proportion of zoo females have bred - around 20%. In contrast, almost all females in wild or extensive conditions breed at least once.
- One cause is a logistical one - the relative paucity of males in the zoo population (present in 51.4% of zoos with Asians and 67.6% with Africans); the lack of mixing sexes held in the same zoo (this may only occur in 29.3% of facilities with Asians and 37.2% with Africans); and transporting males between zoos to females known to be in oestrus can also be difficult.
- However, even females with constant access to males breed rarely (35% do not breed at all, 50% produce a calf only once every 17 to 25 years, and only 10% calve once every 6 to 7 years, compared to every 2.5 to 9.1 years in the wild). Furthermore, only 20% of zoo females taken to another zoo to mate actually conceived.
- One biological explanation is the low fertility of zoo females. They have an apparently high incidence of acyclicity (unfortunately there are no data on the pre-natal loss of early embryos). Around 15 to 20% of adult females in zoos are acyclic at any one time. No comparable data are available for wild animals, but a risk factor seems to be ovarian cysts, and these occur in c. 5% of zoo Asians and c. 15% of zoo Africans, cf. <1% of wild Africans. Other potential causes of female low physiological fertility include excessive body weight (also linked with cysts), stress, and reproductive stress/suppression, for example related to the relative instability of zoo herds. The latter issues have yet to be empirically investigated.
- A second biological explanation is the short reproductive lives of zoo females - 7.2 years in Asian females, at least four times shorter than that seen in the wild (c. 30 years). Zoo females undergo a type of reproductive senescence or failure not seen in the wild (where animals can keep producing calves up until their 50's or 60's).
- Possible causes include infertility linked to increasing body weight; a growing incidence of pathologies such as cysts; and early reproduction (see below).
- Low male fertility and/or libido also seems a contributory factor to the low reproductive rates in zoos. Approximately 30% of males are infertile due to low sperm quality; and about 75% males tested have low sperm volumes (though equivalent data are not available for wild or logging camp elephants). Behavioural problems (e.g. lack of sexual motivation) may also play a role.
- Possible, but uninvestigated, causes of low male fertility include stress, social subordinancy, excessive body weight, and specific nutrient deficiencies (e.g. zinc).
- Another notable feature of zoo reproduction, at least for Asians, is that females breed at far younger ages than in the wild (calving occurs at 15 years, on average, in zoo females compared to 20 to 25 years in timber camps and 18 to 20 years in the wild). This is particularly marked in zoo-bred animals (although not unique to them), suggesting early social experience or early nutrition is important (e.g. greater body fat reserves in zoo elephants).

- This early breeding may have deleterious consequences. Females which start breeding earlier also stop breeding earlier - i.e. they 'senesce' in a manner particularly different from wild animals. More seriously still, they also have a decreased longevity, with females mated before the age of 12 years dying at a younger age than other animals. However, as breeding *per se* does not increase mortality (see Chapter 7), it may be that early onset of cycling, rather than early calving itself, underlies this relationship (with excess bodyweight being a possible mediator).

Behaviour problems (Chapter 10)

- The few studies available suggest that c.40% of zoo elephants perform stereotypies (particularly weaving), although it tends not to take up much time. There is much individual variation, many animals not stereotyping at all, others spending c. 30% observation time in this behaviour. The reasons for this individual variation, and its implications for welfare, are unknown.
- Zoo elephants are less prone to stereotypy than circus elephants (even circus elephants in outdoor enclosures), but anecdotally, more prone than elephants in timber camps that have been reported not to stereotype.
- The causal factors of stereotypies in captive elephants have not been investigated, but anecdotal evidence implicates physical restriction (small enclosure sizes and/or chaining), and social problems in young orphaned elephants. Weaving has been suggested to be a modified form of normal locomotion. However, some weaving is also seen in wild submissives when apprehensive, and the relationship of this behaviour to the stereotypies of captive animals is unknown.
- Intraspecific aggression seems to be more severe among zoo elephants than wild females. Although there are no proper data to test this, possible causal factors include the grouping of unrelated animals, mixing unfamiliar animals, and enclosure sizes and designs that do not permit subordinates to hide or retreat.
- Aggression towards humans makes elephant-keeping currently the most dangerous of all professions in the U.S.A.
- Potential causes relating to husbandry include the use of attempted domination and punishment in traditional systems, chaining, health problems, and aspects of husbandry that prolong the state of musth in bull elephants, and thus the associated aggressive behaviour.

Chapter 11

Conclusions and recommendations

The welfare of zoo elephants

Our remit in this report was to:

- Identify any welfare problems associated with keeping elephants in captivity;
- Scientifically identify relationships between such problems and elements of elephant husbandry;
- Make sound, ethically based recommendations for improving welfare of captive elephants.

To meet this remit, we first surveyed the ways in which elephants are kept, identified aspects of zoo housing that differ greatly from the wild or more extensive conditions (such as Asian timber camps), and considered the evidence that any of these differences caused poor welfare. We then looked at the zoo elephant population as a whole, to assess the prevalence and severity of signs of poor welfare (even if their causal factors could not be specified). We compiled and reviewed data on mortality and morbidity rates; the incidence of stillbirths, infanticide and the maternal rejection of infants; conception rates and other reproductive issues; and the incidence of stereotypies and aggression. Wherever the data allowed, we compared zoo animals with wild conspecifics and those living in more extensive conditions. Within the zoo system, we also aimed to compare animals differing in their housing and husbandry, although in most cases this was not possible due to a lack of suitable studies.

We identified several potential causes of poor welfare for zoo elephants. These are listed in the chapter summaries, but we highlight the most important here. These are as follows: restricted space and opportunities for exercise; cold and wet climates; extended periods of confinement; hard and/or wet flooring substrates; inappropriate diets; the lack of opportunities to perform various natural behaviours; small social groups, and sometimes even isolation-housing; the lack of relatedness or stability within social groups; early weaning; and, in 'free contact' systems only, 'breaking' when young, and the exposure to aversive stimuli during training. Which of these are most important is very hard to assess, and of course different husbandry variables are likely to be associated with different components of welfare (e.g. flooring may be critical for lameness, weaning age and social grouping for reproductive and maternal abnormalities, and diet for various health problems). In rare instances, scientific data allowed us to make a link between specific aspects of husbandry and welfare – but for the most part, these issues remain unresolved due to a lack of research.

However, we did find considerable evidence that zoo elephants experience poor welfare. Again, these are given in the chapter summaries but the most important are highlighted here. Unlike many species kept in zoos, their mortality rates are not lower than those of animals living in the wild, and indeed, compared to one African population, they are significantly higher. For Asian elephants, mortality rates are also significantly higher than those in timber camps (where life expectancy is about 50% longer than that of zoo animals). Infant mortality rates are also much higher (more than double) in zoos than in timber camps. The causes of the relatively high adult mortality rates are hard to quantify, due to the lack of comparable data from wild or extensively housed animals. However, illness is the main reason why zoo elephants tend not to die of 'old age'; we also identified giving birth before the age of 12 (or some correlate of this, such as early puberty) and being captive born, as significant risk factors. Indeed, captive born elephants have a 60% lower life expectancy than those caught from the wild, living to an average age of just 15 years. The incidence of veterinary conditions possibly caused by excess body weight and/or stress (e.g. coronary and circulatory pathologies; skin infections; and lameness due to superficial foot infections and/or arthritis) was also particularly noteworthy. Causes of the high infant mortality in zoos were clearer, however, as they largely arise from stillbirths, maternal rejection and infanticide, which are all seemingly rare in timber elephants, and perhaps also wild elephants. Further reproductive problems consistent with poor welfare include poor conception rates and long inter-birth intervals; and a cessation of reproductive competence in adult females long before it would occur in the wild or in timber camps. Ovarian cysts are notably much more common in zoo than wild elephants – another condition possibly due to excess body weight. Finally, behavioural anomalies consistent with poor welfare included stereotypies, present in 40% of animals for which there are behavioural data; and possibly high levels of aggression directed at other elephants, as well as handlers. Overall, our conclusion is that zoo elephants generally experience poor welfare, stemming from stress and/or poor physical health.

Cost-benefit considerations

If there were numerous benefits from keeping elephants in zoos, then the welfare costs involved might be regarded as acceptable. After all, their welfare is arguably no worse that that of the broiler chicken or laboratory mouse, both forms of animal-use society deems acceptable. On the other hand, if there were few perceived benefits, it would be harder to justify the welfare costs; the farming of mink, for example, was recently banned in the U.K. despite these animals having very low morbidity and mortality. So do the benefits of keeping elephants in zoos justify the *status quo*?

Weighing up incommensurables like this is a subjective process, but we would argue that the benefits of keeping elephants in zoos do not outweigh the costs. As we saw in Chapter 3, zoo elephants have no direct conservation role and their indirect conservation role is unquantified. They have enabled some fascinating and very useful research to be conducted, but zoo elephants are hardly kept 'for research', and it is not obvious that this research could only have been done in zoos. This leaves their role as that of providing entertainment and diversion – important for humans, and indeed a common role for animals (cf. the many that live as pets), but probably not a role most would regard as justifying poor welfare. In addition, there are great financial costs involved in keeping elephants (see Chapter 3), and also great costs in terms of keeper safety (see Chapter 10).

Happily, we suspect many zoos also agree with this analysis. Good zoos would all probably argue that their animals should have not just adequate, but *excellent,* welfare. Zoos have far more scope than most farms or laboratories to give their animals large amounts of space and a variety of environmental enrichments; zoo animals should also receive excellent diets and good, rapidly-available veterinary care; and be exposed to minimal predation or intra-specific aggression. They should also receive high levels of individual attention, and indeed are often cared for by dedicated and well-trained keepers. It is thus unlikely that zoos themselves would regard the situation for elephants as acceptable (and indeed some, such as Edinburgh Zoo and the Cotswold Wildlife Park, already elect not to keep them because they do not believe they can do so adequately).

Implications of these findings

One implication of these findings is that free contact management, the most common system used in Europe and one often said to tackle deficits in the physical and/or social environment of zoo elephants, is obviously not working. We thus agree with Schmid's (1998) assessment that: "The necessary activities of humans in Free Contact keeping of elephants, like skin care, treatment of feet, intervention in social conflicts between the animals, and training activities to maintain physical health through additional movement, show that there are great defects in all elephant keeping systems. No other zoo animal is kept in circumstances, which necessitate such regular human intervention. Keeping animals in natural social units to prevent behavioural disturbances is achieved with most species in zoos, but not with elephants. Zoo elephant keeping needs innovations, but it makes no sense to compensate for unsolved deficits in enclosure enrichment by the use of restrictive keeping methods such as restraining chutes. The right way will be to remove the deficits, e.g. by enrichment to guarantee the wearing-down of feet, skin care and occupation, as well as by forming natural social units...". Free contact may make the best of a bad job, especially for keepers that have 'inherited' small or old-fashioned enclosures (see its positive effects on bodyweight, for example; Chapter 6), but more fundamental solutions would seem needed to really address elephants' housing problems.

The second implication of our findings is that adding any more elephants to the zoo population, either through importation or captive breeding, now looks very hard to justify. There are significant welfare costs to the animals involved, and these are not offset by any real benefits. In addition, captive breeding would seem to bring with it additional welfare costs. For example, a calf born in a zoo has a 10 to 30% chance of dying in its first year, and a one in ten chance that it will be killed or rejected by its own mother; it is likely to be separated from her prematurely; and even if it survives infancy, its mean life expectancy is only 15 to 16 years. Captive breeding also brings with it practical problems, too, as the 50% of progeny that are male are very difficult to house well and safely, and as yet no provisions have made for the expected increase in captive births. And if we turn to importation, in many cases this is only allowed under CITES for the purpose of conservation, education and research (see Chapter 2), roles that we think can be questioned. Thus until the cons are dealt with (or outweighed by real benefits), we feel that no more elephants should be brought into the zoo system.

Solving these problems

Despite the gloomy overall picture, some zoos are not doing too badly in certain areas. For example, captive elephants can breed well (e.g. as in Ramat Gan Zoo and Paris Zoo), have life spans approaching those seen in the wild (e.g. as in Chester Zoo and Rotterdam Zoo), and show low levels of stereotypy (e.g. Whipsnade Zoo and Hamburg Zoo). This suggests that at least some welfare problems can be overcome with appropriate management. However, whether any zoos are getting it *all* right is more questionable. Without the appropriate empirical research it is impossible to tell at the present time, although considering the data it is clear that the majority of zoos are not getting it right. Furthermore, it is also evident that a substantial improvement is required to ensure that elephants have adequate welfare. For instance, infant mortality would have to be reduced by a factor of nine to match that of Asian timber elephants. There is clearly an urgent need for a detailed, statistically sophisticated multivariate study of the factors affecting elephant welfare. We suggest that a thorough research programme, which we estimate would take just three person years (two if stress hormones and stereotypies were not looked at), could answer a lot of key questions (see Box 8) (we also list some other unanswered research questions in Box 9).

Box 8. Researching the causal factors of elephant welfare problems

This project could focus on the 109 European zoos, or aim to encompass more of the 237 facilities world-wide known to hold elephants. It could even encompass more diverse housing systems (e.g. timber camps, elephant sanctuaries), especially for variables for which there is relatively little variance across zoos (e.g. group composition). The aim of such a project would be to identify specific aspects of husbandry that correlate with measures of elephant welfare. This project could also answer specific questions raised in this report, such as: which handling system is best for elephant health; what enclosure size is acceptable to ensure adequate welfare; and what are the implications of solitary housing on the welfare of bull elephants?

The independent variables of interest would be:
a) physical aspects of enclosure design (e.g. size, complexity, flooring substrates);
b) aspects of husbandry and management (diet; handling regime; time spent indoors);
c) aspects of the social environment (group size; sex and age composition); and finally
d) climatic variables (temperature, rainfall etc.).

Dependent variables (from studbooks, zoo veterinary records, zoo questionnaires; existing publications and direct data collection) would be:
a) reproductive success (e.g. inter-birth interval) (controlling for e.g. access to males);
b) morbidity (controlling for age and body weight);
c) mortality, including stillbirths (controlling for age at first calving, source);
d) the incidence of poor maternal care and infanticide;
e) behavioural problems - aggression and stereotypies (controlling for e.g. prior housing in a circus);
f) non-invasive physiological stress indicators (e.g. salivary, urinary or faecal corticosteroid levels).

Box 9. Additional possible research questions

General husbandry

How effective are different environmental enrichments?
What are the best ways to mix unrelated elephants?

Training

How do elephants respond to their handlers in different types of training regimes (e.g. do they show any behavioural signs that they perceive them as the 'matriarch'?)

Mortality and morbidity

What underlies the high adult mortality in zoo elephants, especially captive-born individuals?
What are the veterinary consequences of being overweight?
Does stress play a role in the incidence of skin and foot infections?
To what degree is arthritis a problem in zoo elephants, and what are its causal factors?

Reproductive problems

Why do elephants conceive so rarely (e.g. are there embryonic losses?)
Why do elephants start breeding early, and also stop early?
Are zoo males less fertile than conspecifics in the wild and/or timber camps?
Is dietary zinc or Vitamin A a causal factor in low sperm quality?
What are the risk factors for poor maternal care?

Behaviour problems

How do stereotyping and non-stereotyping individuals differ? And where does weaving develop from?
To what degree is aggression between group members a problem, and what are the casual factors?

We acknowledge that the results of such research may be pessimistic: if warm climates, very large enclosures and social groups prove to be essential for elephant welfare, most zoos will find it difficult, if not impossible, to improve to meet these needs. However, even if we hope for now that all elephants could eventually be kept well in zoos, the question remains, what to do with the existing zoo elephants, in the absence of new scientific information? One approach is to maintain the *status quo*, until we know for sure what the most important factors are. But another, arguably more humane approach (given the evident magnitude of their current problems), is to at least try and improve elephants' environments now, in advance of such data, because it is so clear that many are not adequate.

We therefore make some interim recommendations pending further research. These supplement, or in some cases replace, the existing EAZA and AZA guidelines, and the forthcoming ones from the Zoo Federation of Great Britain and Northern Ireland. They are as follows:

- Leaving young males with their mothers until the natural age of dispersal in the wild (10 to 15 years of age), unless problems with aggression arise within the group.
- Leaving young females with their mothers for life.
- Not singly housing any animal, especially females.

- Not separating females from the herd for parturition, particularly when old, experienced females are present.
- Adding enrichments, like foraging devices, pools, rubbing/scratching posts, mud wallows, to indoor, as well as outdoor, enclosures.
- Not chaining, except for routine maintenance (e.g. washing, foot care).
- Using rubber flooring in indoor enclosures.
- Not housing elephants indoors for more than a few hours per day unless the space available indoors per elephant meets minimum recommendations for outdoor enclosures.
- Revising diets to meet existing recommendations given by de Regt *et al.* (in prep.).
- Discontinuing all forms of breaking described in Chapter 6.
- Greater transparency and record keeping regarding the use of aversive stimuli during breaking and training, so that use can be monitored.

Overall, given the current poor welfare of most zoo elephants, we therefore conclude this report with the following four recommendations:

- The factors responsible for the poor welfare of zoo elephants should be empirically investigated as a matter of urgency.
- The zoo elephant population should be frozen, i.e. breeding and importation should be ceased until these factors have been identified.
- Only zoos that then solve these problems should be allowed to keep elephants in the future.
- Pending these further investigations, zoos should follow several interim guidelines (in addition, or as an alternative, to those of the EAZA and AZA) to improve elephants’ social and physical environments.

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Appendix I

The questionnaire sent out to all U.K. zoos with elephants is given below. None of the zoos replied and so these data were not collected (see Chapter 1).

1) **KEEPER INFORMATION** (Include all keepers who have any contact with the elephants. Please use the additional sheet if necessary)					
Keeper No.	**1**	**2**	**3**	**4**	**5**
Name (optional)					
Position (e.g. head keeper)					
Age					
Sex					
Time spent at present location as an elephant keeper					
Total time spent as an elephant keeper					
No. establishments where you have worked as an elephant keeper					
Other species you have worked with					

2) GENERAL QUESTIONS ABOUT THE ELEPHANTS (Please use the additional sheet provided if necessary)

Elephant No.	1	2	3	4	5
Name					
Species (African or Asian)					
Studbook no.					
Sex					
Weight (kg)					
Shoulder height (m)					
Position in the group hierarchy, if known (e.g. matriarch, or subordinate to 3 and 4, etc.)					
If captive born, was it mother-or hand-reared?					

3) **HANDLING** (If the same applies to all elephants please fill in column 1 only. Please use additional sheet provided if necessary)					
Elephant No. (from Qu. 2)	**1**	**2**	**3**	**4**	**5**
Keepers responsible for each elephant (if rotated evenly, please write 'All')					
Are the elephants managed free-, protected- or no-contact?					
Estimated total no. contact hours per day with all keepers					
Are the elephants trained to respond to commands? If so, where were they trained?					
Estimated no. commands known					
Estimated number of commands used during an average day					
Do they take part in any displays? If so, state the freq.					
Are they taken out of the enclosure for walks? If so, state the freq.					
Is training based on being the dominant member of the herd?					
Is physical punishment ever used, and to what extent?					
If an elephant refuses to obey a command, what procedure is followed?					

4) **GUIDELINES, HEALTH & SAFETY**	
Do you have written guidelines on the premises specific to elephant husbandry and/or elephant training?	
Are new keepers trained on-site, and if so is there a written protocol for their training? If not on-site, please state where training occurs	
Is there an electric goad kept on the premises? If so, under what circumstances would it be used?	

5) **MAINTENANCE & HEALTH** **(If the same applies to all elephants please fill in column 1 only. Please use additional sheet provided if necessary)**

Elephant No.	1	2	3	4	5
How frequently are the elephants washed?					
How frequent is foot care? If on an 'as needed' basis, please roughly estimate the frequency					
Are they chained during the above procedures?					
Estimated no. hours per day spent on the above activities					
Details of any notable medical problems experienced by each elephant during your time with them, e.g. infections, disease, foot problems, joint problems, accidents, etc.					
No. times general anaesthetic has been required					

6) **BEHAVIOUR** (If the same applies to all elephants please fill in column 1 only. Please use additional sheet provided if necessary)					
Elephant No.	**1**	**2**	**3**	**4**	**5**
Details of any stereotypic behaviour shown, e.g. weaving					
Any specific circumstances when stereotypy is shown, or noticeably increases, e.g. mainly prior to being fed					
Estimated amount of time spent stereotyping: never, very seldom; seldom; not often; often; very often; remarkably often					

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7) <u>REPRODUCTION</u> (Please use additional sheet provided if necessary)

Elephant No.	1	2	3	4	5
Is the individual cycling? Please state if 'unknown' or 'not applicable'					
Details of any known reproductive disorders					
Age at first observed oestrus/musth, if applicable. Please state if this was not a full musth					
Males only: usual length of musth. Give a range if variable					
Is breeding being attempted?					
If yes to the above, please estimate the number of breeding attempts so far and age of individual at each time					
Number and cause of failed breeding attempts (i.e. did not become pregnant). For example, would not allow mounting					
No. pregnancies					
No. live births					
Cause of unsuccessful pregnancies, if applicable					
No. calves surviving for at least 1 year					
No. calves rejected. Please state which calf, if more than one					

8) <u>THE ENCLOSURE & GROUPING</u> (If more than one enclosure, please use a separate column for each one. Please use additional sheet provided if necessary)

Enclosure	A	B	C	D	E
Group composition in outdoor enclosure/s (please write 'all' if all elephants are housed in one enclosure)					
Total area of outdoor encl. (m^2)					
Approx. time spent in outdoor encl. in summer (hrs)					
Approx. time spent in outdoor encl. in winter, if different (hrs)					
Main substrate type/s in outdoor encl.					
Is there a pool? If so, please give approx. dimensions.					
Are wallows available?					
Are scratching posts, or some equivalent, available?					
Group composition in indoor enclosure/s (please write 'all' if elephants are all housed in one enclosure)					
Total area of indoor encl. (m^2)					
Main substrate type/s in indoor encl.					
Do you have a restraint chute?					
Are environmental enrichments used? If so, please outline briefly, e.g. scatter feeding, hanging tyres, etc. Please indicate the frequency of use..					

9) **DIET** (If the same applies to all elephants please fill in first column only. Please use additional sheet provided if necessary)		
Elephants referred to, if some individuals are fed differently. Leave blank if all elephants receive the same		
Number of meals per day, and approx. time given		
Estimated weight of each meal (kg)		
Composition of each meal. Please list food items. If some items are given occasionally please mark with an 'O'		
Is browse provided? If so how often?		

10) **YOUR VIEWS** (Please feel free to add an additional sheet for further comments)	
How would you rate the welfare of the elephants at your zoo from 1-5, regardless of constraints such as finances	
What, if any, improvements do you think could be make for your elephants?	
Do you think there should be a minimum group size for elephants, and if so, how many?	
Additional comments: Please use this space to raise issues not considered in this questionnaire or to expand on any points.	

Appendix II

Dietary recommendations for Asian zoo elephants

The table below shows the recommendations for the nutrient content of Asian elephants in zoos, as given by de Regt *et al.* (in prep.). The 'maximum' value represents toxic levels taken from the literature. Superscripts refer to the source of the data. For instance, NRC standards for adult horses were used when data for elephants were lacking. See Chapter 4 for more detail on zoo elephant diets.

Per kg dry matter	Unit	Optimum	Margin	Maximum
Energy	kcal/kg body weight	[‡]13	depends on the elephant	depends on the elephant
Dry matter	kg/day	42	32.5 – 52	-
Crude protein	% dry matter	[†]10	[*]8.0 – 13.0	-
Fat	% dry matter	1.5	[†]1.2 – 1.8	-
Crude fibre	% dry matter	35	[†]20 – 50	-
Calcium	% dry matter	[*]0.4	0.3 – 1.0	depends on % phosphorus
Phosphorus	% dry matter	[*]0.2	0.2 – 0.6	depends on % calcium
Iron	mg/kg dry matter	100	50 – 900	[*]1000
Zinc	mg/kg dry matter	[*]40	30 – 400	[*]500
Magnesium	% dry matter	[*†]0.1	>0.01	-
Potassium	% dry matter	[†]0.6	0.5 – 1.0	-
Sodium	% dry matter	[†]0.2	0.15 – 1.0	[*]3
Vitamin A	IU/kg dry matter	[*]2000	1500 – 10000	[*]16000
Vitamin D	IU/kg dry matter	[*]300	250 – 1000	[*]2200
Vitamin E	IU/kg dry matter	[‡]150	130 – 167	-

[*]NRC standards 1989 (These standards have been established by The National Research Council. The standards are mature maintenance standards for horses): National Research Council (1989). Nutrient Requirements of Horses. Washington D. C., National Academic Press; [†]McCullagh, 1969, In Dierenfeld, E. S. (1994). Nutrition and Feeding: a review of the literature. New York, Wildlife Conservation Society; [‡](Dierenfeld & Dolensek 1988)

Appendix III

Foot problems and their causes

Summary of the main foot conditions encountered in captive elephants, their predisposing factors and the recommended preventative measures and management, taken from Fowler (2001). 1 - Lack of exercise; 2 - Inadequate/improper foot care; 3 - Inappropriate substrate; 4 - Unhygienic conditions; 5 - Malnutrition; 6 - Stereotypic behaviour; 7 - Sharp objects/penetration; 8 - Progression of other condition; 9 – other.

Condition	Description	Predisposing factors (see key above)
Abrasion, sole	Excessive wear of a segment of the sole	6
Abscess, subsolar	An abscess located beneath the sole	7
Abscess, toenail	An abscess located in the toenail	4, 7
Abscess, interdigital	An abscess located between the toenails	8
Arthritis	Inflammation of a joint and surrounding structure	1, 9
Bulla	A large blister	8
Contusion, sole	An injury to the skin or the sole cause by a blow but without a break in the skin or sole	7
Canker		8
Crack, heel	Cracks in the skin near the rear of the foot	8
Crack, toenail	A crack in the toenail	1, 3
Crack, sole	Cracks in the keratinised layer of the sole	1, 3
Cuticle, overgrown	Excessive growth of the epithelium at the top of the nail	3
Fissure	Any cleft or groove in the surface of an organ, such as the skin or sole of the foot	1, 3
Fracture		9
Gravel	An infection that invades the tissue just deep to the nail at the bottom of the foot, and then migrates dorsally to the top of the nail bed	4
Groove, sole		1, 3
Hangnail	A small piece of skin hanging by one end at the side or base of the nail	2
Hematoma	An accumulation of blood in a confined space, in a tissue, such as the fibrous tissue beneath the sole	9
Ingrown toenail	Abnormal growth of a nail into adjacent soft tissue of the nailbed	2
Laceration	A wound caused by a sharp object	7
Maceration, sole	The softening and degeneration of the sole	4
Maceration, skin	The softening and degeneration of the skin of the foot	4

Condition	Description	Predisposing factors (see key above)
Onychia	Inflammation of the matrix of the nails, resulting in loss of the nail	5
Osteomyelitis	An inflammation of bone caused by pyogenic bacteria	8
Paronchia/Perionchyia	Inflammation involving folds of the skin and tissue surrounding the nail	8
Pitting	Holes or cavities in the sole	1, 3
Pockets	A hollow space or an enclosed space	1, 3
Pododermatitis	Inflammation of the skin, nail, and associated structures of the foot	4
Puncture wound	A penetration of the skin, nail and associated structures of the foot	7
Pustule	A visible collection of pus within or beneath the epidermis, often in a hair follicle or sweat pore	8
Ridge, sole	A long, narrow proliferation of keratin in the sole of the foot	1, 3
Ulcers	A local defect or excavation of the surface of the skin or sole, which is produced by the sloughing of inflammatory necrotic tissue	2
Vesicle	Seropurulent fluid-filled pockets in the area of the cuticle	8, 9

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